SKA PHASE 1 SYSTEM REQUIREMENTS SPECIFICATION

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Author ....T. Stevenson et al (see below)

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Name	Designation	Affiliation	Date	Signature
Submitted by:				
T. Stevenson	System Engineer	SPDO	2011-02-14	*TJS*
J.G. Bij de Vaate, A.J. Boonstra, A. Gunst, R. Nijboer, A.J. Faulkner and P. Alexander.				
Approved for release as part of SKA System dCoDR documents:				
P. Dewdney	Project Engineer	SPDO	2011-02-14	*PED*

<u>**Important**</u>
This is a living document and is intended to be filled, extended and augmented as the Requirements Capture activity continues. It will receive its first formal release prior to SKA Phase 1 System Requirements Review.

DOCUMENT HISTORY

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ORGANISATION DETAILS

Name	SKA Program Development Office
Physical/Postal Address	Jodrell Bank Centre for Astrophysics
	Alan Turing Building
	The University of Manchester
	Oxford Road
	Manchester, UK
	M13 9PL
Fax.	+44 (0)161 275 4049
Website	www.skatelescope.org

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LIST OF ABBREVIATIONS

AA.................................Aperture Array

AC.................................Alternating Current

ADC ....Analogue to Digital Converter

ADD ....Architectural design Document

dB ....Decibel

deg.................................degree

DRM ....Design Reference Mission

DC ....Direct Current

EM ....Electro Magnetic

EMC..............................Electro Magnetic Compatibility

FOV ....Field of View

GHz ....Giga Hertz

Hz ....Hertz

Jy ....Jansky

K ....Kelvin

Kg ....kilogram

km...................................kilometre

kVA................................kilo Volt Ampere

LOFAR...........................Low Frequency Array

m.....................................metre

M&C...............................Monitoring and Control

MHz ....Mega Hertz

PAF................................Phased Array Feed

RFI..................................Radio Frequency Interference

SKA ....Square Kilometre Array

SKADS ....SKA Design Studies

SPDO ....SKA Program Development Office

SRS ....System Requirements Specification

SS...................................Survey Speed

TBC ....To Be Confirmed

TBD. ....To Be Determined

V ....Volt

1   Introduction

1.1   Purpose and scope of the document

This document represents the draft SKA Phase 1 (SKA$_1$) System Requirement Specification and as such this document aims to:

1) Capture the envelope of all aspects that will eventually contribute and feed into the system requirements,

2) Provide the source of requirements in a system requirement specification which will flow down to the lower tiers of the Observatory Hierarchy,

This is a living document with applicability throughout all phases of the Project.

It is foreseen that these high level requirements which have been allocated downwards will be influenced as more work at the lower tiers of the Observatory hierarchy is done and the feasibility of meeting them is analysed. These influences will be rolled back up to the system level and possible changes to the system requirements will be analysed against the higher level requirements such as the science requirements in the Design Reference Mission. Trade-offs will have to be performed to confirm possible changes and if changes are to be made, these changes will have to be captured and rolled back down to the lower levels.

During the next system engineering phase, the Definition Phase, the focus will be to continue to gather the requirements from all the relevant sources and stakeholders, to analyse and verify these requirements and to capture these requirements in the system requirements specification. At the end of the phase the aim is to have a complete set of stable and traceable requirements.

The requirements currently contained in this document are based on V1.3 of the Phase 1 Design Reference Mission (DRM), the Phase 2 DRM (V1.0) (to inform the derivation of extensibility requirements) and requirement specifications / experience gained from other radio astronomy instruments such as the Low Frequency Array (LOFAR).

1.2   Notes on document format

This document contains high level, formal requirements that must be:

- Quantifiable

- Justified

- Configuration controlled

- Traceable

- Unambiguous

- Unique

- Singular

- Self contained

- Verifiable

Additionally, and where appropriate (as an aid to verification for instance), requirement numerical values have a tolerance within which the requirement is satisfied.

Requirements have unique identifier codes which are used in circumstances where reproducing the text of the requirement is inappropriate. In this document they are of the format SYS_REQ_nnnn where SYS signifies System level, REQ signifies a requirement conforming to the above rules and nnnn is a unique numerical identifier.

Requirements in this document are of the form:

Identifier	Requirement text	Applicable as Mandatory or Target (or Redundant if exceeded elsewhere)	Traceable from (parent requirement) or Rationale	Verification method

The requirements that appear in this document will be entered into a database whose purpose is (amongst other things) to provide configuration management and analysis through tracing. At present, this representation of system level requirements is the ruling document.

2   References

2.1   Applicable documents

The following documents are applicable to the extent stated herein. In the event of conflict between the contents of the applicable documents and this SKA1 System Requirement Specification (SRS) document, this document shall take precedence over the applicable documents.

[1] SKA Science Working Group, "*The Square Kilometre Array Design Reference Mission: SKA Phase 1*", report, v.1.3, January 2011.
[2] SKA Science Working Group, "*The Square Kilometre Array Design reference Mission: SKA-mid and SKA-lo*", report, v.0.4, October 2009.
[3] The SKA Science and Support Operations Plan WP2-001.010.010-PLA-002
[4] T. Stevenson, "*SKA System Engineering Management Plan*", document WP2-005.010.030-MP-001, Revision F.
[5] K. Cloete et al, "*Strategies and Philosophies*", document WP2-005.010.030-TR-001, Rev F, dated 2011-02-11.

2.2   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.

[6] P. Dewdney et al, '*SKA-Phase 1: High Level System Description*', document WP2-005.030.010-TD-002, Rev A, dated 2011-02-14.

[7] SKA Memo 125: '*Concept Design for SKA Phase 1 (SKA$_1$)*', M.A. Garrett, J.M. Cordes, D. De Boer, J.L. Jonas, S. Rawlings, and R. T. Schilizzi (SSEC SKA Phase 1 Sub-committee), 30 May 2010.

[8] SKA Memo 130: '*SKA Phase 1: Preliminary System Description*', P.E. Dewdney et al, dated November 2010.

