MARKET SURVEY (EXPRESSION OF INTEREST) – MID RXS45

Revision 1

Classification: UNRESTRICTED

Date: 2024-05-13

Role	Name	Designation	Affiliation	Signature	Date
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1 Introduction

This Market Survey Notice (Expression of interest) is to solicit interest from Suppliers in tendering for SKAO requirements: MID MID RXS45 Contract. This procurement is open to organisations within SKAO Member countries, as well as those with an eligible Cooperation Agreement or Arrangement. Interested parties will be expected to register their interest on the Procurement Portal (https://www.kommersannons.se/skaobservatory/). The closing date for this Market Survey is the 10th of June 2024.

2 Description of the SKA Project

The Square Kilometre Array Observatory (SKAO) is a global collaboration of Member States. The mission of this newly established Inter-Governmental Organisation (IGO) is *"to build and operate cutting-edge radio telescopes to transform our understanding of the Universe and deliver benefits to society through global collaboration and innovation"*. The headquarters of the SKA Observatory is co-located with the site of the Jodrell Bank Observatory near Manchester in the United Kingdom. See www.skao.int.

The SKA is a next-generation radio astronomy-driven Big Data facility that will revolutionise our understanding of the Universe and the laws of fundamental physics. Enabled by cutting-edge technology, it promises to have a major impact on society, in science and beyond.

The observatory will consist of two world-class complementary telescopes, one with an array of mid-frequency dishes and one with an array of low-frequency log-periodic antennas, both operating in the radio part of the electromagnetic spectrum:

- SKA MID: An array of 197 dishes, comprising 64 dishes (currently forming the MeerKAT telescope) and 133 15m diameter dishes, the greatest distance between any two dishes being 150km, located in South Africa. The MID Telescope covers a frequency range of 0.35 – 15.4 GHz over 5 bands.
- SKA LOW: An array of ~131,072 antennas grouped in 512 stations, the greatest distance between any two antenna stations being 65km, located in Western Australia. The LOW telescope covers a frequency range from 50 – 350 MHz.

3 Document Purpose

The purpose of this Market Survey is to provide organisations with a description of the MID RXS45 contract and outline the Procurement Process. The desired outcome of this Market Survey is that organisations create an account and register their interest in the MID RXS45 Contract Procurement Process using the guidance below in section 8 for the SKAO Procurement Portal.

The MID RXS45 contract will be awarded to a Contractor via a tender process run by the SKAO, to enable the timely appointment of the time critical MID RXS45 procurement.

The MID RXS45 Contract represents an opportunity for a world class Supplier to engage with one of the great scientific projects of the 21st century. The chosen Contractor will be a key contributor to the success of the SKAO Observatory through its application of technical design expertise and experience with medium scale manufacture.

4 Summary of Requirements

SKAO will competitively procure a **cash** Tier 1 contract to deliver the RXS45 product for SKA-Mid.

The RXS45 contract consists of 80 RXS45 systems plus a minimum of six spares.

The RXS45 forms part of the modules of the Single Pixel Feed Receiver (SPFRx) system for the MID Telescope. The Single Pixel Feed Receiver (SPFRx) is a key performance-determining part of the SKA Mid telescope and its main functions are conditioning and digitisation of the RF output signals from Single Pixel Feeds (SPF), and forwarding the data to the Central Signal Processor (CSP).
The SPFRx consists of three main modules which are the RXS123 (Receiver Sampler for Band 1,2 & 3), **RXS45** (Receiver Sampler Band for 4 & 5) and RXPU (Receiver Pedestal unit). The RXS45 is mounted on the SKA MID Dish Indexer while the RXPU is mounted inside the SKA MID Dish Pedestal.

