
# REQUIREMENTS DOCUMENT FOR THE SIGNAL TRANSPORT AND NETWORKS DOMAIN

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# DOCUMENT HISTORY

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| A | 2011-04-18 | - | First draft release for internal review |
| **B** | 2011-06-06 | | Revamp to conform to new Domain SRS standard |
| | | | |

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# ORGANISATION DETAILS

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| | | |
|---|---|---|
| AA-Lo | ..... | Low Frequency Aperture Array |
| AD | ..... | Applicable Document |
| CoDR | ..... | Concept Design Review |
| DDBH | ..... | Digital Data Back Haul |
| DRM | ..... | Design Reference Mission |
| DSRR | ..... | Domain System Requirements Review |
| HMI | ..... | Human Machine Interface |
| ID | ..... | Identity |
| M&C | ..... | Monitor and Control |
| RFI | ..... | Radio Frequency Interference |
| SATS | ..... | Synchronisation and Timing Sub-System |
| SKA | ..... | Square Kilometre Array |
| SKA1 | ..... | Square Kilometre Array Phase 1 |
| SRR | ..... | Specification Requirements Review |
| STaN | ..... | Signal Transport and Networks |
| TBC | ..... | to be confirmed |
| TBD | ..... | to be determined |
| TBW | ..... | to be written |
| UTC | ..... | Universal Time Co-ordinated |

# 1 Introduction

## 1.1 Scope of the document

This document relates to the Phase 1 SKA Signal Transport and Networks Domain Element and its Sub-elements. It is of a maturity commensurate with a Concept level of definition of the STaN Domain and the SKA Observatory as a whole.

It also forms the working basis of the Domain Requirements Document to be prepared for the future System Requirements Review, and its Table of Contents is intended to be subject to the present Review.

## 1.2 Purpose of the document

The purpose of this document is to provide a summary of all flowed, derived, allocated and introduced Requirements pertaining to the full life cycle of the Domain.

# 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 document, **the applicable documents** shall take precedence.

[1] SKA Phase 1 System Requirements Specification, T. Stevenson et. al, SKA Project Document - WP2-005.030.000-SRS-002.
[2] SKA Science Working Group, "*The Square Kilometre Array Design Reference Mission: SKA Phase 1*", report, v.1.3, January 2011.
[3] SKA Configurations Design, R. Bolton et al, SKA Project Document – WP3-050.020.000-R-002, 2011-02-17.
[4] K. Cloete et al, 'Strategies and Philosophies', document WP2-005.010.030-TR-001, Rev F.
[5] Monitoring & Control Strategy, document WP2-005.065.000-R-001
[6] Operational Concepts WP2-001.010.010PLA-002
[7] Signal Processing Software and Firmware Strategy WP2-040.200.012-PLA-001 (Placeholder)
[8] Quality Assurance & Safety Plan WP2-005.080.010-PLA-001 TBW
[9] RFI/EMC Control Plan WP2-005.080.020.PL-001 TBW
[10] Design & Development Plan WP2-005.080.030-PL-001 TBW
[11] Environment Specification WP2-005.050.030-ENV-001 TBW
[12] Regulatory/Statutory Requirements Summary TBW
[13] SKA Reference and Applicable Standards TBW

## 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.

[14] STaN High Level Description WP2-030.030.030-TD-001 Rev C

# 3 Requirement Overview

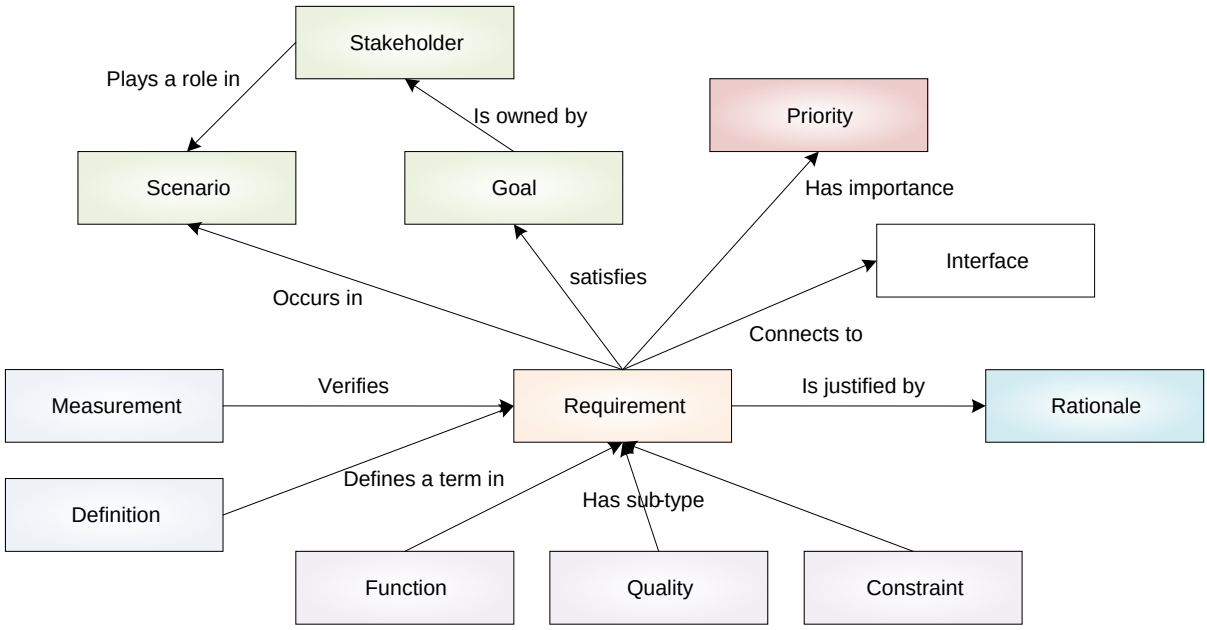


**Figure 1 Requirement Context**

Figure 1 provides a context of the requirements that is applicable within all layers of the system hierarchy. The interconnecting lines define the association between the blocks in the diagram. For example there are three sub types of requirement:

- Functional: A functional requirement is to define what is to be done
- Quality: A quality requirement is to change the way something is done. Quality requirements include: safety, security, reliability, performance, maintainability, and environment.
- Constraint: Constraints are restrictions or limitations on possible solutions.

Each of these requirements is to satisfy a goal owned by a particular stakeholder that plays a role in a scenario of the system. Scenarios are associated with the modes and configurations of the system and define the dynamic behaviour. This document includes Use Cases to provide a path to discovering associated requirements.