3   Functional and Performance Requirements

3.1   Functional Overview

The high level functional context diagram for the SKA$_1$ is shown in Figure 1. From this figure it is clear that the SKA$_1$, and therefore the system requirements, are influenced by various aspects and interact with various aspects. A more detailed description of the context and each of the interfaces can be found in [6].
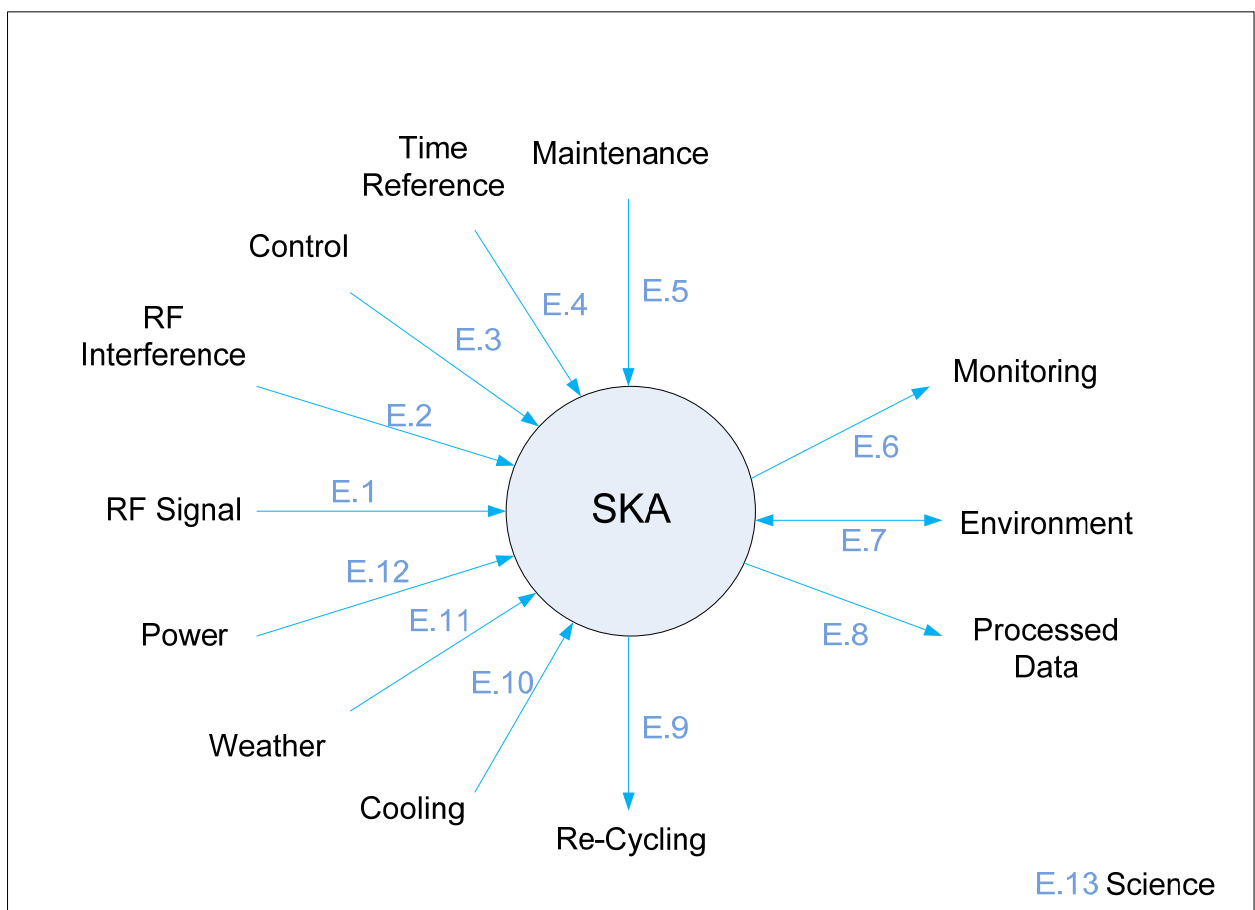
Figure 1: High level SKA1 functional context diagram

The next level of the functional hierarchy is detailed in Figure 2. The primary functions of the SKA_1 are:

1) Reception

2) Signal Processing

3) Computing

4) Synchronisation and Timing

5) Monitoring and Controlling

6) Power generation

7) Cooling

8) Networking

9) Science
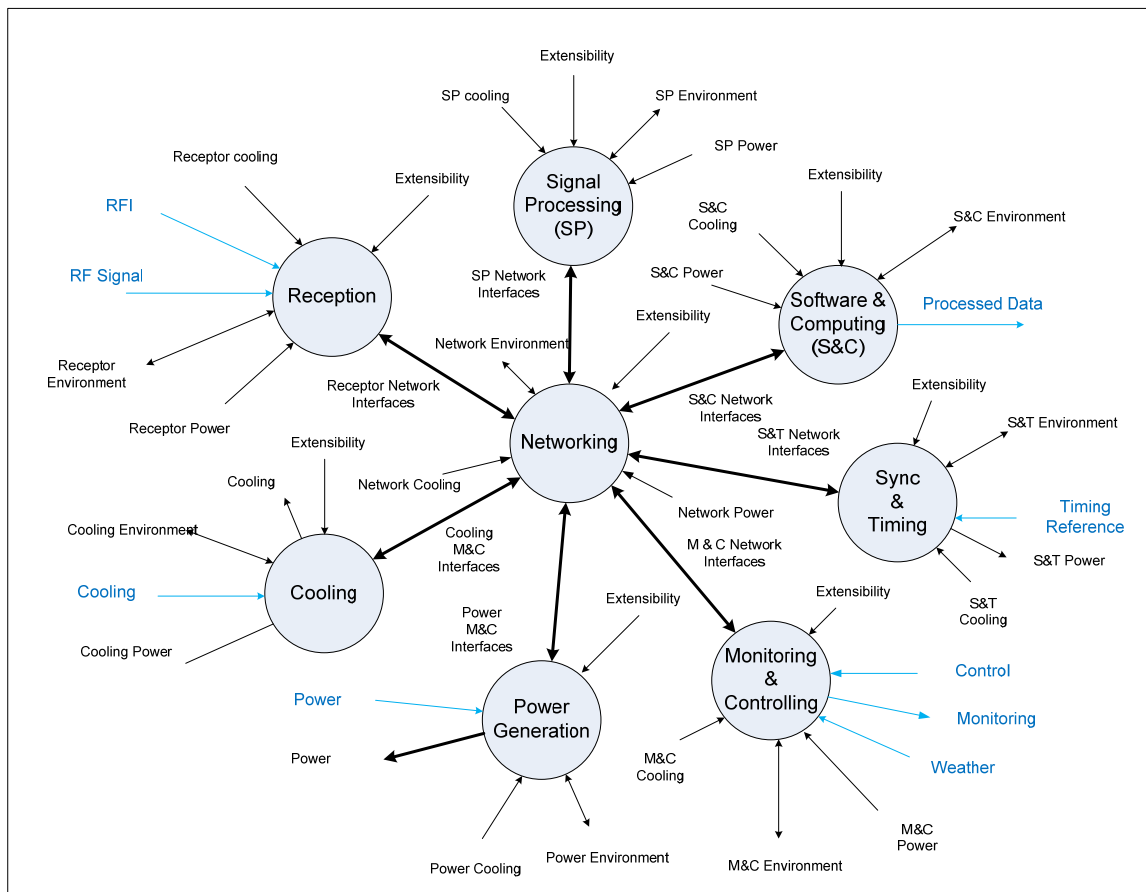
Figure 2: 2nd layer of the SKA_1 functional context

Detailed analysis of all of these functions of the system is provided in RD [6]. Each of the functions and interfaces identified in the figures above will contribute to the requirements for the system. Not all of them are addressed in this document as yet.

3.2 Science Requirements Derivation

The science requirements have primarily been extracted from the science cases discussed in the DRM [1] and are listed below. The numbers are related to the chapter number of the science cases in the DRM document.

2 Probing the Neutral Intergalactic Medium During the Epoch of Reionization
3 Tracking Galaxy Evolution over Cosmic Time via H I Absorption
4 Probing the Epoch of Reionization Using the 21-cm Forest
5 Pulsar Surveys
6 Pulsar Timing
7 Extensibility: Phase 1 to Phase 2

The SKA1 DRM [1] includes a direct translation of astronomical requirements into a limited set of system requirements. It concerns the following observational and technical system requirements:

Spectral:
- frequency range (Hz)
- instantaneous bandwidth (Hz)
- channel width (Hz)
- channel width required for RFI avoidance/suppression (Hz)

Spatial:
- minimum or maximum baseline (m)
- instantaneous FOV (degree^2)
- sky coverage (degree^2)

Temporal
- time resolution (s)

Sensitivity
- sensitivity (Aeff/Tsys, in $m^2 K^{-1}$)
- survey speed ($m^4 K^{-2} deg^2$)

Dynamic range
- imaging dynamic range (dB)
- spectral dynamic range (dB)
- polarization dynamic range (dB)

Three classes of top level requirements can be distinguished, *scientific requirements, derived technical requirements* and *constraint requirements*.

Scientific requirements are directly related to the SKA$_1$ astronomical science cases, and include frequency range, polarisation, and limiting flux density. These requirements are more or less

straightforwardly derived from the astronomical science cases. As these requirements are mutually independent, there are no trade-offs possible between any of the astronomical requirements.