The RXS45 receives radio frequency (RF) signals captured by the dish and pre-amplified by the Single Pixel Feed (SPF) Sub-Element components, when observing band 4 (2.8 – 5.18 GHz), 5a (4.6 – 8.5 GHz) or 5b (8.3 – 15.4 GHz). The RF signals are delivered to SPFRx in two polarities on 50-Ohm coaxial lines, one pair of coaxial lines dedicated to each SPF Band.
The main tasks for the RXS45 are to condition and perform analogue to digital conversion on the incoming RF signals and to send the digital signals to the RXPU for further digital signal processing. The RXS45 operation is controlled by the Dish Local Monitoring and Control (LMC) Sub-Element through the RXPU.
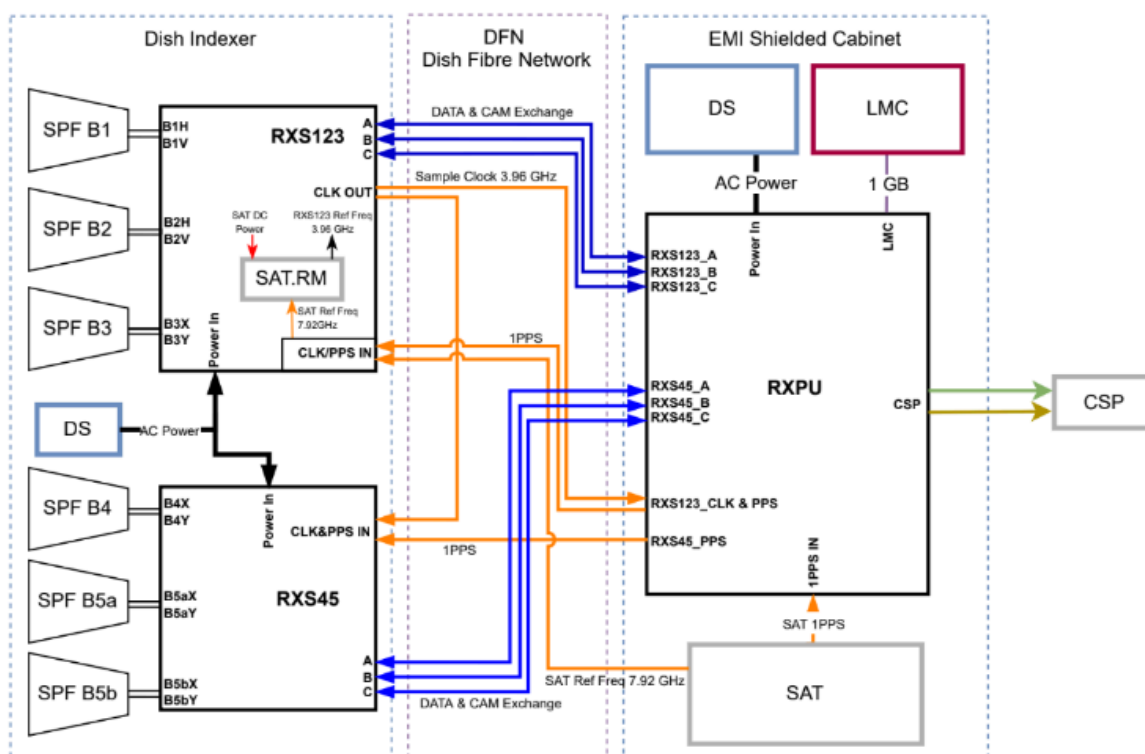
Figure 1: A block diagram of the single pixel feed receiver system (SPFRx). The RXS123, the RXS45 and the RXPU blocks in black as well as the RF cables connecting it to each single pixel feed (SPF) make up the SPFRx. Of the items shown, only the RXS45 + SPF B4,5a, B5b RF Cables are deliverables of this ECC.

SKAO seeks an RXS45 design solution that can meet the SKAO RSX45 requirements in the shortest time. The successful design must interface seamlessly with other products (i.e. RXPU, Dish and CSP) with minimal impact on their designs. SKAO seeks to enter into a NEC4 Engineering Construction Contract (ECC) with a Contractor to design, industrialise and manufacture 80 of the RXS45 systems plus a minimum of 6 spares and related external cables, based on the designs from SKAO. The manufacture and supply of the units will be in batches and delivered over 2.5-3 years, aligned with the SKAO rollout plan.

The applicable incoterm will be FCA Seller's Works.

4.1 Summary of Scope

The scope of the contract covers the design, manufacturing and commissioning of 80 RXS45 systems plus spares for the MID Telescope.

The suitable Contractor will need to be able to demonstrate the design compliance to the SKAO requirements, and after acceptance of the design by the SKAO proceed with manufacturing of the production systems including the relevant spares.

The scope of work also includes management of the RXS45 requirements and ICDs in the relevant platform identified by SKAO (once training is provided by SKAO). The Contractor will need to work closely with other external interface parties to ensure compliance to the defined Interface Control Documentation (ICDs), this include but is not limited to the SPFRx123 Contractor responsible for delivery of the RXPU and the SPFRx FW/SW Contractor.

As part of products delivery and commissioning activities the Contractor will provide training and training material to the SKAO Assembly, Integration and Verification teams. The Contractor will also be responsible for configuration management and quality management of the delivered products, in line with the SKAO plans.

4.2 Summary of Key requirements

Specification	Band 4	Band 5a	Band 5b
RF Range (GHz)	2.8-5.18	4.6-8.5	8.3-15.4
Digitised bandwidth (GHz)	2.38	2 x 2.5	2 x 2.5
Digitised subbands	1	2	2 (tunable)
Effective number of bits (ENOBs)	>4 bits	>4 bits	>4 bits
Third Order Intercept Point (IIP3)	>5dBm	>5dBm	>5dBm
Spurious Free Dynamic Range (SFDR)	>36 dBFS	>27 dBFS	>27 dBFS
Noise Figure	<25 dB	<25 dB	<25 dB

Out of band suppression	>40 dB	>40 dB	>40 dB
Input match (Return Loss)	>15 dB	>15 dB	>15 dB
Gain flatness across any 2.5 GHz	<2 dB p-p	< 1.8 dB p-p	< 1.8 dB p-p
Adjustable gain	+3dB to -8 dB in 1 dB increments Attenuation up to 40 dB in 3dB increments.	+3dB to -8 dB in 1 dB increments Attenuation up to 37 dB in 3dB increments.	+3dB to -8 dB in 1 dB increments Attenuation up to 37 dB in 3dB increments.
Temperature range	-5 to 40 degrees C	-5 to 40 degrees C	-5 to 40 degrees C