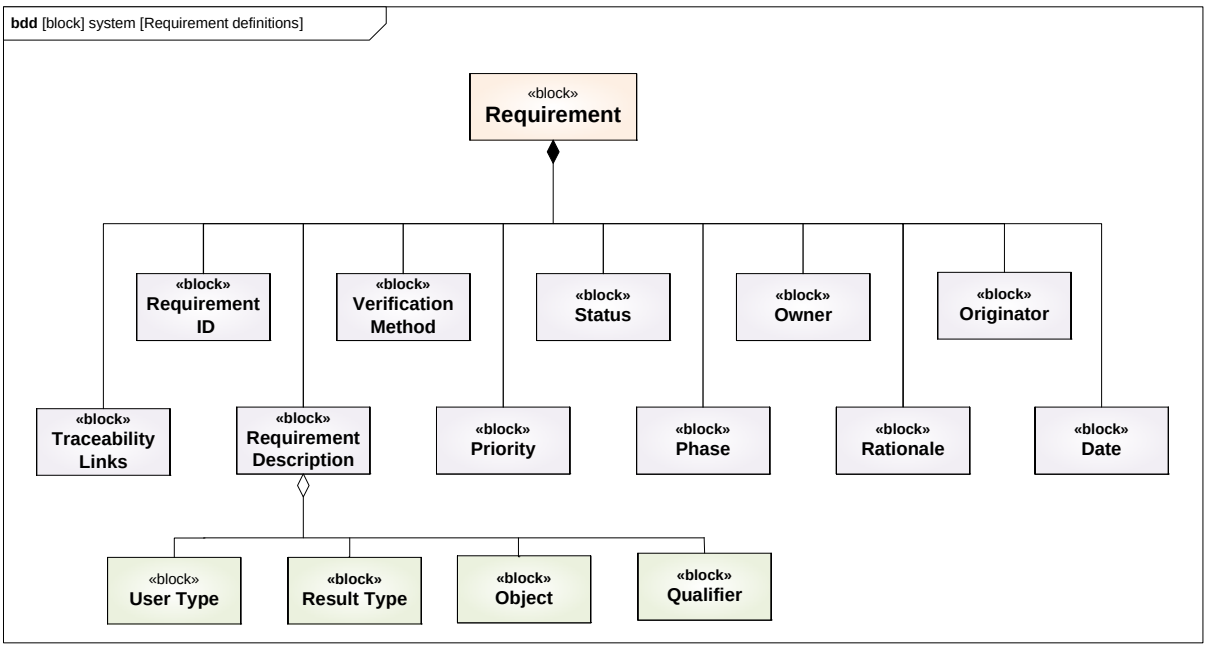


**Figure 2 Requirement Structure**

As detailed in Figure 2 a requirement comprises of more information the just the requirement description. This information in effect forms attributes for the requirement.

## 3.1 Attributes

Requirement ID
The Requirement ID provides a unique identifier for each individual requirement. The Requirement ID takes the form:
<string>_REQ_xxxx
The sting provides a unique descriptor identifying the item within the systems hierarchy that the requirement set is applicable to
xxxx is a four digit decimal number uniquely identifying the requirement within the requirement set.
For example:
“SYS_REQ_0010” identifies the first requirement at the systems level.
Requirement Description
The requirement description has to be clear, concise and verifiable:
The requirement should be a single active sentence as short as possible.
The requirement should focus on naming a single desired result
Every requirement should be verifiable
Requirements should avoid conjunctions such as: “and”, “or”, “with” and “also” as these tend to wrap multiple requirements into one which is not desirable.
Requirements should not specify the design envelope.
The anatomy of the requirement should contain:
User type: A noun identifying the beneficiary of the requirement
Result Type: A verb identifying the action of the requirement
Object: The object that the verb is applicable to
Qualifier: Adverbal phrase identifying the desirable result of the action
An example:
The call centre operator shall be able to view details of the protected household within two seconds of issuing the query
User type: The call centre operator

Result Type: shall be able to view
Object: details of the protected household
Qualifier: within two seconds of issuing the query
Verification Method
As stated in the requirement description, all requirements are to be verifiable. The method of verification is to be attached as an attribute to the requirement. The method of verification should be one of the following:

- Inspection
- Test
- Demonstration
- Analysis
- Simulation
- Priority

The priority of the requirement is to be attached as an attribute to the requirement. The priority should be identified by one of the following:

- Essential
- Useful
- Interesting
- Luxury
- Status

Requirements are not static statements but have a life-cycle. The status within the life-cycle should be identified by one of the following:

- Proposed
- Reviewed
- Accepted
- Rejected
- To be modified
- Phase

Whether the requirement is applicable to Phase 1 or Phase 2 of the SKA should be identified by an attribute associated with the requirement:

- Phase 1
- Phase 2

Originator
The originator of the requirement should be attached as an attribute.
Date
The date that the requirement was created should be attached as an attribute.
Rationale and Assumptions
Making assumptions explicit and connecting them to an argued rationale enables decisions to be re-visited without starting all over again.

An understanding of rationale enables accurate prioritisation and is an aid to preventing essential requirements from being deleted.

## 3.2 Requirements Context

The requirements for STaN form part of the overall system hierarchy as illustrated in Figure 3.