Derived technical requirements are requirements derived from scientific requirements, and from observational constraints such as time allocation and scheduling. Survey speed and sensitivity, for example, can only be connected to astronomical requirements if the required observation time is specified. Also, part of the technical requirements is mutually dependent. This means that some derived technical requirements can be adjusted without compromising the astronomical science requirements. Instantaneous bandwidth and survey speed for example can have any value within certain ranges as long as their product is a specified constant.

Constraint requirements are those stemming from practical considerations and the consequences of accommodating the Observatory in the real world. Examples of these are Regulatory requirements and Human Factor Requirements.

In the current version of the SRS, there is not yet any strict separation between the astronomical requirements and derived technical requirements. Such an approach would require, for each science case, a detailed analysis of the dependencies between the two classes of requirements in relation to the operational constraints.

In Table 1 science cases are classified in terms of observation mode and main requirements specifications: sensitivity, Field of View (FOV), bandwidth, dynamic range, and baseline. The identifier 'X' means that there exists a requirement specification, '-' means that there is no explicit requirement.

Science chapters are:

2	Probing the Neutral Intergalactic Medium during the Epoch of Reionization
3	Tracking Galaxy Evolution over Cosmic Time via H I Absorption
4	Probing the Epoch of Re-ionization using the 21cm Forest
5	Pulsar Surveys with Phase 1 of the SKA
6	Pulsar Timing with Phase 1 of the SKA
7	Additional Telescope Considerations: Phase 1 to Phase 2

Table 1 : Specification classification of DRM science chapters

Science chapter / Parameter	2	3	4	5	6	7
Frequency Range	X	X	X	X	X	X
Survey Speed	-	X	-	-	-	-
A_e/T_{sys}	X	-	-	X	X	-
Frequency Resolution	X	X	X	X	-	-
Temporal Resolution	-	-	-	X	-	-
Polarisation Purity	X	-	-	-	X	X
Imaging Dynamic Range	-	X	-	-	-	X
Spectral Dynamic Range	-	X	X	-	-	-
Required Baseline	-	X	-	-	-	-

3.3 Spectral Characteristics

This section refers to the part of the spectrum to be observed with SKA$_1$. It has an impact on the antenna and receiver specifications, but also on the dimensions of all digital processing.

3.3.1 Operating Frequency

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1110	**Electromagnetic frequency range.** SKA1 shall be able to measure electromagnetic radiation in a frequency range from 70 MHz to 3 GHz.	Mandatory	[1] Table 8.1	Test

3.3.2 Instantaneous Bandwidth

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1120	**Instantaneous bandwidth.** SKA1 shall have an instantaneous bandwidth, of:	Mandatory		Test
	Fractional instantaneous bandwidth: 1 The SKA Phase 1 shall be designed so that the fractional instantaneous bandwidth is comparable to the observing frequency.		[1] Paragraph 1.4.3 and Table 2.2	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1130	**Frequency band positioning.** It shall be possible to position this band anywhere within the operating frequency band, with a positioning accuracy as specified in SYS_REQ_1970 and SYS_REQ_1980. The instantaneous observable frequency band is a contiguous (TBC) band selected from the total frequency range.	Mandatory		Test

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1140	Band selection resolution. The resolution with which the 500 MHz and 1 GHz bands can be selected shall be TBD or less.	Mandatory		Test

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1150	Polarization frequency equality. It shall not be possible to select different digitized bands for the two polarizations of a single dish/antenna/array.	Mandatory		Test

3.3.3 Number, width and placement of station output bands

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1160	**Sub-band bandwidth.** The sub-band bandwidth after station level beamforming shall be less than TBD Hz.	Mandatory		Test

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1170	**DSP signal processing capacity.** The digital processing capacity shall be sufficient to process all sub-bands (Q: and beams, and polarizations, or should there be exchangeability).	Mandatory		Test

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1180	**Beam sub-band and channel phase relations.** The phase relations between the sub-bands and channels within a beam shall be known to such a precision that wider bands and corresponding time series can be reconstructed from sub-bands and/or channels.	Mandatory		Analysis/ Test

3.3.4 Spectral flatness

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1190	**Spectral baseline.** The SKA Phase 1 shall be designed so that the bandpass does not show ripples or systematic fluctuations, on scales smaller than a frequency corresponding to about 300 km s^{-1}, that are larger than twice the thermal noise level after an integration of 1000 hr.	Mandatory	[1] Paragraph 1.4.4	Test

3.3.5 Spectral Resolution

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1210	**Spectral resolution.** SKA1 shall offer a spectral resolution in each polarization for science processing of:			Test
	< 200 Hz in the band 70 to 240 MHz; '*The SKA Phase 1 shall provide a frequency resolution of at least 0.2 kHz.*'	Mandatory	[1] Paragraph 4.4.2 and Table 8-2	
	< 10kHz in the band 400MHz to 3 GHz	Mandatory	[1] Paragraph 5.4, Table 5-2 and Table 8-2	
	100kHz in the band 70 to 240 MHz; '*This requirement follows directly from the radial resolution science requirement. For reference, assuming the concordance cosmology, at these redshifts, the co-moving length is given by ≈ 1.7 Mpc (Δv/100 kHz). Therefore, to match the angular resolution a frequency resolution of about 100 kHz is required.*'	Redundant	[1] Table 8-2 and Paragraph 2.4.2	
	1 kHz in the band 70 to 240 MHz; '*In practice a more stringent requirement of 1 kHz in frequency resolution is required to identify and excise RFI, reduce bandwidth smearing, and calibrate ionospheric effects.*'	Redundant	[1] Paragraph 2.4.2	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1220	**Sub-band and channel phase relations.** The signal processing performed on each sub-band shall leave the relative phases of sub-bands and spectral channels intact or predictable.		TBD	

3.3.6 Spectral Dynamic Range

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1230	**Spectral dynamic range.** SKA1 shall have a spectral dynamic range of:			
	≥61 dB in the band 70MHz to 240 MHz	Mandatory	[1] Paragraph 4.4.3 and Tables 8-1 and 8-2	Test
	≥43 dB in the band 200 MHz to 1.4 GHz	Mandatory	[1] Paragraph 3.4.3 and Table 8-2	Test

3.4 SKA$_1$ Sensitivity and Survey requirements

3.4.1 Sensitivity

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1310	**Sensitivity (A$_{eff}$/T$_{sys}$).** The SKA$_1$ shall have a sensitivity of:	Mandatory	[1]	
	10^3 m^2 K^{-1} in the frequency range 70 MHz - 240 MHz		[1] Table 8-2	
	10^3 m^2 K^{-1} in the frequency range 400 MHz - 3 GHz		[1] Table 8-2	
	10^5 m^2 K^{-1} in the frequency range 800 MHz - 3 GHz		[1] Table 8-2	

3.4.2 Survey speed

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1410	**Survey speed.** The SKA$_1$ survey speed requirement is:			
	~10^7 m^4 K^{-2} deg^2 for the frequency range 200MHz to 1.4 GHz	Mandatory	[1] Table 3-2	
	>10^7 m^4 K^{-2} deg^2	Mandatory	[1] Paragraph 3.4.4 & Table 8-1	

3.4.3   Survey 'On-Sky' time

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1420	The SKA Phase 1 shall be designed so that a major survey can be completed in 2 years of "on-sky" observation time.		[1] Paragraph 1.4.1	Analysis

3.4.4   Deep Field Integration Time

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1430	The SKA Phase 1 shall be designed so that a deep field can be completed in 1000 hr of integration time.	Mandatory	[1] Paragraph 1.4.2	Analysis

