RFI MONITORING TRAILER

REQUIREMENTS SPECIFICATION

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	Name	Designation	Affiliation	Date	Signature
Released By	A. Kotze	RFI Engineer	SARAO	Mar 1, 2023	AG Kotze (Mar 1, 2023 15:50 GMT+2)
Accepted By	J. Havenga	RFI Analyst	SARAO	Mar 6, 2023	
Accepted By	B. Dube	Logistics Engineer	SARAO	Mar 6, 2023	Busie Dube (Mar 6, 2023 11:22 GMT+2)
Approved By	S. Malan	FM: Receiver Systems	SARAO	Mar 6, 2023	

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A	13 February 2023	A. Kotze	Draft – Internal release for review
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2	1 March 2023	A. Kotze	Changed the PDU model number and added a compatible temperature sensor – Submit for RFQ

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Publish in eB and Distribute to all signatories on the document and the relevant line managers.

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COMPANY DETAILS

Name	SARAO, Johannesburg Office (Observatory, Gauteng)	SARAO, Cape Town (Observatory, Cape Town)	SARAO, HartRAO (Hartebeesthoek, Gauteng)	SARAO, Karoo Astronomy Reserve (Northern Cape)
Physical / Postal Address	118A Gill Street, Observatory, Johannesburg, 2183	2 Fir Street, Black River Park, Observatory, Cape Town, 7925	P.O. Box 443, Krugersdorp, 1740, South Africa	Posbus 69, Carnarvon, 8925, South Africa
Tel	+27 11 268 3400	+27 21 506 7300	+27 12 301 3100	+27 21 506 7300
Fax	+27 11 442 2454	+27 21 506 7375	+27 12 301 3300	+27 86 538 6836
Website	www.sarao.ac.za	www.sarao.ac.za	www.hartrao.ac.za	www.sarao.ac.za

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ABBREVIATIONS

AC	Alternating Current
AFE	Analogue Front End
CAD	Computer-Aided Design
CoC	Certificate of Conformance
COTS	Commercial Off-The-Shelf
CPU	Central Processing Unit
DC	Direct Current
FAT	Factory Acceptance Test
MMS	Mobile Monitoring System
PDU	Power Distribution Unit
SARAO	South African Radio Astronomy Observatory
RAM	Random Access Memory
RF	Radio Frequency
RFI	Radio Frequency Interference
RTA	Real-Time Analyser
SAT	Site Acceptance Test
SKA	Square Kilometre Array
SSD	Solid-State Drive
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal

TERMINOLOGY

Validation	A process of confirming that requirements for a system are correct and complete before being allocated to a lower-level item. Acceptable means of validation are one or more of the following: ● Test (including demonstration and inspection) ● Analysis (including reviews) ● Similarity (to proven design)
Verification	A process of confirming that the designed or manufactured item meets a specific requirement. Acceptable means of showing compliance to a requirement is one or more of the following: ● Test (including demonstration and inspection) ● Analysis (including reviews) ● Similarity (to proven design)
Qualification	A process of gathering configured[1] justification evidence that a design meets a specified requirement.
Acceptance	A process of gathering configured justification evidence that each production item performs specified functional requirements. (The acceptance test is a derived subset of the qualification test).
Item	A system, segment, subsystem, assembly or component.
Should	A statement implying a recommendation.
Shall	A statement implying a compulsory requirement.

[1] In this context, configured means: aligned with the Qualification baseline.

1 INTRODUCTION

This document describes the Requirements for a mobile platform in the form of a trailer to conduct Radio Frequency Interference (RFI) measurements on and around the South African Radio Astronomy Reserve (SARAO) in the Karoo, Northern Cape.

In this document, the terms “mobile platform”, “trailer” and “RFI monitoring trailer” are used interchangeably.

1.1 INTENDED USE OF THIS DOCUMENT

This requirements specification document:

[1] Defines performance, interface, environmental, physical, services, safety, logistic support, regulatory (legal), special design, construction, and commissioning requirements which are input to the engineering and development of the item.

[2] Describes the methods that will be used to verify that these requirements have been met when the item is submitted for acceptance.

1.2 APPLICABLE AND REFERENCED DOCUMENTS

1.2.1 Applicable Documents

The following documents apply to the extent stated herein. In the event of a conflict between the contents of the applicable documents and this document, the applicable documents shall take precedence.

[1] **RFI Monitoring Trailer Block diagram**
A. Kotze, SSA-008N-06-102, Rev. 2, 1 March 2023.