Additional notes

- To ensure that phase coherence is maintained across the band changes B5a & 5b should run ADC devices continuously at constant sampling rate
- To suppress digitiser-generated self interference and out-of-band interference sample clock frequencies at each dish is implemented.
- It is envisioned that Band 5a and 5b will have two independent sub-bands of 2.5GHz tunable across the whole frequency range for each polarisation.
- The design shall comply with stringent RFI/EMC requirements (See Annexure 1).
- The short/draft list of functional requirements can be found within this document in Annexure 1.
- The current priority for deployment is bands 5a and 5b; we are able to consider solutions that digitise these bands only should this prove a significant simplification for interested bidders

5 Basis of Proposed Contract Terms

The Tier 1 contractor will be employed by the SKAO under a NEC4 contract. The Tier 1 RXS45 contract will be a NEC4 ECC Option A – priced contract with activity schedule.

All payments by SKAO for work performed under the Tier 1 RXS45 contract will be made upon satisfactory completion of agreed milestones according to the principles defined by the contract.

6 Indicative Procurement Schedule

Market Survey	**2024-05-13 - 2024-06-10**
Industry briefing event	**2024-06-11**
Period for submission of pre-qualification packs	**2024-06-11 - 2024-07-02**
Notice of PQQ outcome	**2024-07-16**
Tender period for submission of ITT packs	**2024-07-16 - 2024-09-10**
Contract award	**2024-11**

7 Indicative Delivery Schedule

Please note the table below does note take into account the spares.

Milestone	Date
Contract Start date	Dec 2024
SITF (#1 - #4)	Mar 2026
AA0.5 to AA1 Systems (#5 - #12)	Jul 2026
AA2 Systems (#13 - #26)	Sep 2026
AA2 Systems (#27 - #64)	Nov 2026
AA* Systems (#65-#80)	Jan 2027
Contract Completion	Dec 2027

8 Market Survey Responses

All tenderers should create an account (if they have not already) and then register their interest in this Market survey through the SKAO Procurement Supplier Portal (https://www.kommersannons.se/skaobservatory/Notice/NoticeList.aspx) by **2024-06-10**.

Tenderers should also inform the relevant country ILO (Industry Liaison Officer) of their interest via email. The responsible ILOs (Industry Liaison officers):

https://www.skao.int/en/opportunities/165/procurement-industry/430/industry-liaison-officers

9 Industry Event

On the 11th of June 2024 at 09h00 GMT SKAO will hold an Industry Event with the aim of providing more information about SKAO and the Mid Band 5 competitive tender. As long as you have registered your interest in the Market Survey on the SKAO Procurement Portal by the 10th of June 2024 at 12h00 GMT using the guidance in "Market Survey Responses", you will be sent a meeting invitation via Zoom.

10 Pre-Qualification

Once parties have registered their interest, a Pre-Qualification Document Pack will be issued to interested parties. The Pre-Qualification Document Pack will contain a Pre-Qualification Questionnaire (PQQ) which includes a Quality Assurance Questionnaire, information security management system (ISMS) Questionnaire and a Health and Safety Questionnaire. Developed in order to accurately determine if the Supplier has the necessary financial, economic, quality, technical and professional capacity and competencies to perform the required scope of work in a manner compliant with SKAO expectations.

11 Tender Evaluation Criteria

Technical and financial submissions will be assessed separately. A minimum quality standard must be achieved.

The Most Economically Advantageous Tender Evaluation Method will be used and tender submissions will be assessed on a 60:40 weighting of technical merit:price.

12 Contact Details

Procurement related questions should in the first instance be directed to Paul Oosthuizen via the Kommers Supplier Portal.

If you are having issues with the Kommers Supplier Portal these should be addressed to Paul Oosthuizen (Procurement Specialist) Paul.Oosthuizen@skao.int via email with the responsible ILO (Industry Liaison officer) in Cc.

- The responsible ILOs (Industry Liaison officers):

- https://www.skao.int/en/opportunities/165/procurement-industry/430/industry-liaison-officers

Additional Information:
- Link to SKAO Procurement Website (https://www.skao.int/en/opportunities).