3.5   Baseline requirements

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1510	**Baseline.** The SKA_1 minimum baseline requirement is:			
	200 km for the range 70 to 240 MHz	Mandatory	[1] Table 2.2 Para 2.4.3	

To be added:

-Instantaneous imaging capability

-Required UV coverage in synthesis mode. How much time you require to fill in the full UV plane

-Sensitivity requirements as a function of elevation. Say 50% sensitivity for elevations down to x degrees

-Subarray requirements

-Latency requirements

-Minimal frequency resolution required

-Linearity requirements

-Passband phase stability

-Required clock/timing accuracy

3.6   Temporal characteristics

3.6.1   Main beam stability

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1610	Main beam stability. The magnitude and phase variations of any SKA1 compound beam over a 12 hours period at any point of its half-power contour shall be less than 1% (TBC) relative to the beam peak.		TBD	

3.6.2   Temporal resolution

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1620	**Temporal resolution.** *The SKA Phase 1 shall have an attainable time resolution of at least as short as 50 µs.*		[1] Paragraph 5.4.4	Test
	Temporal resolution shall be 100 µs		[1] Table 8-1	Test

3.6.3   Spatial side-lobe stability

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1630	**Spatial side-lobe stability.** Spatial side lobes should be stable to within TBD.		TBD	

3.6.4   Beam-switching agility

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1640	**Beam former weight update rate.** Changing the beam former weights shall be possible every 60 seconds (TBC) in the case of scheduled switching sequences.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1650	**Beam former weight ad-hoc update response time.** Changing the beam former weights shall be possible within 60 seconds in case of changes due to manual interaction or changes in schedule.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1660	**Beam-switching downtime flagging.** Observation data (specify: both uv(w)-data and tied array beams) acquired during a change of beam direction shall be flagged.		TBD	

3.6.5   Frequency switching agility

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1670	The SKA shall be able to 'switch between observing frequencies within 10 minutes or less' (in the band 0.8–3 GHz)	Mandatory	[1] Paragraph 6.4.4 and Table 6-2	Test
	'near simultaneous access to multiple frequencies'		[1] Table 8-1	

3.7   Polarisation characteristics

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1710	**Beam polarization stability.** The polarization properties of the beams shall be stable enough to allow their calibration to better than 0.5% (TBC)			

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1720	External calibration measurements shall be necessary at a rate of no more than once per hour (TBC).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1730	**Stokes parameters.** SKA1 shall provide visibility data in all four Stokes parameters.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1740	**Instrumental polarisation.** The polarisation introduced by the instrument, after calibration, shall be less than 0.5% of the total intensity. (TBC)		TBD	

3.8   RFI avoidance

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1810	The SKA$_1$ shall have limited (TBD) susceptibility to bursty/spiky RFI (for pulsars, transients)		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1820	**Transient RFI detection.** The post station level processing shall detect and flag invalid data.		TBD	

Note: Section to be expanded.

3.9   Imaging characteristics

3.9.1   Instantaneous field of view

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1910	**Instantaneous field of view**			
	'These requirements imply a field of view greater than 5 degrees.'		[1] Paragraph 2.3.5	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1920	**Field of view imaging.** It shall be possible to image the entire field of view		TBD	

3.9.2   Imaging dynamic range

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1940	**Imaging dynamic range.** SKA$_1$ shall be able to provide an imaging dynamic range for continuum imaging (thermal noise imaging to classical (micro Jansky (Jy)) confusion limits) of at least:			
	35dB for the band 200MHz-1.4 GHz	Mandatory	[1] Table 8-2	
	'studies of star formation at high redshift with a continuum deep field require a dynamic range of 74 dB in imaging'		[1] Paragraph 7.4 and Table 8-2	

3.9.3   Pointing accuracy

The mechanical and electronic pointing accuracy requirements of the dishes and the AAs are listed below.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1950	**Dish beam absolute pointing accuracy.** The pointing accuracy of the dish beams is: TBD		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1960	**AA beam absolute pointing accuracy.** The pointing accuracy of the AA beams is: TBD		TBD	

3.9.4   Pointing estimation accuracy

The mechanical and electronic pointing estimation accuracy requirements of the dishes and the AAs, are listed below.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1970	**Dish beam pointing estimation accuracy.** The pointing estimation accuracy of the dish beams is: TBD		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_1980	**AA beam pointing estimation accuracy.** The pointing estimation accuracy of the AA beams is: TBD		TBD	

3.10 Monitoring and Control (M&C) Function

Monitoring And Control is a central system responsible for acquiring monitoring data and for control of the SKA1 systems. It has a level of autonomy and its sub-systems are distributed to local areas.

3.10.1 Top-level requirements

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2110	**M&C.** SKA_1 shall provide a monitoring and control function.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2120	**M&C purpose.** The monitoring and control function shall ensure that all parts of the system work together coherently. All control functions, except certain local maintenance functions, are part of the M&C system.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2130	**M&C failure detection.** The monitoring and control function shall ensure that failures in hardware, software or signal transport are detected and reported.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2140	**M&C autonomy.** The monitoring and control function shall take autonomous action to ameliorate failures where possible and support a fail-safe philosophy.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2150	M&C shall take autonomous action in safety critical situations such as system power failure, over-temperature, and storms (dish-stowing).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2160	**M&C transparency.** The monitoring and control function shall give user transparent and hierarchical access to the instruments functions and parameters.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2190	**M&C remote operation.** The monitoring and control function shall be designed to operate the instrument fully remotely.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2210	**M&C performance monitoring.** The monitoring and control function shall provide TBD performance monitoring data to users.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2220	**M&C monitoring data.** All SKA1 subsystems shall provide monitoring data to the monitoring and control function (for performance monitoring and closed-loop control functions)		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2230	**M&C logging.** The monitoring and control function shall provide for a long-term logging sub-function with workflow support for the Operational Team and with sufficient information to relate system events to artefacts in the data.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2240	**M&C observation interrupt.** It shall be possible to abort an observation if monitor parameters exceed user specified limits (including RFI mitigation performance indication parameters).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2250	**M&C calibration information.** Individual element calibration information shall be available to the measurement function.		TBD	

The requirements on the M&C function related to Health and Safety still needs to be analysed, verified and added.

3.10.2 Control requirements

Requirements regarding control of the instrument (configuration of beam forming, correlation etc)

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2310	**Control system.** SKA1 shall have a control system that actively controls all system settings in the instrument.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2320	**Control system autonomy.** The control system shall be capable of autonomously calculating system settings in response to changes in instrument status, environment or measurement results.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2330	**System settings activation.** It shall be possible to activate the calculated system settings either automatically (autonomous control) or after explicit confirmation by the operator (manual control).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2340	**System setting activation autonomy.** It shall be possible to specify when settings should be activated automatically and when they need to be confirmed by the operator.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2350	**Schedule update.** It shall be possible to receive and accept updated schedules before the end-time of the currently active schedule has expired.		TBD	

3.10.3 Monitoring requirements

Requirements regarding monitoring the status of the instrument (configuration and health)

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2410	**Monitoring data consolidation.** It shall be possible to consolidate monitoring information to produce high-level monitoring information from low-level monitoring information.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2420	**Subsystem-M&C action reports.** Subsystems shall report completion of actions to M&C		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2430	**M&C summary reports.** It shall be possible for all user roles (specification of these roles TBD) to produce summarized historical monitoring information.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2440	**Control data augmentation.** The results of control actions shall be verified with measurements made expressly for the purpose.		TBD	
	If the normal measurement sequence does not provide for control verification in a timely fashion, such measurements shall be made out of sequence.			