1.2.2 Referenced Documents

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

[2] **MIL-STD-285**
Attenuation Measurements for Enclosures - Electronic Shielding - For Electronic Test Purposes

[3] **IEEE-STD-299-1997**
IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures

2 BACKGROUND

There is an increasing need for RFI monitoring within and near the South African Radio Astronomy Observatory (SARAO) in the Karoo, Northern Cape. The site already hosts the MeerKAT telescope and other guest instruments, and will soon host the Square Kilometre Array (SKA) radio telescope. The combined presence of active astronomy instrumentation and construction presents an RFI risk. Due to an increase in activity, a dedicated mobile platform is required to conduct RFI measurements on and around the site.

The SARAO RFI team currently uses the RFI monitoring vehicle shown in Figure 2.1, to conduct mobile RFI measurements at different locations in and around the site.

Figure 2.1: RFI monitoring vehicle

The vehicle forms part of the SARAO RFI team Mobile Monitoring Systems (MMS) and needs to be expanded to include two fully equipped RFI monitoring trailers.

The RFI monitoring trailers should be able to:

[1] Provide a mobile platform that allows the safe transport of measurement equipment used to perform sensitive RFI measurements.

[2] Provide a mobile platform capable of handling the rugged terrain and protects the installed equipment against the harsh weather conditions in the area.

A conceptual layout of the RFI monitoring trailer is shown in Figure 2.2.

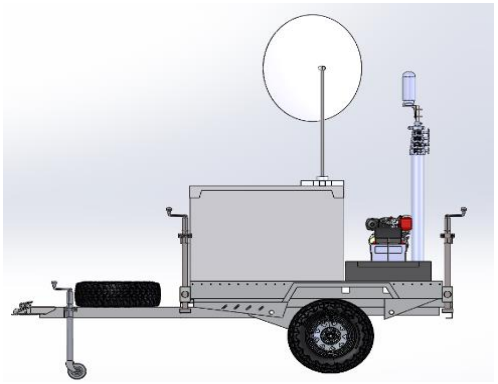

Figure 2.2: RFI monitoring trailer conceptual layout

3 CLIENT FURNISHED EQUIPMENT

SARAO will supply the equipment listed below.

3.1.1 Real-Time Analyser (RTA)

An RTA receiver per trailer will be required and will be supplied by SARAO.

The RTA has the specifications defined in the table below.

Table 3.1: RTA specifications

Model	RTA 3.6
Frequency range	70 MHz – 3 GHz
Power consumption	120 W
Operating temperature	0 – 40 °C
Rack height	3U
Dimensions (WxD)	42.80 cm x 45.00 cm
Weight	18.0 kg

Figure 3.1: Photo of the RTA

3.1.2 Analogue Front End (AFE)

An AFE per trailer will be required and will be supplied by SARAO.

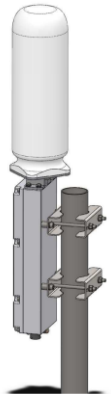

Figure 3.2: Drawing of the AFE and antenna

The AFE and an omni-directional antenna are shown in the drawing above.

The antenna will be specified by SARAO and shall be supplied by the Contractor. See 4.9.2 for the specification of the antenna.

3.1.3 Very Small Aperture Terminal (VSAT)

A VSAT per trailer will be required for internet connectivity at remote locations. The VSAT will be supplied by SARAO, including the internet service subscription.

The VSAT router and the antenna have the specifications defined in the table below.

Table 3.2: VSAT specifications

Manufacturer	Hughes
Router Model number	HT2000
Operating temperature	0 – 50 °C
Router dimensions (HxWxD)	18.39 cm x 6.71 cm x 14.81 cm
Router weight	0.50 kg
Antenna dimensions (⌀)	98 cm

3.1.4 Power Distribution Unit (PDU)

A switched rack PDU and a compatible temperature sensor will be required for each trailer to remotely power cycle and monitor the power consumption of the installed equipment. The PDU will be supplied by SARAO, including the temperature sensor.

The PDU and the temperature sensor have the specifications defined in the table below.

Table 3.3: PDU specifications

Manufacturer	Schneider Electric
PDU Model number	APC EPDU1016M
Temperature sensor Model number	APC EPDU-TH
Operating temperature	-5 – 45 °C
Rack height	1U
PDU dimensions (HxWxD)	4.44 cm x 48.2 cm x 4.40 cm
Weight	0.70 kg

3.1.5 Network Switch

SARAO will select a suitable network switch. A network switch per trailer will be required and will be supplied by SARAO.