LIST OF ABBREVIATIONS

ECC	Engineering and Construction Contract
EMC	Electromagnetic Compatibility
HSE	Health, Safety & Environment
IGO	Intergovernmental Organisation
ILO	Industry Liaison Officer
ISMS	Information Security Management System
ITT	Invitation to Tender
NEC	New Engineering Contract
PQQ	Pre-qualification Questionnaire
QA	Quality Assurance
RFI	Radio Frequency Interference
SKA	Square Kilometre Array
SKAO	SKA Observatory
UK	United Kingdom

DOCUMENT HISTORY

Revision	Date Of Issue	Engineering Change Number	Comments
A	2024-05-06		First draft release for internal review
1	2024-05-13		First release

DOCUMENT SOFTWARE

	Package	Version	Filename
Word processor	MS Word	Office 365	MARKET SURVEY_MID RXS45
Block diagrams			
Other			

ORGANISATION DETAILS

Name	SKA Observatory
Registered Address	Jodrell Bank Lower Withington Macclesfield Cheshire, SK11 9FT, UK
Fax	+44 (0)161 306 9600
Website	www.skao.int

ANNEXURE 1: Draft Functional Requirements

1.1.1 Receive SPF B4&B5 RF Signals

Req. ID	Name & Description	Refines
R.RXS45.P.2	**RXS45 Input match**. The RF inputs of the RXS45 shall exhibit characteristic impedance of 50 Ohm with return loss > 13 dB, with a design goal of > 15dB, across the specified band frequency ranges.	R.SRx.P.2

1.1.2 RXS45 external Control

Req. ID	Name & Description	Refines
R.RXS45.SM.7	**RXS45 Band Control.** RXS45, when commanded by the RXPU to provide digitised data for a particular frequency band, shall configure itself to operate in the commanded frequency band within 10 seconds.	R.SRx.SM.7
R.RXS45.F.3.4	**RXS45 Adjustable gain Band 4.** The RXS45 shall, when commanded by the RXPU, change the nominal gain of the RF signal conditioning chain for Band 4, for each polarisation channel separately, over the range +3 dB to - 8dB, in 1 dB ±0.5dB increments.	R.SRx.F.3.4
R.RXS45.F.3.5	**RXS45 Adjustable gain Band 5a.** The RXS45 shall, when commanded by the RXPU, change the nominal gain of the RF signal conditioning chain for Band 5a, for each polarisation channel separately, over the range +3 dB to -8 dB, in 1 dB ±0.5dB increments.	R.SRx.F.3.5
R.RXS45.F.3.6	**RXS45 Adjustable gain Band 5b.** The RXS45 shall, when commanded by the RXPU, change the nominal gain of the RF signal conditioning chain for Band 5b, for each polarisation channel separately, over the range +3 dB to -8 dB, in 1 dB ±0.5dB increments.	R.SRx.F.3.6
R.RXS45.F.4.4	**RXS45 Max adjustable gain Band 4.** The RXS45 shall, when commanded by the RXPU, decrease the nominal gain of the RF signal conditioning chain for Band 4, for each polarisation channel separately, by up to 40 dB, in 3 dB ±0.5dB increments.	R.SRx.F.4.4

Req. ID	Name & Description	Refines
R.RXS45.F.4.5	**RXS45 Max adjustable gain Band 5a.** The RXS45 shall, when commanded by the RXPU, decrease the nominal gain of the RF signal conditioning chain for Band 5a, for each polarisation channel separately, by up to 37 dB, in 3 dB ±0.5dB increments.	R.SRx.F.4.5
R.RXS45.F.4.6	**RXS45 Max adjustable gain Band 5b.** The RXS45 shall, when commanded by the RXPU, decrease the nominal gain of the RF signal conditioning chain for Band 5b, for each polarisation channel separately, by up to 37 dB, in 3 dB ±0.5dB increments.	R.SRx.F.4.6
R.RXS45.F.6	**RXS45 Internal Noise Source Control.** RXS45, when commanded by the RXPU, shall switch the inputs of the RF conditioning chain between either the currently selected RF inputs or internally provided noise sources for both polarisations simultaneously.	R.SRx.LRA.2

1.1.3   Condition RF Signals

Req. ID	Name & Description	Refines
R.RXS45.F.1	**RXS45 Input protection**. The RXS45 shall implement measures as required to prevent RF input signals with instantaneous power up to 10 dBm from damaging its circuitry.	R.SRx.F.1
R.RXS45.F.2	**RXS45 Constant gain.** The RXS45 shall not perform any closed-loop, active gain control.	R.SRx.F.2
R.RXS45.P.1.4	**RXS45 Gain flatness Band 4.** The magnitude of the RXS45 Band 4 spectra, determined from the digitised voltage signals when presented with a wide band noise signal comparable to the nominal input signal of R.RXS45.P.5, shall vary by <= 2 dBp-p across the specified band frequency range.	R.SRx.P.1.4
R.RXS45.P.1.5	**RXS45 Gain flatness Band 5a.** The magnitude of the RXS45 Band 5a spectra, determined from the digitised voltage signals when presented with a wide band noise signal comparable to the nominal input signal of R.RXS45.P.5, shall vary by <= 1.8 dBp-p across any 2.5 GHz interval in the specified band frequency range.	R.SRx.P.1.5