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2450	**Monitoring information consolidation.** It shall be possible to consolidate monitoring information both on the physical instrument status and on designated logical concepts like observation, correlator.		TBD	

3.11 Data Acquisition Characteristics

This section describes the functions in the acquisition and initial processing path. This includes the definition of observation modes (synthesis imaging, tied array, fly's eye, pulsar detection) and of intermediate and final data products. Also the functional and performance requirements for RFI mitigation, the data transport network and some derived performance parameters for data handling are listed here.

Note: Section to be expanded.

3.12 Observational Modes

This section identifies the top-level observational modes.

3.12.1 Top level modes

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2710	**Synthesis imaging mode.** SKA1 shall provide a synthesis imaging mode where compound beams are correlated to form visibilities.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2720	**Visibilities.** In synthesis imaging mode it shall be possible to form visibilities between all corresponding monochromatic compound beams (same frequency, same direction) from all dishes or all aperture arrays (stations). This means that the central processing function should be able to handle the full data stream from the dishes or aperture arrays in synthesis imaging mode.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2730	**Tied array mode.** SKA1 shall provide a tied array mode where the signals from all dishes are phased up, after real-time correction of instrumental effects, and transformed back into time series for pulsar processing.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2740	**Fly's eye mode.** SKA1 shall provide a fly's eye mode (TBC). In this mode the Autocorrelations of all single dishes / aperture (sub)arrays are recorded. Each dish / sub-array is tracking a different position on the sky.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2750	**Aggregate mode.** SKA1 shall provide an aggregate mode in which bandwidth is exchanged for spatial coverage in the correlator.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2760	**Real-time calibration.** SKA1 shall provide instrumental real-time calibration functions in all observational modes.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2770	**Re-processing archive data.** It shall be possible to re-process data retrieved from archive. To which extent this will be supported needs further discussion.		TBD	

3.12.2 Data Products

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2810	**Automated data products.** SKA1 shall be able to produce final data products based on automated and interactive (manual) processing of acquired data.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2820	**Data product types.** SKA1 shall produce recordable intermediate data products, for example pulsar voltage time series and RFI statistics.		TBD	

4   Operational Requirements

4.1   General

This section states general operational requirements.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3110	**Up-time.** SKA1 shall be aimed to be operated continuously (7 days per week 24 hours per day).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3130	**Remote M&C from sites.** It shall be possible for the operator to control and monitor the SKA1 instrument from the SKA station sites and core site.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3140	**Physical access security.** The system shall provide security to prevent unauthorized physical access to facilities and resources.		TBD	

To be added: security measures for other aspects such as network access, server access, encryption of M&C messages.

4.2   Routine operations

This section gives system level requirements for the routine operations of SKA$_1$.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3150	**Reconfiguration time.** Reconfiguration of SKA1 from one observational mode to another shall not take longer than 5 minutes (TBC) provided all software applications are present at their designated location.		TBD	

4.3 Start-up and shutdown

This section gives system level requirements for SKA$_1$ start-up and shutdown, including check-out at initialization.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3160	**Full remote control.** It shall be possible to control all SKA1 functions from the operational centre, without requiring physical access to the instrument, including start-up and shut down.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3170	**Start-up sequence.** The start-up of SKA1 functions shall follow a pre-defined sequence taking not longer than:		TBD	
	10 minutes for a hot start (= restart)			
	24 hours for a cold start			

To be added: definition of hot and cold start.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3180	**Start-up and shut-down individual antenna systems.** It shall be possible to start-up or shutdown individual dishes or aperture arrays without disturbance [TBC] of routine operations.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3190	**Shut-down sequence.** The shutdown of SKA1 shall follow a pre-defined sequence taking not longer than TBD minutes. SKA1 shall also have an emergency shut-down for wind (stowing dishes), lightning, and electric power anomalies.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3210	**Control over start-up and shut-down.** Initialization of shut-down and start-up sequences shall be restricted to designated operators and engineers. To be defined: security requirements on different access levels (e.g. engineering mode).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3220	**Start-up and shut-down dependencies.** Any dependencies in the start-up and shutdown sequences shall be automatically verified (so they do not depend on operator intervention).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3230	**Subsystem shut-down.** The shutdown of pre-defined parts of the SKA1 system shall have no (TBC) impact on SKA1 operations after appropriate re-calibration performed automatically.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3240	**Initial check-out.** SKA1 shall be designed to enable an operational readiness check, including redundancies, prior to commencement of any SKA1 operations (initial check-out).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3250	**Operational readiness check.** The operational readiness check shall not take longer to complete than 5 minutes.		TBD	

4.4   Failure management[1]

4.4.1   General

General requirements regarding failure management

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3310	**Personnel safety.** As far as possible, no single failure in the SKA1 shall lead to personnel safety hazards.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3320	**Failure propagation.** Failures in one of the SKA1 subsystems shall not lead to failures in other subsystems.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3330	**Operator command safety.** No single operator command shall cause catastrophic, serious, or major consequences.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3340	**Voltage transients consequences .** No voltage-transients or "cut-off" of electrical power shall lead to catastrophic or serious consequences. This includes voltage transients applied to the input of the receivers.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3350	**Operator command absence.** The absence of operator commands shall not cause catastrophic or serious consequences.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3360	**Single-point failures.** Single-point-failures in the design shall be listed.		TBD	

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[1] Section still to be aligned with Logistic Engineering Management Plan.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3370	**Single-point failure justification.** Each-single-point failure in the design shall be justified, and assessed against alternative design(s) where this single-point-failure would not occur.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3380	**Single-point failure watchdog.** The correct functioning of each single-point-failure in the design shall be monitored by a watchdog function.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3410	**Failing equipment.** Failing equipment shall not provide data (TBC). Failing equipment shall indicate the problem if power is on, and the control function shall take appropriate measures.		TBD	

4.4.2 Detection and reporting

Requirements regarding failure detecting equipment and how failures are to be reported including level of detection.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3520	**Status report availability time.** The status report of the functioning of a subsystem shall be available in 5 seconds.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3530	**Status report request.** The status report of a subsystem shall reflect the functioning of the subsystem at or after the operator request has been submitted to the system.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3540	**Status report scope.** The status report shall display the status of a function, together with the system time the status was determined.		TBD	

4.4.3   Diagnosis and recovery

Requirements regarding distinguishing of failures and how failures are to be recovered from

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3610	**System interrogation reply.** Each dish or aperture array system shall have the capability to answer to an operator interrogation, in case of detected failures at the dish, which antenna chain has failed.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3620	**System autonomous and manual control modes.** The system shall have the capability to be operated by an operator in an autonomous mode, and in a manual control mode.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3630	**Autonomous malfunctioning actions.** In the autonomous mode, all malfunctioning equipment and/or stations may be switched off autonomously, and a message with all details of this action shall be brought to the attention of the operator, and recorded in the systems log-file.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3640	**Manual control switch on/off.** In the manual control mode, the operator shall have the capability to switch on or off all equipment and/or stations.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3650	**Operator actions logging.** Operator actions shall be recorded in the systems log-file, in such a way that a complete picture of all correct functioning and/or all malfunctioning equipment, together with their operational and/or switch off statuses, can be achieved.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3660	**Recovery actions.** It shall be possible to take recovery actions without consequences for other parts of SKA1; the system shall minimize impact of recovery actions.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3670	**Autonomous recovery.** SKA1 shall be able to recover autonomously in case of failures that are classified as minor or negligible.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3680	**Effect of disabled units.** The SKA1 design shall ensure that disabled units do not corrupt the remaining system.		TBD	

4.4.4 Lifetime

Operational lifetime requirements, including spare parts and supporting equipment

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3710	**Continuous operation period.** SKA1 shall be designed for a continuous operational period of 6 month. After this time maintenance may be necessary, e.g. exchange/cleaning of air-conditioning filters and refurbishment of cryogenic systems.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3720	**Minimum life time.** SKA1 shall be designed for a minimum life time of TBD years, including initial installation, testing and commissioning period.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3730	**Availability.** The average availability of SKA1 during the operational period shall be better than 90% (TBC). Availability is defined here as being available for scheduled observations in at least one of the supported operational modes.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3740	**Upgradeability** SKA_1 shall be upgradable.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3750	**Life-time extension.** Large scale maintenance and/or an upgrade shall give the possibility to reach a life time of 50 years (TBC).		TBD	

4.5 Maintenance[2]

Requirements regarding maintenance concept, corrective and preventive

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3810	**Full fail rate.** SKA1 shall be designed to fully fail less than two times per year (TBC), the number determined as average over its operational period.		TBD	

Note: Full failure is defined here as an unscheduled inability to operate in any observational mode for more than two hours due to malfunctioning of one or more subsystems. The requirement applies to the period after initial commissioning of the system or any upgraded components.