4 RFI MONITORING TRAILER REQUIREMENTS

The system requirements in this specification document are the functional and performance baseline requirements for the RFI monitoring trailer/s.

4.1 SCOPE OF SUPPLY

[R1] The scope of supply for the two RFI monitoring trailers shall include all the components necessary to meet the specified requirements.

4.2 MOBILE PLATFORM

SARAO requires a fully equipped RFI monitoring trailer that is easily deployed to measure RFI around the SKA core site. A Toyota Hilux D4D or Toyota Hilux GD6 should be able to tow the trailer from site to site and must be able to travel on gravel roads and off-road without damaging any onboard equipment.

4.2.1 Platform

[R2] SARAO requires a mobile platform in the form of a trailer.

4.2.2 Weight

[R3] The trailer shall have a total weight that does not exceed 2500 kg.

4.2.3 Ground Clearance

[R4] The trailer shall have a vertical clearance from the lowest point on the chassis to the road of at least 400mm.

4.2.4 Travelling Speed

[R5] The trailer shall be able to be towed at speeds of at least:

[1] 100km/h on tar roads

[2] 80km/h on gravel roads

4.2.5 Tires

[R6] The correct size tires, including the spare tyre should be specified by the Contractor based on the design.

4.2.6 Stability

[R7] The trailer shall be able to be manually levelled on uneven terrain when deployed.

4.3 SHIELDING

The RFI monitoring trailer will be deployed close to radio telescopes and needs to adhere to strict RFI restrictions.

The SARAO-supplied receiver shall be shielded from the power equipment, such as power inverters and battery chargers on board the trailer platform.

4.3.1 Effective Shielding

[R8] The shielded enclosure/s, with door/s, terminated interfaces, and the specified equipment shall achieve effective shielding of no less than:

[1] 80 dB from 50 MHz – 3 GHz

[2] 60 dB from 3 – 18GHz

The effective shielding test method is based on [2] MIL-STD-285 and refined in [3] IEEE-STD-299-1997.

4.3.2 Receiver Isolation

[R9] The RTA shall be shielded separately from power electronics on the trailer platform. The power electronics shall be installed in a separate shielded enclosure.

4.4 REMOTE OPERATION

Power and fibre will be available at certain locations where the trailer is deployed, however, it must also be self-sufficient on remote sites where power and the SARAO network are not available. A means of connecting to the equipment remotely shall be provided.

Ambient temperature and power consumption of the RTA and Server shall be monitored and shall be available remotely. Being on a remote site, it shall be possible to power cycle individual equipment remotely.

4.4.1 Network Interface

[R10] On sites with existing infrastructure, a means of connecting the trailer to the on-site fibre shall be provided. A network switch per trailer will be required and will be supplied by SARAO.

4.4.2 Power Interface

[R11] On sites with existing infrastructure, a means of connecting the trailer to the on-site 220VAC supply shall be provided.

4.4.3 VSAT Throughput

[R12] On sites where existing infrastructure is not available, remote communication of the trailer must have a throughput of no less than 1 Mbps for both uplink and downlink.

4.4.4 Virtual Private Network (VPN)

[R13] Remote access to the trailer using VSAT internet will require a VPN. VPN access between the SARAO network and the server on board the trailer will be required and shall allow for communication between the SARAO network and the trailer. The SARAO network team shall assist in setting up the VPN connection.

4.4.5 Temperature Logging

[R14] The ambient temperature inside the shielded enclosure that houses the RTA must be logged once a second and stored locally on a server. A user shall be able to read this temperature value remotely.

4.4.6 Power Control

[R15] A user shall be able to remotely power cycle individual equipment inside the shielded enclosure that houses the RTA.

4.4.7 Power Consumption

[R16] A user shall be able to remotely monitor the power consumption of the installed equipment.

4.5 POWER

The trailer will be deployed at remote sites, the RTA and the additional equipment on board shall be able to run unmanned for at least 2 days before service is needed (i.e. refuelled or recharged).

4.5.1 Uninterrupted Power

[R17] The trailer power source shall be able to provide uninterrupted power for normal operation at remote locations.

4.5.2 Operating Time

[R18] The trailer shall be able to run unmanned for at least 2 days, using a diesel generator.

4.5.3 Gracefully Shutdown

[R19] The installed equipment shall gracefully shut down in case of power from both the inverter batteries and the generator is depleted.

4.5.4 Filtered Power

[R20] There shall be power-line filtered power inside each shielded enclosure.