R.RXS45.P.1.6	**RXS45 Gain flatness Band 5b.** The magnitude of the RXS45 Band 5b spectra, determined from the digitised voltage signals when presented with a wide band noise signal comparable to the nominal input signal of R.RXS45.P.5, shall vary by <= 1.8 dBp-p across any 2.5 GHz interval in the specified band frequency range.	R.SRx.P.1.6
R.RXS45.P.12.4	**RXS45 Band 4 Out-of-band suppression.** The RXS45 Band 4 shall provide out-of-band suppression in the analogue domain in excess of the following piecewise linear limit line: 10MHz:40dB; 2500MHz:40dB; 2800MHz:0dB; 5300MHz:0dB; 5600MHz:40dB; 12GHz:40dB with the 0dB referenced to the average of the response in the pass band as permitted by R.RXS45.P.16.4.	R.SRx.P.12.4
R.RXS45.P.12.5	**RXS45 Band 5a Out-of-band suppression.** The RXS45 Band 5a shall provide out-of-band suppression in the analogue domain in excess of the following piecewise linear limit line: 10MHz:60dB; 4250MHz:60dB; 4500MHz:0dB; 8800MHz:0dB; 9300MHz:40dB; 20GHz:40dB with the 0dB referenced to the average of the response in the pass band as permitted by R. RXS45.P.16.5.	R.SRx.P.12.5
R.RXS45.P.12.6	**RXS45 Band 5b Out-of-band suppression.** The RXS45 Band 5b shall provide out-of-band suppression in the analogue domain in excess of the following piecewise linear limit line: 10MHz:60dB; 7600MHz:60dB; 8000MHz:0dB; 15800MHz:0dB; 16280MHz:40dB; 26GHz:40dB with the 0dB referenced to the average of the response in the pass band as permitted by R. RXS45.P.16.6.	R.SRx.P.12.6
R.RXS45.P.13.1	**RXS45 Spurious signal suppression - IIP3.** The RXS45, for all gain settings implied by R.RXS45.F.4.4 to R.RXS45.F.4.6, shall have **Third order intercept points**, referred to its inputs, of >= +5 dBm across the specified frequency ranges.	R.SRx.P.13.1
R.RXS45.P.16.4	**RXS45 Band 4 frequency range.** The RXS45 shall, for its band 4 receiver, meet all its performance requirements over a frequency range from 2.80 to 5.18 GHz for both polarisations simultaneously.	R.SRx.P.16.4
R.RXS45.P.16.5	**RXS45 Band 5a frequency range.** The RXS45 shall, for its band 5a receiver, meet all its performance requirements over a frequency range from 4.6 to 8.5 GHz for both polarisations simultaneously.	R.SRx.P.16.5
R.RXS45.P.16.6	**RXS45 Band 5b frequency range.** The RXS45 shall, for its band 5b receiver, meet all its performance requirements over a frequency range from 8.3 to 15.4 GHz for both polarisations simultaneously.	R.SRx.P.16.6

Req. ID	Name & Description	Refines
R.RXS45.P.5	**RXS45 Nominal signal levels.** The RXS45 shall amplify a nominal input signal with power spectral density of -132 dBm/Hz at the RF input port to a level equivalent to -12 dBFS.	R.SRx.P.5
R.RXS45.P.6	**RXS45 Noise figure.** The RXS45's analogue circuitry shall have a noise figure < 25 dB across the specified frequency ranges and for all gain settings implied by R.RXS45.F.3.4 - R.RXS45.F.3.6.	R.SRx.P.6
R.RXS45.P.8	**RXS45 Linear passband fit.** The magnitude of the RXS45 gains shall not vary by more than 0.1%, relative to a piecewise linear fit over fractional bandwidths of 0.1%, across the specified band frequency ranges.	R.SRx.P.8
R.RXS45.P.9	**RXS45 Gain stability.** The RXS45, under standard and degraded operating conditions and in the absence of interfering signals, shall have a wide band gain stability over 5 s, when sampled with 20 ms intervals, of <= 0.05% RMS.	R.SRx.P.9
R.RXS45.P.25	**SPFRx RF Cross-coupling.** The RXS45 shall limit cross-coupling between any two RF paths to less than -30 dB where frequency ranges overlap.	R.SRx.P.25

1.1.4 Phase stability and timing

Req. ID	Name & Description	Refines
R.RXS45.P.10.4	**RXS45 Band 4 Phase stability - p-p.** The RXS45 Band 4, under standard and degraded operating conditions (including dish orientation changes and the effects of the dish switching to any other band and then back) and measured between the receiver's analogue input and digital output ports, shall exhibit phase stability over 5 minutes when sampled with 5 s intervals of <= 5° peak to peak.	R.SRx.P.10.4
R.RXS45.P.10.5	**RXS45 Band 5a Phase stability - p-p.** The RXS45 Band 5a, under standard and degraded operating conditions (including dish orientation changes and the effects of the dish switching to any other band and then back) and measured between the receiver's analogue input and digital output ports, shall exhibit phase stability over 5 minutes when sampled with 5 s intervals of <= 3.5° peak to peak.	R.SRx.P.10.5