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[2] Section still to be aligned with Logistic Engineering Management Plan.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3820	**Repair period.** The maximum period of repair once a failure of SKA1 has been established, shall be 1 (TBC) week. Here, a failure is defined as not being able to meet the scientific specifications due to (sub)system failure(s).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3830	**Non-availability information.** All users with scheduled measurements during the failure period shall be informed of the non-availability of the system		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3840	**Data loss due to power outage.** All subsystems shall not lose more than 4 hours of acquired or processed measurement data (not yet permanently stored) as a result of an outage in the external power supply.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3850	**Autonomous restart after power outage.** All subsystems shall have the capability to restart autonomously and without failures, after an outage in external power supply.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3860	**System availability after restart.** All subsystems shall be available within 5 minutes (TBC) after restart. (Note – there may be subsystems such as cryo coolers that will probably not comply to the requirement and will need to be handled differently).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3870	**Software/firmware re-installation.** All software/firmware in SKA1 shall allow its re-installation.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3880	**Software/firmware upgrades.** It shall be possible to replace all software/firmware configuration items in SKA1 through software-upgrades, initiated by an engineer.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3890	**Software code identification.** Software configuration items shall provide unambiguous inputs to allow the maintenance of a configuration management database.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3910	**Software code identification response time.** The software identification shall be available to the operator within 10 seconds (TBC) after the request was made.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_3920	**Subsystem maintenance functions.** All subsystems shall include functions that allow maintenance of hardware and software.		TBD	

4.6 Disposal phase

Requirements regarding used materials, ecological aspects, programmatic reserve.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_4110	**Environmental rule compliancy.** The SKA1 design shall be fully compliant to all environmental rules applicable to the SKA site.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_4120	**Lasting environmental effects.** SKA1 shall be designed to have no lasting adverse environmental effects on the facility and site.		TBD	

5 Design constraints

This chapter specifies the design constraining requirements such as determined by the environment the instrument will be placed in or relating to mechanical and electrical guidelines, product assurance, safety hazards, government regulations etc. Some requirements provided in this chapter which appear to be only applicable at subsystem level may be moved to the "supporting specifications" as these are established.

5.1 Environmental Requirements

5.1.1 General

General environmental requirements

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5110	**Climatic and environmental conditions.** SKA1 shall be designed or protected against any deterioration leading to failure to meet the requirements specified herein caused by climatic and environmental conditions during its complete lifetime (both operating and non-operating).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5120	**Compliancy with local environment.** The design of SKA1 shall be appropriate (TBD) for operation in the natural environment for the geographical deployment location of the SKA1.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5130	**Transportation conditions.** SKA1 equipment shall be designed for the induced transportation environment appropriate to the mode of transport being used (road, air, sea, etc.) between place of manufacturing and final installation on the SKA site (to be included: packaging requirements).		TBD	

5.1.2 Site and infrastructure requirements

General requirements for station sites, building locations, connecting roads

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5210	**Building climate conditioning.** Buildings or parts of buildings containing central processing equipment and operator areas shall have a climatic conditioning system which can control the temperature within the range of 18 ºC to 23 ºC and the humidity within the range of 50 % to 70 % independent of weather conditions.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5220	**Facilities and equipment intrusion.** SKA1 equipment and operating facilities shall be adequately protected against intrusion by unauthorized persons or by "larger" wandering animals.		TBD	

5.1.3 Contamination and precipitation

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5230	**Precipitation.** SKA1 equipment shall be able to operate without degradation of the performance during any type of precipitation (to be specified).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5240	**Pollution and contamination protection.** SKA1 equipment shall be adequately protected against performance degradation caused by contaminating particles (dust, sand etc), polluted air or any precipitation.		TBD	

5.1.4 Climatic requirements

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5310	**Humidity.** SKA_1 equipment located at the dishes or aperture arrays or outside the central processing and operating facilities shall be able to withstand moisture and humidity levels up to 100 % RH.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5320	**Allowable air temperature range.** SKA1 equipment located at the dishes or aperture arrays or outside the central processing and operating facilities shall be able to withstand (non-operating if necessary) an outside air temperature within the range of -15 ºC (TBC) to +60 ºC (TBC).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5330	**Air temperature operation range.** SKA1 equipment located at the dishes or 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 (TBC) to +50 ºC (TBC).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5340	**Wind velocities.** SKA1 equipment shall be able to survive wind velocities up to 160 km/hr (TBC), and shall operate within normal specification ranges for wind velocities up to 40 km/hr (TBC).		TBD	

5.1.5   Radio Frequency Interference

Protection and measures against interfering signals from outside the instrument

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5410	**Damaging interference levels.** SKA1 shall not be damaged by RFI signals less than TBD V/m.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5420	**EM immunity.** SKA1 shall not be susceptible to RFI signals, in-band or out-band, other than via the receptors.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5430	**ADC clipping.** The dynamic range of the ADC's in the SKA1 shall be such that no clipping will occur. Clipping occurs when the range of the input signal voltages to the ADC is larger than the ADC voltage range. The number of ADC bits shall therefore be sufficient to prevent clipping due to strong interfering signals such as aircraft Distance Measuring Equipment (DME) and satellite signals.		TBD	

5.1.6   Electro Magnetic Compatibility

During each phase of the SKA1 life, from equipment integration until its end of life, the instrument shall neither cause disturbance to other systems, nor suffer loss of performance due to other systems or to the RFI environment.

The ability of the SKA1 to perform its mission within the required performance shall be demonstrated by tests, analysis, inspection, verification of records or demonstration according to the system verification requirements.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5610	**EMC safety margin.** The EMC safety margin, which is defined as the ratio between susceptibility threshold and the interference at any point within the system, shall be greater than TBD dB.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5620	**EMC compatibility marking.** All "off-the-shelf" equipment applied within SKA1 shall posses as a minimum the host country EMC marking, including electrical and electronic supporting and infrastructural equipment.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5630	**Grounding concept.** A hybrid grounding concept as shown in figures TBD shall be used for EMC purposes. Ground loops involving DC, and low frequency AC, currents shall be avoided inside the system. Intentional currents through structure are not permitted. (to be elaborated)		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5640	**EMC design efforts.** Maximum effort (to be detailed) shall be put into designing signal interfaces to withstand noisy environments and to minimize the generation of excessive noise.		TBD	

Emission requirements and tests. Emission requirements, both conducted and radiated) and tests (to be elaborated)

Susceptibility requirements and tests. Susceptibility requirements and tests (to be elaborated)

5.1.7   Self-generated RFI environment

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_2910	**Self-generated RFI susceptibility.** Interference due to self-generated RFI shall not degrade the performance of the instrument by greater than 1% by any measure (TBC).		TBD	