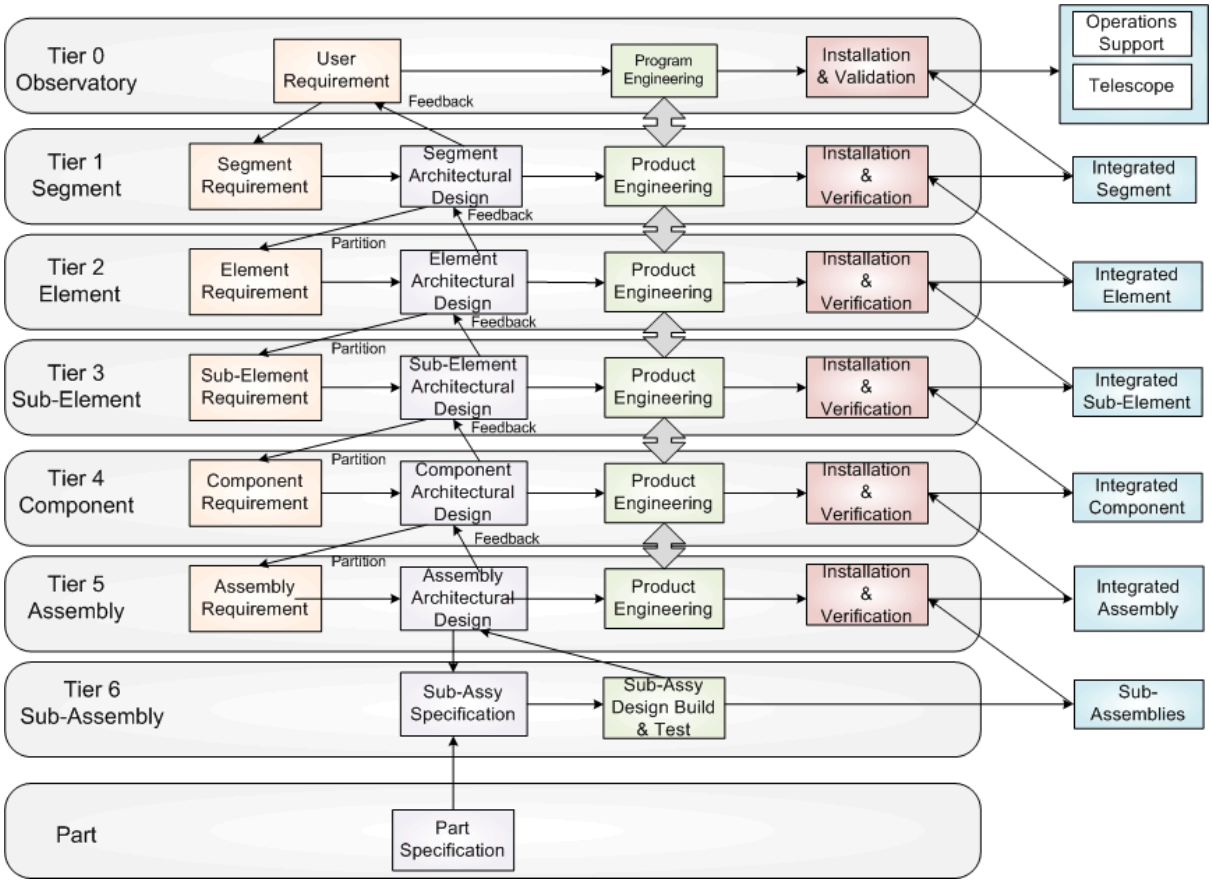


**Figure 3 Requirements Hierarchy**

Each tier in the hierarchy has its own set of requirements which are derived from the next hierarchical tier above. There is also a feedback path via the architectural design process to inform the requirements at the higher tier whether there are any issues. The flow-down and feedback is an on-going process iterating towards a stable and eventually base-lined requirement set.

The initial requirements for the concept phase of STaN Sub-Element level is the scope of this document. It identifies the subset of concept phase system requirements that are applicable to STaN and presents additional requirements where there are gaps. This process forms part of an iterative feedback path to the system level. In the next phase these requirements will be refined so that they can be utilised by each of the STaN Sub-Elements.

### 3.2.1 Definition Phase

The aim of the next phase in the project is the definition of the requirements. The quality, design, development and other requirements will be developed in the next phase and the constraints identified. These will be presented at the STaN System Requirements Review.

In this phase requirements analysis and validation are undertaken in order to ensure that the complete set of requirements is understood and is present. Gaps will be identified and actions to address these shortcomings will be initiated. The result of these activities will be captured in the relevant Requirement Specifications to be reviewed at the conclusion of this phase.

Architectural design activities will also be initiated with the aim of producing a first draft design document at the end of the phase.

Interfaces will be refined and finalised as far as possible (especially functional interfaces).

This phase will be concluded by the (Sub) System Requirements Review (SRR).

### 3.2.2 STaN Element

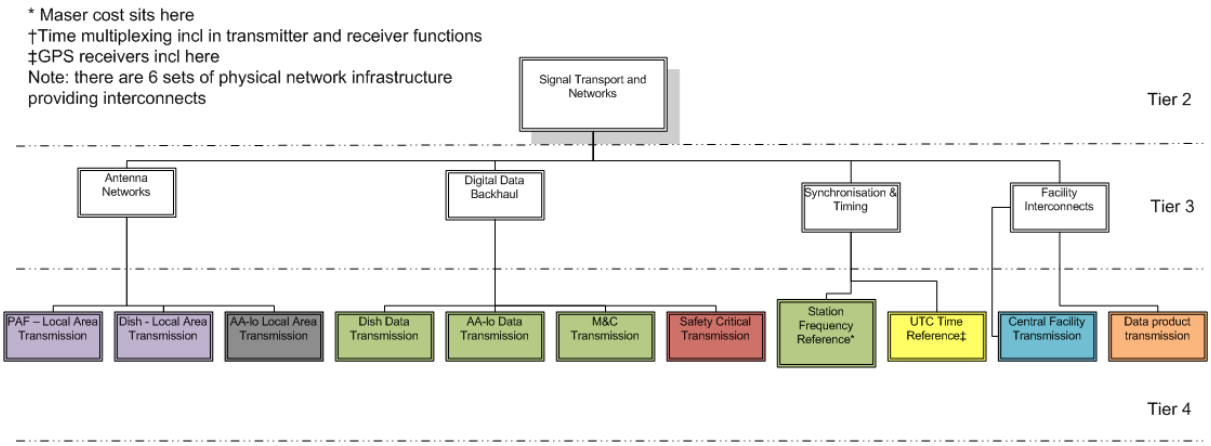


**Figure 4 STaN Hierarchy diagram**

The STaN hierarchy is shown in Figure 4. It shows how the STaN Sub-Elements fit within the STaN domain.

### 3.2.3 Applicability to AD[1]

This section provides an Applicability Matrix showing the Applicability of AD[1] Requirements to the STaN Domain and whether the requirement has been analysed in the scope of the STaN CoDR.

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| SYS_REQ_1110 | Electromagnetic frequency range. SKA1 shall be able to measure electromagnetic radiation in a frequency range from 70 MHz to 3 GHz. | | |
| SYS_REQ_1120 | Instantaneous bandwidth. SKA1 shall have an instantaneous bandwidth, of: Fractional instantaneous bandwidth: 1 The SKA Phase 1 shall be designed so that the fractional instantaneous bandwidth is comparable to the observing frequency. | | |
| 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. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_1160 | Sub-band bandwidth. The subband bandwidth after station level beamforming shall be less than TBD Hz. | | |
| 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). | | |
| 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. | | |
| 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. | | |