Req. ID	Name & Description	Refines
R.RXS45.P.10.6	**RXS45 Band 5b Phase stability - p-p.** The RXS45 Band 5b, under standard and degraded operating conditions (including dish orientation changes and the effects of the dish switching to any other band and then back) and measured between the receiver's analogue input and digital output ports, shall exhibit phase stability over 5 minutes when sampled with 5 s intervals of <= 3.5° peak to peak.	R.SRx.P.10.6
R.RXS45.P.11	**RXS45 Phase stability – RMS.** The RXS45, under standard and degraded operating conditions (including orientation changes and the effects of the dish switching to any other band and then back) and measured between the receiver's analogue input and digital output ports, shall have a phase stability of <= 0.5° RMS over 5 minutes, after subtracting a linear fit through the data points of the 5 minutes, when sampled with 5 s intervals.	R.SRx.P.11
R.RXS45.CTF.3	**RXS45 Propagate time reference.** The RXS45 shall propagate the time reference provided by the RXPU, into the sampled data stream with accuracy better than 2 ADC sample clock periods.	R.SRx.CTF.3

1.1.5   Convert SPF Analog to Digital

The RXS45 receives analogue RF signals for Band 4 and Bands 5a and 5b from the SPF 345 and has to digitise these signals and stream the digitised data to the RXPU in the Dish Pedestal. Requirements are defined below.

Req. ID	Name & Description	Refines
R.RXS45.P.13.3.4	**RXS45 Band 4 SFDR.** The RXS45 Band 4, with nominal gain as per R.RXS45.P.5, shall have *Spurious-Free Dynamic Range*, referred to its input and across the specified frequency range, of >= 36 dBFS.	R.SRx.P.13.3.4
R.RXS45.P.13.3.5	**RXS45 Band 5a SFDR.** The RXS45 Band 5a, with nominal gain as per R.RXS45.P.5, shall have *Spurious-Free Dynamic Range*, referred to its input and across the specified frequency range, of >= 27 dBFS.	R.SRx.P.13.3.5
R.RXS45.P.13.3.6	**RXS45 Band 5b SFDR.** The RXS45 Band 5b, with nominal gain as per R.RXS45.P.5, shall have *Spurious-Free Dynamic Range*, referred to its input and across the specified frequency range, of >= 27 dBFS.	R.SRx.P.13.3.6

Req. ID	Name & Description	Refines
R.RXS45.P.19	**RXS45 Sampler jitter noise.** The theoretical noise floor due to clock and aperture jitter combined shall be at least 6 dB below the noise floor of R.RXS45.P.7.4 to R.RXS45.P.7.6, when referred to the RXS45 input ports. Note: For the purpose of this requirement, jitter is measured relative to the clock applied at the interface boundary and only reflects time scales 0 - 1 seconds.	R.SRx.P.19
R.RXS45.P.7.4	**RXS45 Band 4 Bit resolution.** The RXS45 Band 4 receiver shall digitise the conditioned input signal with *Effective Number of Bits* >=4 bits across the specified frequency range.	R.SRx.P.7.4
R.RXS45.P.7.5	**RXS45 Band 5a Bit resolution.** The RXS45 Band 5a receiver shall digitise the conditioned input signal with *Effective Number of Bits* >= 4 bits across the specified frequency range.	R.SRx.P.7.5
R.RXS45.P.7.6	**RXS45 Band 5b Bit resolution.** The RXS45 Band 5b receiver shall digitise the conditioned input signal with *Effective Number of Bits* >=4 bits across the specified frequency range.	R.SRx.P.7.6
R.RXS45.CTX.1	**RXS45 Bits per sample.** The RXS45 shall digitise the incoming RF signals per Band with the number of bits per digitised single-polarisation sample, N_{bits}/sample, for: a) Band 4: 6 bits b) Band 5a1, 5a2: 6 bits c) Band 5b1, 5b2: 6 bits Note: this requirement should be moved to "Interface Design Description RXPU to RxS45" [AD4] at the next update.	R.SRx.P.7.4 R.SRx.P.7.5 R.SRx.P.7.6

Req. ID	Name & Description	Refines
R.RXS45.P.26	**RXS45 Sampling rate.** TheRXS45 shall use the 3.96 + kΔf/1e9 GHz reference clock, as provided by SAT and and received via the RXS123, to generate and employ a sampling rate derived from multiplying the SAT frequency (3.96 + kΔf/1e9 GHz) by a multiplicative rational number. Note 1: The constant "k" is a unique (per Dish) integer number between 1 and 2222 selected by others and used by SAT to generate a unique sample clock for each dish in the SKA1 Dish array. The selected value of "k" for a Dish will be communicated to that Dish by TM for all dishes. Note 2: The clock frequency offset value "Δf" is fixed at 1800 Hz.	***R.SRx.CTF.4***
R.RXS45.P.22	**RXS45 Clock continuity.** The RXS45 sampling clocks shall not be interrupted by any frequency band change.	R.SRx.P.22