5.1.8   Lightning

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5710	**Lightning discharge susceptibility.** The SKA_1 shall be able to withstand the electromagnetic field impact defined in TBD during operation or in any other mode without any damage or characteristics degradation because of a lightning discharge.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5720	**Lightning protection.** SKA1 dedicated buildings and equipment located on sites shall be protected to minimize the effects of a direct lightning strike using certified methods (e.g. as described in NEN 1014).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5730	**Lightning discharge flagging.** Observation data taken during a lightning strike shall be flagged.		TBD	

Direct strikes. TBC

5.1.9   Grounding

Requirements regarding grounding of equipment, personnel safety and instrument performance (electrical grounding concept), use of design standards

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5810	**Safety ground.** Electrical safety ground shall be designed according to the regulations imposed by the local government.		TBD	

5.1.10 Corrosion

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5820	**Corrosion protection.** SKA1 equipment and buildings shall be protected against corrosion.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5830	**Corrosion protection in air flows.** SKA1 electronics and connectors in areas with a higher air flow (for cooling) or outdoor environment shall be additionally protected against corrosion.		TBD	

5.1.11 Seismicity

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_5910	**Earthquakes.** SKA1 equipment and buildings shall be protected against earthquakes with a magnitude up to Richter 3.8 (TBC).		TBD	

5.1.12 Other Aspects

Additional aspects that will need consideration in this chapter include:

- Temperature and humidity
  - Operational
    - External/exposed equipment
    - Internal equipment
    - Human accessible and work areas
  - Non operational (storage and transportation)
- Exposure to rain
  - Operational with full performance
  - Survival
- Hail
  - Survival
- Ice and snow (TBC)
- Lightning

- Direct strike
- Nearby strike
- Wind
  - Operational
  - Survival
- Pressure
  - Operational
  - Survival (air transport)
- Solar radiation (over and above the ambient temperature)
- Ingress protection (IP rating) of equipment is different areas (exposed, indoors, etc)
- Dust and sand
  - Exposed equipment against dust storms
  - Dust ingress into equipment and buildings especially fibre optics
  - Electrically charged dust
- Salt laden atmosphere
  - Outlying stations close to coastal environments
- Vibration
  - Operational
  - Non operational (transportation of equipment)
- Shock
  - Operational
  - Non operational (transport of equipment)
  - Non operational (handling)
- Solvents
  - Cleaning of equipment
- Fauna and flora
  - Fungal growth
  - Animals
- Severe weather
  - Floods
  - Severe rain
  - High winds
  - Hail

5.2   Engineering Design Constraints

5.2.1   General

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_6110	**Deployment locations.** The SKA_1 shall be installed at the SKA core site and at the SKA1 station sites.		TBD	

Fixed antenna locations. SKA1 will not have movable antenna receptors for the purpose of changing baseline length. The uv(w) coverage is fixed.

5.2.2 Size and weight

The front-end is defined as all equipment that is installed in the feedbox. The weight of this is TBD.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_6210	**Feed Payload volume.** The SKA1 front-end and cabling shall fit in the available feedboxes.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_6220	, **Feed payload mass limit**. The total mass of any feed payload, including the RF cables to the ground, shall not exceed: TBD.		TBD	

Note: this section needs to be expanded.

5.2.3 Materials and Processes

Use is to be made of adequate and (ecological) allowed permissible materials, deviations to be approved by the project, including management of applied materials.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7110	**Materials, Parts and Processes lists.** Each subsystem supplier shall establish, collect, review and deliver the Materials, Parts and Processes lists including all the Materials, Parts and Processes intended for use in the SKA1 equipment by his suppliers and himself.		TBD	
	They shall reflect the current design at the time of issue.			

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

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7130	**Parts availability.** The estimated availability of the Parts and products obtained from Materials and Processes used shall be compatible with the final system's life cycle (tests, storage, mission).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7140	**Material environmental rule compliance.** All materials used in the SKA1 design shall be fully compliant to all environmental rules applicable to the SKA1 core and remote sites.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7150	**Long-term environmental effects.** Materials used in the SKA1 design shall not have any lasting effect on the site location.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7160	**Maintenance free materials.** Materials used for the parts subject to the outdoors environment shall be maintenance free. (TBC)		TBD	

5.2.4 Marking

Components, (sub) systems, instruments, equipment, and materials shall be marked for configuration control purposes and maintenance support purposes.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7210	**Part identification.** Each part, material or product shall be identified with a unique and permanent part or type number.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7220	**Marking method.** Method of marking shall be compatible with the nature of the item and its use.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7230	**Documentation marking.** Identification numbers shall be marked on documentation and, where possible, on respective items.		TBD	

5.2.5   Power and other utilities

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7310	**Mains supply.** The SKA1 shall connect to the available power distribution at the SKA core and remote sites.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7320	**Dish or AA power consumption.** The power consumption of all equipment at any AA or dish station, including the motors driving the dishes, shall be less than TBD kVA.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7330	**Observatory power consumption.** The total power consumption of the SKA1 observatory shall be less than TBD kVA.		TBD	

5.3   Quality Factors Requirements

Requirements related to the quality of the product.

5.3.1   General

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7410	**Quality standard.** SKA1 equipment and electronics shall be developed and produced according to the ISO9001 (TBC) quality standard.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7420	**Field return rate.** The field return rate of equipment shall be less than 0.5% (TBC) during installation and the first year full usage.		TBD	

5.3.2   Workmanship

Good workmanship expected for mechanical, electrical and software production. It refers to the physical characteristics relating to the level of quality introduced by the manufacturing and assembly activities.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7510	**General workmanship standards.** General workmanship standards shall be applied as specified in the Product Assurance Plan (TBD) both for Software and Hardware production. These include ISO9001 (TBC).		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7520	**Scope of workmanship standards.** SKA1 dedicated workmanship standards shall be specified in project dedicated documents		TBD	
	and shall: a) cover all phases of production, assembly and integration, testing, handling, and include clear requirements for acceptance/rejection criteria.			

5.3.3   System Safety

Safety critical functions, propagation paths, design margins

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7610	**Design margins.** The SKA_1 design shall possess design margins to cover all uncertainties in environment, analysis and properties of the materials and processes used.		TBD	

5.3.4 Security

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7720	**User-dependent accessibility.** It shall be possible to specify on a per user basis which SKA1 facilities and resources (both hardware and software) may be accessed by the user.		TBD	

5.3.5 Reliability[3]

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7810	**SKA1 equipment reliability.** The reliability of SKA1 equipment to meet its performance requirements over a period of 10 years shall be greater than 99.4 % (TBC).		TBD	

5.3.6 Maintainability[4]

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7820	**Tools and test equipment.** The SKA1 design shall require a minimum of special tools and test equipment to perform assembly, integration and repair and maintenance activities.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7830	**Inaccessible hardware maintenance.** Inaccessible hardware or structures shall require no maintenance during operation and should have built in test capability when applicable.		TBD	

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[3] Section still to be aligned with Logistic Engineering Management Plan.