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| SYS_REQ_1210 | Spectral resolution. SKA1 shall offer a spectral resolution in each polarization for science processing of: < 200 Hz in the band 70 to 240 MHz; 'The SKA Phase 1 shall provide a frequency resolution of at least 0.2 kHz.' | | |
| SYS_REQ_1211 | Spectral resolution. SKA1 shall offer a spectral resolution in each polarization for science processing of: < 10kHz in the band 400MHz to 3 GHz | | |
| SYS_REQ_1212 | Spectral resolution. SKA1 shall offer a spectral resolution in each polarization for science processing of: 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 (v/100 kHz). Therefore, to match the angular resolution a frequency resolution of about 100 kHz is required.' | | |
| SYS_REQ_1213 | Spectral resolution. SKA1 shall offer a spectral resolution in each polarization for science processing of: 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.' | | |
| SYS_REQ_1220 | Sub-band and channel phase relations. The signal processing performed on each sub-band shall leave the relative phases of subbands and spectral channels intact or predictable. | | |
| SYS_REQ_1230 | Spectral dynamic range. SKA1 shall have a spectral dynamic range of: ≥61 dB in the band 70MHz to 240 MHz | | |
| SYS_REQ_1231 | Spectral dynamic range. SKA1 shall have a spectral dynamic range of: ≥43 dB in the band 200 MHz to 1.4 GHz | | |
| SYS_REQ_1310 | Sensitivity (Aeff/Tsys). The SKA1 shall have a sensitivity of: $10^3$ $m^2$ $K^{-1}$ in the frequency range 70 MHz - 240 MHz | | |
| SYS_REQ_1311 | Sensitivity (Aeff/Tsys). The SKA1 shall have a sensitivity of: $10^3$ $m^2$ $K^{-1}$ in the frequency range 400 MHz - 3 GHz | | |
| SYS_REQ_1312 | Sensitivity (Aeff/Tsys). The SKA1 shall have a sensitivity of: $10^5$ $m^2$ $K^{-1}$ in the frequency range 800 MHz - 3 GHz | | |
| SYS_REQ_1410 | Survey speed. The SKA1 survey speed requirement is: ~$10^7$ $m^4$ $K^{-2}$ $deg^2$ for the frequency range 200MHz to 1.4 GHz | | |
| SYS_REQ_1411 | Survey speed. The SKA1 survey speed requirement is: >$10^7$ $m^4$ $K^{-2}$ $deg^2$ | | |
| 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. | | |
| SYS_REQ_1430 | The SKA Phase 1 shall be designed so that a deep field can be completed in 1000 hr of integration time. | | |
| SYS_REQ_1510 | Baseline. The SKA1 minimum baseline requirement is: 200 km for the range 70 to 240 MHz | | |
| 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. | | |
| SYS_REQ_1620 | Temporal resolution. The SKA Phase 1 shall have an attainable time resolution of at least as short as 50 μs. | | |
| SYS_REQ_1621 | Temporal resolution shall be 100 μs | | |
| SYS_REQ_1630 | Spatial side-lobe stability. Spatial side lobes should be stable to within TBD. | | |
| 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. | | |
| 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. | | |
| 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. | | |
| 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) | | |
| SYS_REQ_1671 | The SKA shall be able to provide 'near simultaneous access to multiple frequencies' | | |
| 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) | | |

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| SYS_REQ_1720 | External calibration measurements shall be necessary at a rate of no more than once per hour (TBC). | | |
| SYS_REQ_1730 | Stokes parameters. SKA1 shall provide visibility data in all four Stokes parameters. | | |
| SYS_REQ_1740 | Instrumental polarisation. The polarisation introduced by the instrument, after calibration, shall be less than 0.5% of the total intensity. (TBC) | | |
| SYS_REQ_1810 | The SKA1 shall have limited (TBD) susceptibility to bursty/spiky RFI (for pulsars, transients) | | |
| SYS_REQ_1820 | Transient RFI detection. The post station level processing shall detect and flag invalid data. | | |
| SYS_REQ_1910 | 'These requirements imply a field of view greater than 5 degrees.' | | |
| SYS_REQ_1920 | Field of view imaging. It shall be possible to image the entire field of view | | |
| SYS_REQ_1940 | Imaging dynamic range. SKA1 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 | | |
| SYS_REQ_1941 | 'studies of star formation at high redshift with a continuum deep field require a dynamic range of 74 dB in imaging' | | |
| SYS_REQ_1950 | Dish beam absolute pointing accuracy. The pointing accuracy of the dish beams is: TBD | | |
| SYS_REQ_1960 | AA beam absolute pointing accuracy. The pointing accuracy of the AA beams is: TBD | | |
| SYS_REQ_1970 | Dish beam pointing estimation accuracy. The pointing estimation accuracy of the dish beams is:TBD | | |
| SYS_REQ_1980 | AA beam pointing estimation accuracy. The pointing estimation accuracy of the AA beams is: TBD | | |
| SYS_REQ_2110 | M&C. SKA1 shall provide a monitoring and control function. | | |
| 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. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_2150 | M&C shall take autonomous action in safety critical situations such as system power failure, over-temperature, and storms (dish-stowing). | | |
| SYS_REQ_2160 | M&C transparency. The monitoring and control function shall give user transparent and hierarchical access to the instruments functions and parameters. | | |
| SYS_REQ_2190 | M&C remote operation. The monitoring and control function shall be designed to operate the instrument fully remotely. | | |
| SYS_REQ_2210 | M&C performance monitoring. The monitoring and control function shall provide TBD performance monitoring data to users. | | |
| 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) | | |
| 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. | | |
| SYS_REQ_2240 | MM&C observation interrupt. It shall be possible to abort an observation if monitor parameters exceed user specified limits (including RFI mitigation performance indication parameters). | | |
| SYS_REQ_2250 | M&C calibration information. Individual element calibration information shall be available to the measurement function. | | |
| SYS_REQ_2310 | Control system. SKA1 shall have a control system that actively controls all system settings in the instrument. | | |
| 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. | | |
| 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). | | |

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| 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. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_2420 | Subsystem-M&C action reports. Subsystems shall report completion of actions to M&C | | |
| SYS_REQ_2430 | S&C summary reports. It shall be possible for all user roles (specification of these roles TBD) to produce summarized historical monitoring information. | | |
| SYS_REQ_2440 | Control data augmentation. The results of control actions shall be verified with measurements made expressly for the purpose. | | |
| SYS_REQ_2441 | If the normal measurement sequence does not provide for control verification in a timely fashion, such measurements shall be made out of sequence. | | |
| 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. | | |
| SYS_REQ_2710 | Synthesis imaging mode. SKA1 shall provide a synthesis imaging mode where compound beams are correlated to form visibilities. | | |
| 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. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_2750 | Aggregate mode. SKA1 shall provide an aggregate mode in which bandwidth is exchanged for spatial coverage in the correlator. | | |
| SYS_REQ_2760 | Real-time calibration. SKA1 shall provide instrumental real-time calibration functions in all observational modes. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_2820 | Data product types. SKA1 shall produce recordable intermediate data products, for example pulsar voltage time series and RFI statistics. | | |
| SYS_REQ_3110 | Up-time. SKA1 shall be aimed to be operated continuously (7 days per week 24 hours per day). | | |
| 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. | | |
| SYS_REQ_3140 | Physical access security. The system shall provide security to prevent unauthorized physical access to facilities and resources. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_3170 | Start-up sequence. The start-up of SKA1 functions shall follow a pre-defined sequence taking not longer than: 10 minutes for a hot start (= restart) | | |
| SYS_REQ_3171 | Start-up sequence. The start-up of SKA1 functions shall follow a pre-defined sequence taking not longer than: 24 hours for a cold start | | |
| 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. | | |