1.1.6 Report Monitoring Data

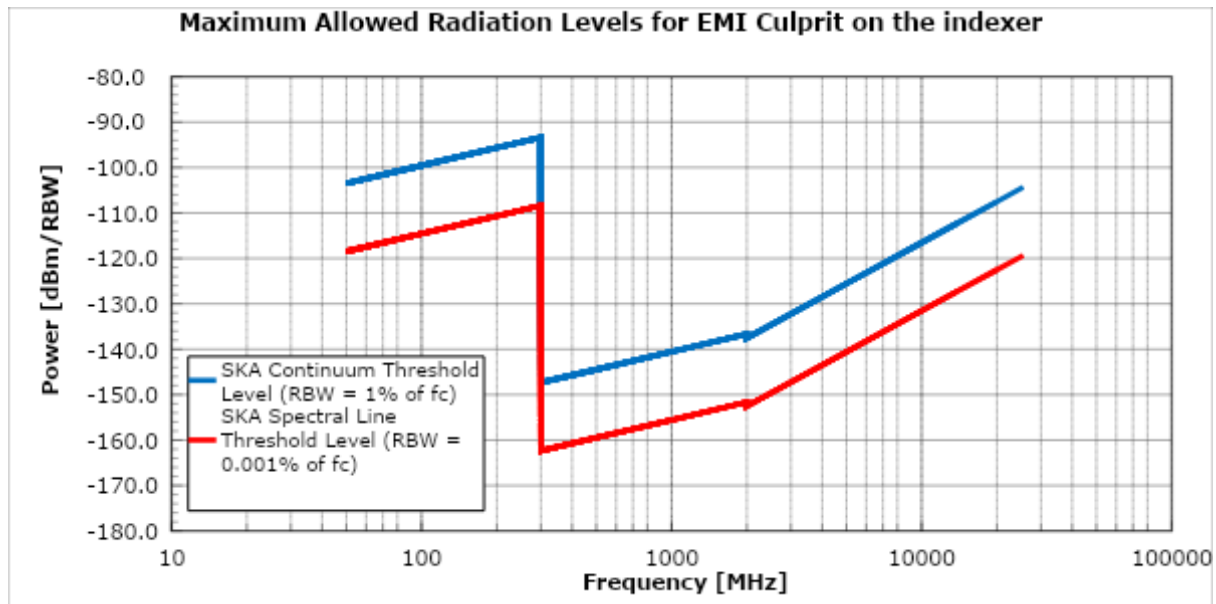| Req. ID	Name & Description	Refines
R.RXS45.CM.10	**RXS45 Report Sensors.** RXS45 shall report, with a latency of no more than 2 seconds, monitoring points to enable fault diagnostics and to preventative maintenance for the RXS45 sub-element as identified in the "RXS45 to RXPU Data Exchange ICD" [AD4]. Note: The monitoring points will be negotiated between the RXS45 Design team and the SPFRx team with guidance from the SPFRx FMECA report.	R.SRx.CM.10 R.SRx.CM.7 R.SRx.CM.9 R.SRx.CM.1 R.SRx.CM.2 R.SRx.CM.3

1.1.7 Provide Remote Support Capability

Req. ID	Name & Description	Refines
R.RXS45.CRS.3	**RXS45 Report serial numbers.** RXS45 shall report its serial numbers to the RXPU.	R.SRx.CRS.3
R.RXS45.CRS.4	**RXS45 Power Reset.** RXS45 shall provide a facility for, upon command from the RXPU, power cycling the its internal digital circuits.	R.SRx.CRS.4

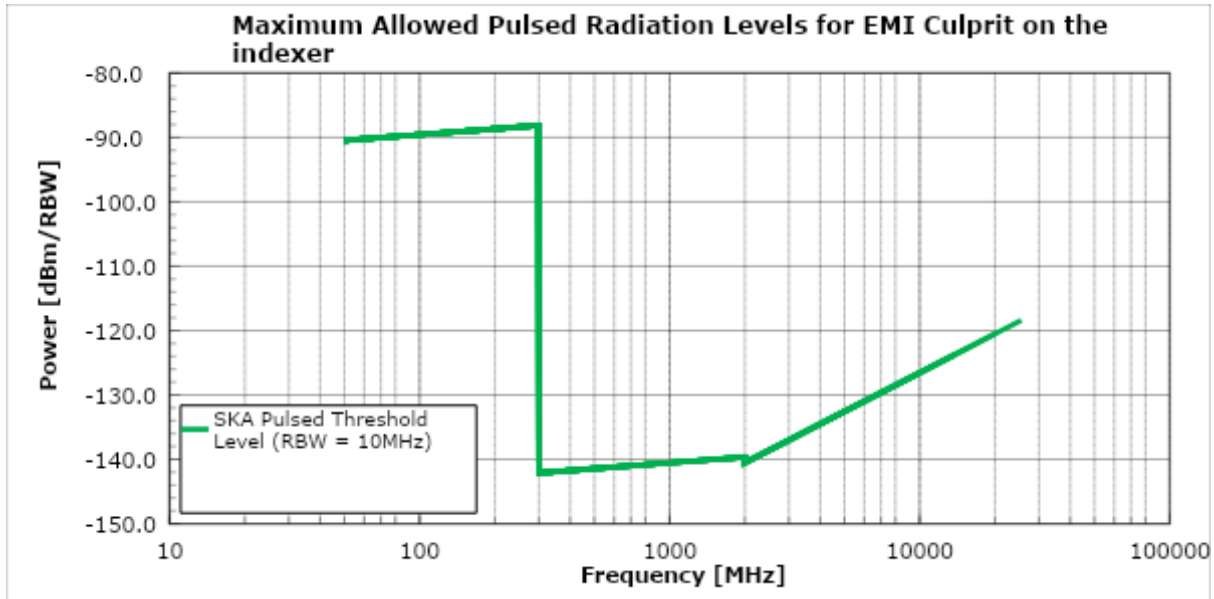| Req. ID	Name & Description	Refines
R.RXS45.CRS.6	**RXS45 Power Loss Recovery** RXS45 shall provide a mechanism to prevent it from being damaged and recover gracefully after sudden power loss.	SKAO-DISH_SRx_REQ-234
R.RXS45.CRS.6	**RXS45 Power Reset Recovery** RXS45 shall provide a mechanism to prevent it from being damaged and recover gracefully after sudden power reset.	SKAO-DISH_SRx_REQ-238