4.5.5 Surge Protection

[R21] The installed equipment shall be surge protected.

4.5.6 Earth

[R22] The trailer chassis shall have an external attachment where the trailer can be earthed using an earth spike when deployed.

4.6 TEMPERATURE

The RFI monitoring trailer will operate in the Karoo where the temperatures range from 0 – 45°C.

4.6.1 Internal

[R23] The temperature of the RTA shall remain within the specified temperature range of 0 – 40°C. The specified temperature ranges of all the other equipment shall also be taken into account for normal operation.

4.6.2 Safely Shutdown

[R24] The installed equipment shall safely shut down in case temperature limits are exceeded.

4.6.3 Ambient

[R25] The trailer will operate in an environment where temperatures range from 0 – 45°C. Equipment shall be protected from the external ambient temperature and remain within its specified temperature range.

4.6.4 Storage

[R26] The trailer including all the installed equipment shall be able to handle a temperature range of -10 – 55°C when stored and not operating.

4.6.5 Colour

[R27] The enclosures that contain the installed equipment shall be painted white to deflect the heat from direct sunlight.

4.7 USABILITY

A maximum of 2 persons should be needed to deploy the trailer quickly and efficiently.

4.7.1 Required Personnel

[R28] It shall be possible to completely deploy the trailer with no more than two trained technicians in no more than 30 minutes.

4.7.2 Mast

[R29] The mast shall be easy to deploy and stowed safely during transport.

4.7.3 VSAT Antenna

[R30] The VSAT antenna shall be easy to deploy and stowed safely during transport.

4.7.4 Tools

[R31] All the tools required to deploy the RFI monitoring trailer shall be supplied and kept within the trailer.

4.8 EQUIPMENT

A suitable 19-inch equipment rack shall be available inside the shielded enclosure housing the RTA. Additional storage space shall be provided for the equipment such as tools, antenna, etc.

4.8.1 Rack Accommodation

[R32] A total of 10U rack space is required and 3U shall be reserved for the RTA.

4.8.2 Rack Depth

[R33] The 19-inch equipment rack shall have a depth of at least 560 mm to allow fitment of the RTA. Any other equipment that may require more depth shall be taken into account.

4.8.3 Shock Mount

[R34] The RTA shall be shock mounted in the 19-inch rack, to compensate for the difference between the vibration experienced by the rack and the vibration that the RTA can withstand. The rack shock profile shall be derived from MIL-STD-810-G

4.8.4 Storage Space

[R35] Additional storage space will be required, including but not limited to the antenna, RF cables, mast hand pump, etc. The storage space must protect the equipment during storage and transport.

4.9 CONTRACTOR-SUPPLIED EQUIPMENT

The equipment listed below shall be supplied by the Contractor.

4.9.1 Server

A ruggedised server is required that can process live data from the RTA and provide local data storage.

[R36] A server per trailer is required with the minimum specifications defined in the table below:

Table 4.1: Server specifications

CPU	Intel Core i7 9th gen or better
RAM	32 GB
Storage space	4 x 1TB SSD in RAID
Rack height	1U

4.9.2 Antenna

The RTA requires an externally mounted antenna suitable for RFI monitoring.

[R37] An antenna per trailer is required with the minimum specifications defined in the table below:

Table 4.2: Antenna specifications

Manufacturer	Alaris Antennas
Model	OMNI-A0190-04
Frequency range	20 MHz – 6 GHz
Gain	≥ 0 dBi

4.9.3 Mast and Hand pump

A mast is required to mount the antenna, including the hand pump to extend and retract the mast.

[R38] A pneumatic mast per trailer and a compatible hand pump are required with the minimum specifications defined in the table below:

Table 4.3: Mast specifications

Manufacturer	Clark Masts
Mast Height	≥ 6 m
Mast Headload	≥ 20 kg

4.10 INTERFACE

4.10.1 Interface Panel

[R39] An interface panel shall be installed onto each shielded enclosure housing the RTA and shall include all fasteners and gaskets to meet the requirement in [R8].

[R40] The interface panel shall have the following interfaces:

[1] 4x N-type female-female adapters (RTA and 3x spare)

[2] 1x F-type female-female (VSAT)

[3] 4x FC fibre adapters (RTA control pair and a spare pair)

[4] 1x SOURIAU-8D0-17F06PN251 (AFE power supplied by the RTA)

[R41] All interfaces shall be protected against galvanic corrosion.

[R42] The enclosure shall provide strain relief for cables installed on the interface panels.