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| 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. | | |
| SYS_REQ_3210 | Control over start-up and shutdown. 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). | | |
| 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). | | |
| 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. | | |
| 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). | | |
| SYS_REQ_3250 | Operational readiness check. The operational readiness check shall not take longer to complete than 5 minutes. | | |
| SYS_REQ_3310 | Personnel safety. As far as possible, no single failure in the SKA1 shall lead to personnel safety hazards. | | |
| SYS_REQ_3320 | Failure propagation. Failures in one of the SKA1 subsystems shall not lead to failures in other subsystems. | | |
| SYS_REQ_3330 | Operator command safety. No single operator command shall cause catastrophic, serious, or major consequences. | | |
| SYS_REQ_3340 | Voltage transients consequences . No voltage-transients or "cutoff" of lectrical power shall lead to catastrophic or serious consequences. This includes voltage transients applied to the input of the receivers. | | |
| SYS_REQ_3350 | Operator command absence. The absence of operator commands shall not cause catastrophic or serious consequences. | | |
| SYS_REQ_3360 | Single-point failures. Single-pointfailures in the design shall be listed. | | |
| 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-pointfailure would not occur. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_3520 | Status report availability time. The status report of the functioning of a subsystem shall be available in 5 seconds. | | |
| 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. | | |
| 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. | | |
| 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. | | |
| 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. | | |
| 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. | | |
| 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. | | |
| 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. | | |
| 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. | | |

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| SYS_REQ_3670 | Autonomous recovery. SKA1 shall be able to recover autonomously in case of failures that are classified as minor or negligible. | | |
| SYS_REQ_3680 | Effect of disabled units. The SKA1 design shall ensure that disabled units do not corrupt the remaining system. | | |
| 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 airconditioning filters and refurbishment of cryogenic systems. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_3740 | Upgradeability SKA1 shall be upgradable. | | |
| 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).. | | |
| 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. | | |
| 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). | | |
| 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 | | |
| 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. | | |
| 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. | | |
| 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). | | |
| SYS_REQ_3870 | Software/firmware reinstallation. All software/firmware in SKA1 shall allow its re-installation. | | |
| SYS_REQ_3880 | Software/firmware upgrades. It shall be possible to replace all software/firmware configuration items in SKA1 through softwareupgrades, initiated by an engineer. | | |
| SYS_REQ_3890 | Software code identification. Software configuration items shall provide unambiguous inputs to allow the maintenance of a configuration management database. | | |
| 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. | | |
| SYS_REQ_3920 | Subsystem maintenance functions. All subsystems shall include functions that allow maintenance of hardware and software. | | |
| SYS_REQ_4110 | Environmental rule compliancy. The SKA design shall be fully compliant to all environmental rules applicable to the SKA site. | | |
| SYS_REQ_4120 | Lasting environmental effects. SKA shall be designed to have no lasting adverse environmental effects on the facility and site. | | |
| SYS_REQ_5110 | Climatic and environmental conditions. SKA 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). | | |
| SYS_REQ_5120 | Compliancy with local environment. The design of SKA shall be appropriate (TBD) for operation in the natural environment for the geographical deployment location of the SKA. | | |
| SYS_REQ_5130 | Transportation conditions. SKA 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). | | |

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| 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. | | |
| SYS_REQ_5220 | Facilities and equipment intrusion. SKA equipment and operating facilities shall be adequately protected against intrusion by unauthorized persons or by "larger" wandering animals. | | |
| SYS_REQ_5230 | Precipitation. SKA equipment shall be able to operate without degradation of the performance during any type of precipitation (to be specified). | | |
| SYS_REQ_5240 | Pollution and contamination protection. SKA equipment shall be adequately protected against performance degradation caused by contaminating particles (dust, sand etc), polluted air or any precipitation. | | |
| SYS_REQ_5310 | Humidity. SKA 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. | | |
| SYS_REQ_5320 | Allowable air temperature range. SKA 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). | | |
| SYS_REQ_5330 | Air temperature operation range. SKA 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). | | |
| SYS_REQ_5340 | Wind velocities. SKA equipment shall be able to survive wind velocities up to 160 km/hr (TBV), and shall operate within normal specification ranges for wind velocities up to 40 km/hr (TBC). | | |
| SYS_REQ_5410 | Damaging interference levels. SKA shall not be damaged by RFI signals less than TBD V/m. | | |
| SYS_REQ_5420 | EM immunity. SKA shall not be susceptible to RFI signals, in-band or out-band, other than via the receptors. | | |
| SYS_REQ_5430 | ADC clipping. The dynamic range of the ADC's in the SKA 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 airplane DME and satellite signals. | | |
| 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. | | |
| SYS_REQ_5620 | EMC compatibility marking. All "off-the-shelf" equipment applied within SKA shall posses as a minimum the host country EMC marking, including electrical and electronic supporting and infrastructural equipment. | | |
| 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) | | |
| 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. | | |
| SYS_REQ_2910 | Self-generated RFI susceptibility. Interference due to selfgenerated RFI shall not degrade the performance of the instrument by greater than 1% by any measure (TBC). | | |
| SYS_REQ_5710 | Lightning discharge susceptibility. The SKA 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. | | |
| SYS_REQ_5720 | Lightning protection. SKA 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). | | |
| SYS_REQ_5730 | Lightning discharge flagging. Observation data taken during a lightning strike shall be flagged. | | |
| SYS_REQ_5810 | Safety ground. Electrical safety ground shall be designed according to the regulations imposed by the local government. | | |
| SYS_REQ_5820 | Corrosion protection. SKA equipment and buildings shall be protected against corrosion. | | |

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| SYS_REQ_5830 | Corrosion protection in air flows. SKA electronics and connectors in areas with a higher air flow (for cooling) or outdoor environment shall be additionally protected against corrosion. | | |
| SYS_REQ_5910 | Earthquakes. SKA equipment and buildings shall be protected against earthquakes with a magnitude up to 3.8 (TBV) on the scale of Richter. | | |
| SYS_REQ_6110 | Deployment locations. The SKA1 shall be installed at the SKA core site and at the SKA station sites. | | |
| SYS_REQ_6210 | Feed Payload volume. The SKA1 front-end and cabling shall fit in the available feedboxes. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_7111 | Materials, Parts and Processes lists shall reflect the current design at the time of issue. | | |
| 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). | | |
| 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.. | | |
| SYS_REQ_7150 | Long-term environmental effects. Materials used in the SKA1 design shall not have any lasting effect on the site location. | | |
| SYS_REQ_7160 | Maintenance free materials. Materials used for the parts subject to the outdoors environment shall be maintenance free. (TBC). | | |
| SYS_REQ_7210 | Maintenance free materials. Materials used for the parts subject to the outdoors environment shall be maintenance free. (TBC). | | |
| SYS_REQ_7220 | Marking method. Method of marking shall be compatible with the nature of the item and its use. | | |
| SYS_REQ_7230 | Documentation marking. Identification numbers shall be marked on documentation and, where possible, on respective items. | | |
| SYS_REQ_7310 | Mains supply. The SKA1 shall connect to the available power distribution at the SKA core and remote sites. | | |
| 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. | | |
| SYS_REQ_7330 | Observatory power consumption. The total power consumption of the SKA1 observatory shall be less than TBD kVA. | | |
| SYS_REQ_7410 | Quality standard. SKA1 equipment and electronics shall be developed and produced according to the ISO9001 (TBC) quality standard. | | |
| 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. | | |
| 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). | | |
| SYS_REQ_7520 | Scope of workmanship standards. SKA1 dedicated workmanship standards shall be specified in project dedicated documents | | |
| SYS_REQ_7521 | Scope of workmanship standards. SKA1 dedicated workmanship standards shall and shall cover all phases of production, assembly and integration, testing, handling, and include clear requirements for acceptance/rejection criteria. | | |
| SYS_REQ_7610 | Design margins. The SKA1 design shall possess design margins to cover all uncertainties in environment, analysis and properties of the materials and processes used. | | |
| 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. | | |
| 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). | | |