[4] Section still to be aligned with Logistic Engineering Management Plan.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7840	**Test and repair instructions.** Test and repair instructions shall be written for fault detection and maintenance of the SKA1 equipment.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7850	**Maintenance team size.** It should be possible to execute regular maintenance jobs with not more than two (2) people per job.		TBD	

5.3.7 Flexibility and upgradability

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7860	**Modular design.** The SKA1 design (hardware and software) shall have a modular approach.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7870	**System flexibility and expandability.** The SKA1 design (hardware and software) shall provide flexibility and expandability to support anticipated areas of growth or changes in technology or mission. (e.g. in the field of but not limited to: network bandwidth, storage space, processing power)		TBD	

5.3.8 Accessibility and testability

Requirements regarding the design of equipment, access in case of maintenance, trouble shooting, test connectors etc

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7880	**Self-test capability.** The SKA1 design for both hardware and software shall provide self-test capabilities.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7890	**Servicing point making.** All servicing and test points shall be clearly marked using TBD labelling standards.		TBD	

5.3.9   Transportability and storage

Requirements regarding transport of equipment, vibration and shock environment of different transport possibilities

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7910	**Handling heavy equipment.** SKA1 parts, test equipment or supporting equipment with mass exceeding 25 kg shall be provided with provisions for handling and transportation.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7920	**Disassembly for transport.** It shall be possible to disassemble SKA1 equipment for the reason of transportation or storage in its main parts.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7930	**Long term storage.** It shall be possible to store SKA1 equipment (spare parts) for 10 years without any degradation of its function or performance.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7935	If special storage facilities are needed they shall be supplied as part of the spares procurement.		TBD	

5.3.10 Life

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7940	**Reusability.** Reusability of SKA1 equipment shall be ensured through design and by refurbishment and maintenance where this has been demonstrated as being cost effective.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7950	**Spare parts.** SKA1 spare parts shall have a storage life consistent with availability and use during the full operational lifetime of the SKA1 equipment to which it applies.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_7960	**Support equipment life-time.** SKA1 support equipment shall be designed to maintain SKA1 for 12 (TBC) years.		TBD	

6   Interface Requirements

External Interfaces are defined as interactions or communications with the world outside SKA1. Internal interfaces are defined as interactions or communications between or internal in SKA1 subsystems.

6.1   External Interfaces

6.1.1   Power

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_8110	**Supply power.** The power supplied to the SKA1 systems shall have the following characteristics (TBC): a) voltage 380 V +/- 10% b) 3 phases c) 50 Hz +/- 1 Hz		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_8130	**Central facility UPS.** The power source to the central facility shall have back-up provisions for controlled shut-down (TBC).		TBD	

6.1.2 Data synchronization

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_8140	**Subsystem time standard.** Each SKA1 AA or dish system shall maintain an internal time standard with an accuracy of TBD nanoseconds		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_8150	**Central time standard.** All SKA1 subsystems shall synchronize their internal time standards to the central timing standard with an accuracy of TBD nanoseconds.		TBD	

6.2 Internal Interfaces

6.2.1 Power

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_8160	**Limiting excessive currents.** SKA1 equipment circuitry shall be protected against excessive currents by a current limiting device, which shall not itself produce excessive currents.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_8170	**Power surge protection.** SKA1 sub-systems shall be protected against power transients and surges.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_8180	**Polarity mis-connection protection.** SKA1 equipment circuitry shall be protected against the effects of inadvertent wrong polarity connections. (TBC)		TBD	

6.3 Synchronization

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_8210	**Data time-tagging.** All dishes and aperture arrays shall time-tag received and processed data with the accuracy of their internal time standard.		TBD	

7 Support Requirements

7.1 Maintenance

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_9110	**Test resources.** SKA1 subsystems shall specify what special test resources they require in the operational phase.		TBD	

7.2 Logistics

Logistic requirements during built-up and operations, may include: system maintenance, software support, system transportation modes, supply-system requirements, impact on existing facilities, and impact on existing equipment.

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_9130	**Preventive maintenance.** Preventive maintenance of SKA1 hardware shall be performed in accordance with the maintenance program established for SKA1.		TBD	

8 Extensibility Requirements

Phase 1 of the SKA is to be followed by a Phase 2, designed to meet a superset of science requirements given in AD1.

8.1 Extension interfaces

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_10110	**Dish/PAF interfaces.** SKA1 Dishes shall be designed, built and verified such that they can accommodate Phased Array Feeds.		TBD	

8.2 Extension performance

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_10120	**Frequency Coverage.** SKA1 Dishes shall be designed, built and verified such that they can meet AD1 optical requirements up to 10GHz.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_10130	**Polarization Purity.** SKA1 feeds, receivers and digital processing subsystems shall be designed to provide the AD1 polarization purity requirement of 40dB.		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_10140	**Imaging dynamic range.** SKA1 elements shall be designed to provide an imaging dynamic range of 74 dB up to 10GHz		TBD	

Ident	Requirement	Applicability	Parent	Verification
SYS_REQ_10150	**Spectral dynamic range**. SKA1 elements shall be designed to provide a spectral dynamic range of 67 dB.		TBD	

9   Quality Assurance Provisions

This section will describe the formal tests/verifications of System requirements specified in the body of this specification.

Management and planning information pertaining to product verification and validation should be described in the system Test and Evaluation Master Plan.

9.1   System Qualification testing

Tests shall mainly be performed to verify that the SKA1 complies to the performance requirements specified in this specification.

An incremental qualification approach shall be adopted starting at Material level and culminating at SKA1 system level in a Test & Qualification (T&Q) program. For existing products (COTS) proof of qualification, including the specification, method of testing and results, will be utilised. No re-qualification of these products will be performed. However, wherever interfaces have been modified/added, regression testing will be performed to confirm the integrity of the interface against it's original interface control specification.

The tests to be performed on the various subsystems and elements of the SKA1 will be described here. It will include aspects such Factory Acceptance Tests and Site Acceptance Tests (stand alone and integrated).

9.2   Test Methods

The requirements specified in this document shall be verified by one or more of the following test methods:

•   Inspection (I)

        Verification shall be by visual examination, comparison with engineering data and simple measurement without the use of precision measuring equipment.

•   Test (T)

        Verification shall be by analysis or review of test data recorded using special measurement equipment and procedures.

•   Demonstration (D)

        Verification shall be by application of go/no go criteria without the use of elaborate measurement equipment.

•   Analysis (A)

        Verification shall be by analysis or review of calculated or simulated data.

Appendix 1. List of DRM technical specifications

The table below lists the quantities, their values and their units as specified in the SKA1 DRM . The units in the table below are defined by: Chapter; the science cases as specified in the DRM, Frequency Range (MHz), survey speed (m^4K^{-2} degree^2), Aeff/Tsys (m^2K^{-1}), frequency resolution (kHz), temporal resolution (s), polarization purity (dB), imaging dynamic range (dB), spectral dynamic range (dB), Observation type.

Chapter	Title	Frequency Range (MHz)	Survey Speed (m^4 K^-2 deg^2)	Ae/Tsys (m^2 K-1)	Frequency Resolution (kHz)	Temporal resolution (s)	polarisation purity	Imaging dynamic range (dB)	Spectral Dynamic Range (dB)	Observation type	Key Science Case Ref	Notes
2	Probing the Neutral Intergalactic Medium during the Epoch of Reionization	70-240	N/A	1000	100	SL	full	N/A	N/A	Line	Probing the Dark Ages	
3	Tracking Galaxy Evolution over Cosmic Time via HI absorption	200-1400	1.0E+07	N/A	5	SL	N/A	35	43	Line	Galaxy Evolution, Large-Scale Structure, & Dark Energy	possible technology change
4	Probing the Epoch of Reionization with the 21-cm Forest	70-240	N/A	N/A	0.2	SL	N/A	N/A	61	Line	Probing the Dark Ages	
5	Pulsar Surveys with the SKA1	400-3000	N/A	1000	10	5.00E-05	N/A	N/C	N/C	Time Domain	Strong Field Tests of Gravity Using Pulsars and Black Holes	non-imaging data required
6	Pulsar Timing with the SKA1	800-3000	N/A	10000			40 dB	N/C	N/C	Time Domain	Strong Field Tests of Gravity Using Pulsars and Black Holes	high frequency agility required, non-imaging data required, polarization purity likely needs to be achieved only on-axis, post-calibration
7	Additional Telescope Considerations	70-10,000					full-field capability	74 dB capable			multiple		"forward capatibility"