4.11 PART IDENTIFICATION

4.11.1 Nameplate

[R43] Each RFI monitoring trailer shall have a nameplate with the following information:

[1] Manufacturer name

[2] SARAO logo

[3] SARAO part number and version (Supplied by SARAO)

[4] Serial number (Supplied by SARAO)

4.12 QUALIFICATION AND VERIFICATION

4.12.1 Design Review

[R44] Each major design iteration shall undergo a paper review against the items indicated in Table 5.1, before manufacturing.

4.12.2 EMC Qualification Testing

[R45] The first RFI monitoring trailer produced according to an approved design configuration shall undergo integrated EMC qualification testing against the items indicated in Table 5.1.

4.12.3 Factory Acceptance Test (FAT)

[R46] Each RFI monitoring trailer shall undergo factory acceptance testing against the items indicated in Table 5.1, before delivery.

[R47] As part of the FAT, each shielded enclosure shall undergo a shielding effectiveness test with parameters as determined in the Qualification Test, before delivery.

4.12.4 Site Acceptance Test (SAT)

[R48] Each RFI monitoring trailer shall undergo site acceptance testing against the items indicated in Table 5.1, at delivery.

4.13 DOCUMENTATION

4.13.1 Datapack

[R49] One datapack per major design iteration shall be supplied, consisting of:

[1] A system description, describing major components and their function

[2] Soft and hard copies of a populated 3D CAD model

[3] Manufacturing drawings, assembly drawings and build instructions for all designed components

[4] A parts list for Commercial off-the-shelf (COTS) parts stating vendor and part number

[5] A list of recommended spare parts and quantities

4.13.2 Maintenance Documentation

[R50] Maintenance documentation shall be supplied for each major design iteration that contains:

[1] Identification of user-maintainable items

[2] Inspection and maintenance task descriptions

[3] A list of consumables and equipment required to maintain these items

[4] Inspection and preventative maintenance intervals

4.13.3 Certificate of Conformance

[R51] Each RFI monitoring trailer shall be delivered with a CoC which contains:

[1] The serial number/s

[2] The date of approval

[3] A completed compliance matrix indicating compliance, partial compliance, or non-compliance to each requirement

[4] Shielding effectiveness test results for the enclosures

[5] A complete list of process control sheets, including visual inspection reports, tests, or other evidence of compliance to each stated requirement (i.e. build history).

[6] As-built documentation that clearly defines any deviations from the qualified design, as well as a record of the SARAO acceptance of such.

[7] A valid roadworthy and applicable road use registration documentation for each trailer.

5 VERIFICATION

5.1 METHODS OF VERIFICATION

5.1.1 Demonstration (D)

Verification shall be accomplished by operation, adjustment or reconfiguration of items performing their design functions under specific scenarios. The items may be instrumented and quantitative limits of performance monitored, but only check sheets rather than actual performance data are required to be recorded.

5.1.2 Test (T)

Verification shall be accomplished through systematic exercising of the application item under appropriate conditions, with or without instrumentation, and the collection, analysis, and evaluation of quantitative data.

5.1.3 Analysis (A)

Verification shall be accomplished by technical or mathematical evaluation, mathematical models or simulations, algorithms, charts, or circuit diagrams, and representative data.

5.1.4 Inspection (I)

Verification shall be accomplished by a visual examination of the item, reviewing descriptive documentation, and comparing the appropriate characteristics with predetermined standards to determine conformance to requirements without the use of laboratory equipment or procedures.

5.1.5 Similarity (S)

Verification is accomplished by referencing verification data from similar equipment.

5.2 COMPLIANCE AND VERIFICATION MATRIX

The supplier shall complete Table 5.1. *Comply/intend to comply/Non-compliance* shall be indicated in the relevant column and supporting documentation shall be provided. Please note that if no supporting documentation is provided, the paragraph will be marked as *Non-compliance*.

This matrix will form the basis for recording the outcome of all verification and qualification activities.