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| 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. | | |
| 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. | | |
| SYS_REQ_7840 | Test and repair instructions. Test and repair instructions shall be written for fault detection and maintenance of the SKA1 equipment. | | |
| SYS_REQ_7850 | Maintenance team size. It should be possible to execute regular maintenance jobs with not more than two (2) people per job. | | |
| SYS_REQ_7860 | Modular design. The SKA1 design (hardware and software) shall have a modular approach. | | |
| 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) | | |
| SYS_REQ_7880 | Self-test capability. The SKA1 design for both hardware and software shall provide self-test capabilities. | | |
| SYS_REQ_7890 | Servicing point making. All servicing and test points shall be clearly marked using TBD labelling standards. | | |
| 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. | | |
| 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. | | |
| 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 | | |
| SYS_REQ_7935 | If special storage facilities are needed they shall be supplied as part of the spares procurement. | | |
| 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. | | |
| 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. | | |
| SYS_REQ_7960 | Support equipment life-time. SKA1 support equipment shall be designed to maintain SKA1 for 12 (TBC) years. | | |
| SYS_REQ_8110 | Supply power . The power supplied to the SKA systems shall have the following characteristics (TBV):<br>a) voltage 380 V +/- 10%<br>b) 3 phases<br>c) 50 Hz +/- 1 Hz | | |
| SYS_REQ_8130 | Central facility UPS. The power source to the central facility shall have back-up provisions for controlled shut-down (TBV). | | |
| SYS_REQ_8140 | Subsystem time standard. Each SKA AA or dish system shall maintain an internal time standard with an accuracy of TBD nanosec. | | |
| SYS_REQ_8150 | Central time standard. All SKA subsystems shall synchronize their internal time standards to the central timing standard with an accuracy of TBD nanosec | | |
| SYS_REQ_8160 | Limiting excessive currents. SKA equipment circuitry shall be protected against excessive currents by a current limiting device, which shall not itself produce excessive currents. | | |
| SYS_REQ_8170 | Power surge protection. SKA sub-systems shall be protected against power transients and surges. | | |
| SYS_REQ_8180 | Polarity mis-connection protection. SKA equipment circuitry shall be protected against the effects of inadvertent wrong polarity connections. (TBC) | | |
| 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. | | |
| SYS_REQ_9110 | Test resources. SKA subsystems shall specify what special test resources they require in the operational phase. | | |
| SYS_REQ_9130 | Preventive maintenance. Preventive maintenance of SKA1 hardware shall be performed in accordance with the maintenance program established for SKA. | | |

| | | =Yes | =No |
|---|---|---|---|
| Requirement ID | Requirement text | Applicability to STaN | In CoDR scope |
| SYS_REQ_10110 | Dish/PAF interfaces. SKA1 Dishes shall be designed, built and verified such that they can accommodate Phased Array Feeds. | | |
| SYS_REQ_10120 | Frequency Coverage. SKA1 Dishes shall be designed, built and verified such that they can meet AD1 optical requirements up to 10GHz. | | |
| SYS_REQ_10130 | Polarization Purity. SKA1 feeds, receivers and digital processing subsystems shall be designed to provide the AD1 polarization purity requirement of 40dB. | | |
| SYS_REQ_10140 | Imaging dynamic range. SKA1 elements shall be designed to provide an imaging dynamic range of 74 dB up to 10GHz | | |
| SYS_REQ_10150 | Spectral dynamic range. SKA1 elements shall be designed to provide a spectral dynamic range of 67 dB. | | |

### 3.2.4 Traceability

The requirements traceability matrix in figure 1. shows the STaN functional requirements as a subset of the system level requirements described in AD[1].

| STaN Requirements Matrix | Electromagnetic Frequency Range | Instantaneous Bandwidth | Spectral baseline | Sub-Band and channel Phase relations | Spectral Dynamic Range | Sensitivity | Survey Speed | Survey On-Sky Time | Baseline | Main Beam stability | Frequency switching agility | Beam polarisation stability | External calibration measurement rate | Stokes parameters | Instrumental polarisation | Instantaneous Field of View | Field of View imaging | Imaging dynamic Range | Absolute time of arrival of pulses | Long term accuracy of | N/A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Tier 2 Requirement number** | STaN_REQ_0010 | STaN_REQ_0020 | STaN_REQ_0050 | STaN_REQ_0060 | STaN_REQ_0070 | STaN_REQ_0080 | STaN_REQ_0090 | STaN_REQ_0100 | STaN_REQ_0110 | STaN_REQ_0120 | STaN_REQ_0130 | STaN_REQ_0140 | STaN_REQ_0150 | STaN_REQ_0160 | STaN_REQ_0170 | STaN_REQ_0180 | STaN_REQ_0190 | STaN_REQ_0200 | STaN_REQ_0210 | STaN_REQ_0220 | |
| | **System requirement Description** | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1110 | Electromagnetic Frequency Range | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1120 | Instantaneous Bandwidth | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1130 | Frequency Band positioning | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1140 | Band Selection resolution | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1150 | Polarisation Frequency Equality | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1160 | Sub-band bandwidth | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1170 | DSP signal processing capacity | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1180 | Beam sub-band and channel phase relations | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1190 | Spectral baseline | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1210 | Spectral Resolution | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1220 | Sub-Band and channel Phase relations | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1230 | Spectral Dynamic Range | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1310 | Sensitivity | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1410 | Survey Speed | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1420 | Survey 'On-Sky' Time | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1430 | Deep Field Integration Time | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1510 | Baseline | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1610 | Main Beam stability | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1620 | Temporal resolution | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1630 | Spatial side-lobe stability | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1640 | Beam former weight update rate | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1650 | Beam former weight ad-hoc update response time | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1660 | Beam-switching downtime flagging | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1670 | Frequency switching agility | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1710 | Beam polarisation stability | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1720 | External calibration measurement rate | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1730 | Stokes parameters | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1740 | Instrumental polarisation | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1810 | RFI avoidance | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1820 | Transient RFI detection | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1910 | Instantaneous Field of View | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1920 | Field of View imaging | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1940 | Imaging dynamic Range | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1950 | Dish beam absolute pointing accuracy | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1960 | AA beam absolute pointing accuracy | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1970 | Dish beam pointing estimation accuracy | | | | | | | | | | | | | | | | | | | | |
| SYS_REQ_1980 | AA beam pointing estimation accuracy | | | | | | | | | | | | | | | | | | | | |
| | Absolute time of arrival of pulses | | | | | | | | | | | | | | | | | | | | |
| | Long term accuracy of time stamps | | | | | | | | | | | | | | | | | | | | |