Radio Frequency Interference

| Req. ID	Name & Description	Refines
R.RXS45.RFI.1	**Maximum Allowed Radiation Levels for the RXS45.** Over the specified frequency band from 50MHz to 25.5 GHz, the RXS45 shall not radiate EMI above: - The Spectral Line Threshold Level depicted in the figure below and measured in a RBW of 0.001% of centre frequency, and - The Continuum Threshold Level depicted in the figure below and measured in a RBW of 1% of centre frequency.	R.SRx.RFI.1

RXS45 Maximum Allowed Radiation Levels

Req. ID	Name & Description	Refines
R.RXS45.RFI.4	**Maximum Allowed Pulsed Radiation Levels for the RXS45.** Over the specified frequency band from 50 MHz to 25.5GHz, the RXS45 shall contaminate less than 5% of 500 ms data blocks with RFI pulses larger than the Pulsed Threshold level depicted in the figure below when measured in a 10 MHz resolution bandwidth and 1 µs integration time.	R.SRx.RFI.4

RXS45 Maximum Allowed Pulsed Radiation Levels

Req. ID	Name & Description	Refines
R.RXS45.RFI.7	**Maximum Allowed Self-induced EMI Levels for RXS45.** Over the specified frequency band from 300MHz to 20GHz, the RXS45 shall not add RF power to the signal chain, referenced at the input to the LNA, above: - The Spectral Line Threshold Level depicted in the figure below and measured in a RBW of 0.001% of centre frequency, and - The Continuum Threshold Level depicted in the figure below and measured in a RBW of 1% of centre frequency. Assume a SPF gain of 56dB to adjust the threshold to be referenced at the SPFRx input.	R.SRx.RFI.7
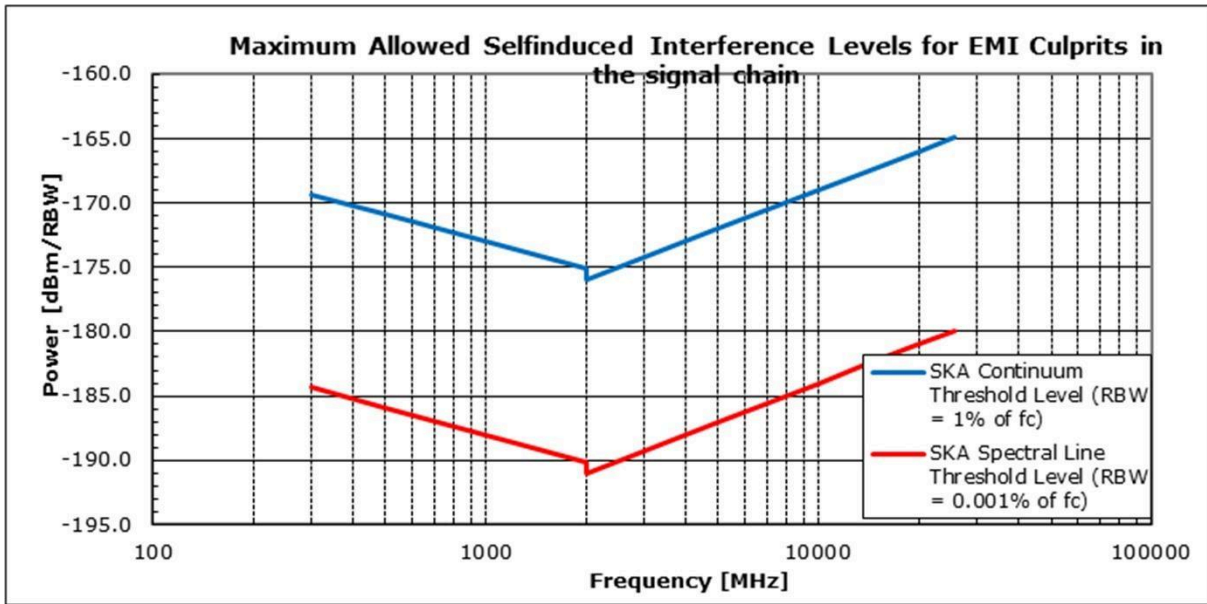
RXS45 Maximum Allowed Self-induced RFI Levels