Table 5.1: Compliance and Verification Matrix

Req. No.	Description	Para-graph	Test Method				Compliance			Supporting Source Documentation (Traceability)	Priority	Comments
			Design Review	Qualification	FAT	SAT	Comply	Intend to comply	Non-compliance			
[R1]	Scope of Supply	4.1		I	I					Derived	Mandatory	
[R2]	Platform	4.2.1		I	I					Derived	Mandatory	
[R3]	Weight	4.2.2	A	I	I					Derived	Mandatory	
[R4]	Ground Clearance	4.2.3		I	I					Derived	Mandatory	
[R5]	Travelling Speed	4.2.4			D	D				Derived	Mandatory	
[R6]	Tires	4.2.5			I	I				Derived	Mandatory	
[R7]	Stability	4.2.6			D	D				Derived	Mandatory	
[R8]	Effective Shielding	4.3.1		T	T					Derived	Mandatory	
[R9]	Receiver Isolation	4.3.2		I	I					Derived	Mandatory	
[R10]	Network Interface	4.4.1		I	I					Derived	Mandatory	
[R11]	Power Interface	4.4.2		I	I					Derived	Mandatory	
[R12]	VSAT Throughput	4.4.3		I	I					Derived	Mandatory	
[R13]	VPN	4.4.4		D	D					Derived	Mandatory	
[R14]	Temperature Logging	4.4.5		D	D					Derived	Mandatory	
[R15]	Power Control	4.4.6		D	D					Derived	Mandatory	
[R16]	Power Consumption	4.4.7		D	D					Derived	Mandatory	
[R17]	Uninterrupted Power	4.5.1	A	D	D					Derived	Mandatory	

Req. No.	Description	Para-graph	Test Method				Compliance			Supporting Source Documentation (Traceability)	Priority	Comments
			Design Review	Qualification	FAT	SAT	Comply	Intend to comply	Non-compliance			
[R18]	Operating Time	4.5.2	A	D	D					Derived	Mandatory	
[R19]	Gracefully Shutdown	4.5.3		D	D					Derived	Mandatory	
[R20]	Filtered Power	4.5.4		I	I					Derived	Mandatory	
[R21]	Surge Protection	4.5.5		I	I					Derived	Mandatory	
[R22]	Earth	4.5.6		I	I					Derived	Mandatory	
[R23]	Internal Temperature	4.6.1		I	I					Derived	Mandatory	
[R24]	Safely Shutdown	4.6.2		D	D					Derived	Mandatory	
[R25]	Ambient Temperature	4.6.3		I	I					Derived	Mandatory	
[R26]	Storage Temperature	4.6.4		I	I					Derived	Mandatory	
[R27]	Colour (enclosures)	4.6.5		I	I					Derived	Mandatory	
[R28]	Required Personnel	4.7.1			D	D				Derived	Mandatory	
[R29]	Mast (deploy and stow)	4.7.2			D	D				Derived	Mandatory	
[R30]	VSAT Antenna (deploy and stow)	4.7.3			D	D				Derived	Mandatory	
[R31]	Tools	4.7.4			I	I				Derived	Mandatory	
[R32]	Rack Accommodation	4.8.1			I	I				Derived	Mandatory	
[R33]	Rack Depth	4.8.2			I	I				Derived	Mandatory	
[R34]	Shock Mount	4.8.3			I	I				Derived	Mandatory	
[R35]	Storage Space	4.8.4			I	I				Derived	Mandatory	

Req. No.	Description	Para-graph	Test Method				Compliance			Supporting Source Documentation (Traceability)	Priority	Comments
			Design Review	Qualification	FAT	SAT	Comply	Intend to comply	Non-compliance			
[R36]	Server	4.9.1			I	I				Derived	Mandatory	
[R37]	Antenna	4.9.2			I	I				Derived	Mandatory	
[R38]	Mast and Hand pump	4.9.3			I	I				Derived	Mandatory	
[R39]	Interface Panel	4.10.1			I	I				Derived	Mandatory	
[R40]	Interfaces	4.10.1			I	I				Derived	Mandatory	
[R41]	Protected against Corrosion	4.10.1			I	I				Derived	Mandatory	
[R42]	Strain Relief	4.10.1			I	I				Derived	Mandatory	
[R43]	Nameplate	4.11.1			I	I				Derived	Mandatory	
[R44]	Design Review	4.12.1	I							Derived	Mandatory	
[R45]	EMC Qualification Test	4.12.2		D						Derived	Mandatory	
[R46]	Factory Acceptance Test	4.12.3			D					Derived	Mandatory	
[R47]	Shielding Effectiveness Test	4.12.3		T	T					Derived	Mandatory	
[R48]	Site Acceptance Test	4.12.4				D				Derived	Mandatory	
[R49]	Datapack	4.13.1			I	I				Derived	Mandatory	
[R50]	Maintenance Documentation	4.13.2			I	I				Derived	Mandatory	
[R51]	Certificate of Conformance	4.13.3				I				Derived	Mandatory	

RFI Monitoring Trailer Requirements Specification Rev 2

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Document created by Ashley Kotze (akotze@ska.ac.za)
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