Colour Key

| |
|---|
| Requirement is traceable to the DRM [2] |
| Requirement has yet to be defined |
| Requirement is traceable to the DRM [2]with requests for clarification |
| Not Applicable |

# 4 Allocated, Derived and Introduced Requirements

## 4.1 Science Requirements

### 4.1.1 Functional

#### *4.1.1.1 Spectral*

##### 4.1.1.1.1 Operating Frequency

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0010 | **Electromagnetic frequency range.** Sub-elements of STaN shall support the measurement of electromagnetic radiation in a frequency range from 70 MHz to 3 GHz. | Mandatory | SYS_REQ_1110 | Test |

##### 4.1.1.1.2 Instantaneous Bandwidth

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0020 | **Instantaneous bandwidth.** Sub-elements of STaN shall support an instantaneous bandwidth, of:<br>Fractional instantaneous bandwidth: 1<br>The SKA1 shall be designed so that the fractional instantaneous bandwidth is comparable to the observing frequency. | Mandatory | SYS_REQ_1120 | Test |

Clarification request Submitted to System Level:
Need to know the instantaneous bandwidth to a defined accuracy

### 4.1.2 Performance

#### *4.1.2.1 Spectral Performance*

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0050 | **Spectral baseline.** Sub-elements of STaN shall support a bandpass that 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 | SYS_REQ_1190 | Test |

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0060 | **Sub-band and channel phase relations.** Sub-elements of STaN shall support signal processing performed | | SYS_REQ_1220 | |

| | | | | |
|---|---|---|---|---|
| | on each sub-band that leaves the relative phases of sub-bands and spectral channels intact or predictable. | | | |

#### *4.1.2.2 Spectral Dynamic Range*

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0070 | **Spectral dynamic range.** Sub-elements of STaN shall support a spectral dynamic range of: | | SYS_REQ_1230 | |
| | ≥61 dB in the band 70MHz to 240 MHz | Mandatory | | Test |
| | ≥43 dB in the band 200 MHz to 1.4 GHz | Mandatory | | Test |

#### *4.1.2.3 Sensitivity and Survey requirements*

##### 4.1.2.3.1 Sensitivity

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0080 | **Sensitivity ($A_{eff}/T_{sys}$).** Sub-elements of STaN shall support an SKA sensitivity of: | Mandatory | SYS_REQ_1310 | |
| | $10^3$ $m^2$ $K^{-1}$ in the frequency range 70 MHz - 240 MHz | | | |
| | $10^3$ $m^2$ $K^{-1}$ in the frequency range 400 MHz - 3 GHz | | | |
| | $10^5$ $m^2$ $K^{-1}$ in the frequency range 800 MHz - 3 GHz | | | |

##### 4.1.2.3.2 Survey speed

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0090 | **Survey speed.** Sub-elements of STaN shall support an $SKA_1$ survey speed of: | | SYS_REQ_1410 | |
| | ~$10^7$ $m^4$ $K^{-2}$ $deg^2$ for the frequency range 200MHz to 1.4 GHz | Mandatory | | |
| | >$10^7$ $m^4$ $K^{-2}$ $deg^2$ | Mandatory | | |

##### 4.1.2.3.3 Survey On-Sky Time

| Ident | Requirement | Applicability | Parents | Verification |
|---|---|---|---|---|
| STaN_REQ_0100 | Sub-elements of STaN shall support the SKA design such that a major survey can be completed in 2 years of "on-sky" observation time. | Mandatory | SYS_REQ_1420 | Analysis & Test |

#### *4.1.2.4 Baseline requirements*

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0110 | **Baseline.** Sub-elements of STaN shall support the SKA1 minimum baseline requirement of: | | SYS_REQ_1510 | |
| | 200 km for the range 70 to 240 MHz | Mandatory | | |

The layout of receptors is defined by the configuration, which can be found in the SKA configurations design [3].

##### 4.1.2.4.1 Temporal characteristics

###### *4.1.2.4.1.1 Main beam stability*

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0120 | **Main beam stability.** Sub-elements of STaN shall support the requirement that 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. | | SYS_REQ_1610 | |

Clarification request Submitted to System Level:
We are not sure if this is applicable or not. The parent in the SRS is TBD, so it is not clear where it comes from and what it refers to.

###### *4.1.2.4.1.2 Pulsar Timing requirements*

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0210 | **Sub-elements of STaN shall support the requirement that the absolute time of arrival of pulses should be known to TBD over TBD.** | | TBD | |

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0220 | **Sub-elements of STaN shall support the requirement that the long term accuracy of time stamps in SKA1 shall be better than TBD over 10 years.** | | TBD | |

Clarification request Submitted to System Level:
These are new system level requirements identified as important. Are there any other transient requirement timings that need to be included at system level?

#### *4.1.2.5 Frequency switching agility*

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| STaN_REQ_0130 | Sub-elements of STaN shall support the requirement that the SKA shall be able to 'switch between observing frequencies within 10 minutes or less' (in the band 0.8–3 GHz) | Mandatory | SYS_REQ_1670 | Test |
| | Sub-elements of STaN shall support the requirement that 'near simultaneous access to multiple frequencies' is possible | | | |

Clarification request Submitted to System Level:
Upon switching do the receivers need to return to the same phase? Perhaps, this is an operations requirement.

#### *4.1.2.6 External Calibration measurement Rate*

| Ident | Requirement | Applicability | Parents | Verification |
|---|---|---|---|---|
| STaN_REQ_0150 | **External calibration interval.** Sub-elements of STaN shall support the requirement that Measurements of the Phase 1 Dish Array shall be necessary at a rate of no more than once per hour (TBC). | | SYS_REQ_1720 | Analysis |

Clarification request Submitted to System Level:
This requirement does not appear in the SPF Receiver requirements – should it?

#### *4.1.2.7 Polarisation Performance*

##### 4.1.2.7.1 Beam polarisation Stability

| Ident | Requirement | Applicability | Parents | Verification |
|---|---|---|---|---|
| STaN_REQ_0140 | **Beam polarization stability.** Sub-elements of STaN shall support the requirement that the polarization properties of the beams shall be stable enough to allow their calibration to better than 0.5% (TBC) | | SYS_REQ_1710 | Analysis |

##### 4.1.2.7.2 Stokes Parameters

| Ident | Requirement | Applicability | Parents | Verification |
|---|---|---|---|---|
| STaN_REQ_0160 | **Stokes parameters**. Sub-elements of STaN shall support the requirement that SKA1 shall provide visibility data in all four Stokes parameters. | | SYS_REQ_1730 | Analysis |

#### 4.1.2.7.3 Instrumental Polarisation

| Ident | Requirement | Applicability | Parents | Verification |
|---|---|---|---|---|
| STaN_REQ_0170 | **Instrumental polarisation**. Sub-elements of STaN shall support the requirement that the polarisation introduced by the instrument, after calibration, shall be less than 0.5% of the total intensity. (TBC) | | SYS_REQ_1740 | Analysis |

### *4.1.2.8 Field of View*

#### 4.1.2.8.1 Instantaneous Field of View

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0180 | **Instantaneous field of view** | | SYS_REQ_1910 | |
| | Sub-elements of STaN shall support the requirement that *'These requirements imply a field of view greater than 5 degrees.'* | | | |

#### 4.1.2.8.2 Field of View Imaging

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0190 | **Field of view imaging.** Sub-elements of STaN shall support the requirement that it shall be possible to image the entire field of view | | SYS_REQ_1920 | |

Clarification request Submitted to System Level:
Does this imply it should be possible to image the entire field of view at the same time or can this be achieved in increments?

### *4.1.2.9 Imaging Dynamic Range*

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN_REQ_0200 | **Imaging dynamic range**. Sub-elements of STaN shall support the requirement that SKA1 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 | SYS_REQ_1940 | Test |
| | Sub-elements of STaN shall support the requirement that 'studies of star formation at high redshift with a continuum deep | | | |

| | | | | |
|---|---|---|---|---|
| | field require a dynamic range of 74 dB in imaging' | | | |

## 4.2 STaN Sub Element Interface Requirements

### 4.2.1 General

STaN interfaces are discussed in RD[14]. They are broadly classified as External, namely those interfaces to entities outside the STaN Element, and Internal, between Sub-elements of STaN. Some of the External interface requirements, such as those stemming from interfaces to the environment, operations, monitoring and control functions (as opposed to fulfilling network functions for M&C), sustaining engineering and human actors, are found in their dedicated sections.

This section, as of STaN CoDR, is highly preliminary as this stage is in advance of formal Architecture development.

### 4.2.2 Interfaces

It is expected that, in addition to an analysis of the Architecture and negotiations between the System Engineering disciplines of the Elements and Sub-elements, AD[13] will provide Requirements in this section.

These requirements are intended to be general, but where specific, reference will be made to Interface Control Documents (ICDs). ICDs undergo a great deal of change until late in the development and therefore are the proper repository of such low level, changeable data. These data should not be expressed as requirements for this reason.

#### *4.2.2.1 External*

4.2.2.1.1 Antennas

##### *4.2.2.1.1.1 Dishes*

Gain

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Impedance

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Physical, electrical and data Interfaces

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Return loss

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Noise Figure

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

1dB Compression point

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

3rd order intercept

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Power requirements

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Frequency range

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

#### *4.2.2.1.1.2 Aperture Arrays*

Gain

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Impedance

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Physical, electrical and data Interfaces

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Return loss

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Noise Figure

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

1dB Compression point

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

3rd order intercept

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Power requirements

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

Frequency range

| Ident | Requirement | Applicability | Parent | Verification |
|---|---|---|---|---|
| STaN _REQ_ | TBD | | | |

4.2.2.1.2 Receivers

TBW

4.2.2.1.3 Digitising stages

TBW

4.2.2.1.4 Signal processing

TBW

4.2.2.1.5 High performance computing

TBW

4.2.2.1.6 Monitor and control Element

TBW

4.2.2.1.7 Site infrastructure

TBW

4.2.2.1.8 Power

TBW

4.2.2.1.9 Cooling

TBW

*4.2.2.2 Internal*

TBW

## 4.3 STaN Sub Element Operations Requirements

It is expected that these requirements will be sourced primarily from ADs [5], [6] & [8].

### 4.3.1 Modes

TBW

### 4.3.2 Observation

TBW

### 4.3.3 Monitor and Control

TBW

### 4.3.4 Inventory, Maintenance & Diagnostics

TBW

### 4.3.5 Modification

TBW

### 4.3.6 Safety

TBW

### 4.3.7 Quality Assurance

TBW

## 4.4 STaN Sub Element Design requirements

It is expected that these requirements will be sourced primarily from AD[1] (Extensibility),[7] [8], [9] & [10].

### 4.4.1 Extensibility to SKA Phase 2

TBW

### 4.4.2 RFI Emissions

TBW

### 4.4.3 Electronic

TBW

### 4.4.4 Information Systems

TBW

### 4.4.5 Electrical/Electromechanical

TBW

### 4.4.6 Mechanical

TBW

### 4.4.7 Thermal

TBW

### 4.4.8 Sustainability

TBW

## 4.5 STaN Sub Element Development requirements

It is expected that these requirements will be sourced primarily from ADs [4] [7] [8] & [10].

### 4.5.1 Units of Measure

TBW

### 4.5.2 Modelling

TBW

### 4.5.3 Verification

TBW

### 4.5.4 Configuration Control

TBW

### 4.5.5 Product Assurance

TBW

## 4.6 STaN Sub Element Environmental requirements

These requirements will be sourced primarily from ADs [9] & [11]

### 4.6.1 Climatic & meteorological

TBW

### 4.6.2 Geotechnical

TBW

### 4.6.3 RFI Susceptibility

TBW

### 4.6.4 Biological threats

TBW

## 4.7 STaN Sub Element Human Factors requirements

These requirements will be sourced primarily from ADs [5], [6], [8], [12] & [13].

### 4.7.1 HMI

TBW

### 4.7.2 Training

TBW

### 4.7.3 Safety

TBW

### 4.7.4 Security

TBW

## 4.8 STaN Sub Element Statutory/Regulatory requirements

These requirements will be sourced primarily from AD [12].

### 4.8.1 Consents

TBW

### 4.8.2 Governance

TBW

### 4.8.3 Employment

TBW

### 4.8.4 Health & Safety

TBW

### 4.8.5 Security

TBW

### 4.8.6 Land use

TBW

### 4.8.7 Restitution

TBW

### 4.8.8 Energy use

TBW

### 4.8.9 Waste management

TBW

# 5 List of TBDs, TBWs and TBCs

**Table 1 :** List of TBDs, TBWs & TBCs

| Paragraph | Resolved by |
|---|---|
| 2.1<br>Quality Assurance & Safety Plan WP2-005.080.010-PLA-001 TBW<br>RFI/EMC Control Plan WP2-005.080.020.PL-001 TBW<br>Design & Development Plan WP2-005.080.030-PL-001 TBW<br>Environment Specification WP2-005.050.030-ENV-001 TBW<br>Regulatory/Statutory Requirements Summary TBW<br>SKA Reference and Applicable Standards TBW | DSRR |
| 3.2.3<br>Many – inherited from AD[1] | DSRR |
| 4.1.2.4.1.1<br>Inherited from AD[1] | DSRR |
| 4.1.2.4.1.2<br>Inherited from AD[1] | DSRR |
| 4.1.2.6<br>Inherited from AD[1] | DSRR |
| 4.1.2.7.1<br>Inherited from AD[1] | DSRR |
| 4.1.2.7.3<br>Inherited from AD[1] | DSRR |
| 4.2.2<br>Inherited from AD[1] | DSRR |
| Sections 4.3 to 4.8 | DSRR |