RECEIVER SYSTEM

FOR THE MOBILE RFI MONITORING SYSTEM

Document number M2925-0001-009
Revision 1
Classification ..... Commercial in Confidence
Prepared by ..... A. Kotze

Approval Date ..... December 2018

Organisation	:	NRF (National Research Foundation)
Facility	:	SARAO (South African Radio Astronomy Observatory)
Project	:	Mobile RFI Monitoring System
Document Type	:	Requirement Specification
Function/Discipline	:	N/A

DOCUMENT APPROVALS

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DOCUMENT HISTORY

Revision	Date Of Issue	Prepared By	Comments (e.g. ECN Number or changes to document)
A	April 2018	N/A	First Draft - issued for input
B	31 October 2018	N/A	Reviewed and added additional RF frontend information
C	27 November 2018	N/A	Updated the shielded enclosure Entry panel information
1	03 December 2018	N/A	Submit for RFQ

DOCUMENT DISTRIBUTION

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

DOCUMENT SOFTWARE

Package		Version	Filename
Word Processor	Ms Word	Word 2007	M2925-0001-009 - Rev 1 - Requirement Specification - Receiver System for the RFI mobile monitoring system.docx

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ABBREVIATIONS

SARAO	South African Radio Astronomy Observatory
RFI	Radio Frequency Interference
RMS	RFI Monitoring System
SE	Shielded Enclosure
CFE	Customer Furnished Equipment
SM	Single Mode
LNA	Low Noise Amplifier
AC	Alternating Current
DC	Direct Current
RF	Radio Frequency

1 INTRODUCTION

SARAO is currently busy with the modification of a Toyota Hilux D4D D/C 4x4 vehicle into a Mobile RFI Monitoring System (RMS) that must be able to conduct sensitive RFI measurements.

Due to an increase in activity at the SARAO South Africa Karoo Astronomy Reserve, a dedicated vehicle is required to conduct mobile RFI measurements on site and the surrounding areas. The Mobile RMS should be able to:

1. Provide a stable mobile platform to conduct sensitive RFI measurements on different types of rugged terrain in the Karoo and in various types of weather conditions.
2. Conduct both static point as well as mobile / drive-by measurements.

Figure 1: Vehicle used for Mobile RMS

2 EXISTING VEHICLE FEATURES

SARAO will provide the vehicle with the features described in Section 2.1.

2.1 VEHICLE

The 2012 Toyota Hilux 3.0 D-4D D/C 4x4 Raised Body Raider has the following specification / features:

1. Nudge bar and tow bar
2. Aluminium canopy with a roof rack and a telescopic access ladder
3. Fabricated 8 mm base plate for the load bay that all current equipment is mounted on
4. Nycoil cable management assembly that has and cable basket fitted to the canopy roof
5. Clark telescopic mast mounted to load bay base plate
6. Equipment rack mounted to load bay base plate
7. The equipment rack contains a Clark Model 40E compressor and a Yaesu G5500 rotator control unit
8. Yaesu G5500 rotator fitted to the top of the mast
9. Tait TM8115 Radio installed at the front passenger seat
10. Foldable tray for a laptop fitted at the front passenger
11. Back passenger seats removed and a storage bin fitted

Figure 2: Vehicle used for Mobile RMS

2.2 TELESCOPIC MAST

The telescopic mast mounts to the vehicle load bay base plate and protrudes through the roof of the canopy.

Table 1: Clark mast specifications

Manufacturer and Model	Clark PT16-6
Extended / Retracted Height	6.07 m / 1.73 m
Maximum Head load	30 Kg

2.3 MAST COMPRESSOR

The mast compressor mounts to the equipment rack in the vehicle load bay and extracts or retracts the 6 m telescopic mast.

Table 2: Mast compressor specifications

Manufacturer and Model	Clark Model 40E
Input Voltage	12 VDC
Current consumption	11 – 13 A
Dimensions (WxHxD)	131 x 265 x 232.5 mm
Weight	7 kg

Figure 3: Clark Model 40E compressor

2.4 ANTENNA ROTATOR AND CONTROLLER

The Rotator mounts to the top of the mast while the Controller mounts to the equipment rack in the load bay.

Table 3: Rotator and controller specifications

Manufacturer and Model		Yaesu G5500
Power consumption		120 VA
Power	Controller	220 - 240 VAC
	Rotator	24 VAC – Supplied by Controller
Dimensions (WxHxD)	Controller	200 x 130 x 193 (mm)
	Rotator	254 x 349.25 x 190.5 (mm)
Weight	Controller	3 kg
	Rotator	9 kg

Figure 4: Yaesu G5500 Rotator and Controller

2.5 CABLE MANAGEMENT ASSEMBLY

The Nycoil cable management basket mounts to the roof of the canopy and holds a tube, which in turn contains all the cables.

Table 4: Nycoil cable management specifications

Manufacturer	Nycoil
Tube diameter	1” Inner Diameter
Tube length	12 m

Below are specifications of the cables contained in the Nycoil tube:

Table 5: Coaxial cable specifications

Manufacturer and Model	Times Microwave LMR400
Connectors	N-type
Datasheet link	https://www.timesmicrowave.com/documents/resources/LMR-400.pdf
Length	± 15 meters
Quantity	1

Table 6: Fibre optic cable specifications

Manufacturer and Model	CBi electric - Field Deployable fibre cable
Datasheet number	FDC/03
Fibre type	SM 9/125 µm
Specification	ITU-T G. 652
Fibre connectors	SC
Fibre count	12
Length	± 15 meters
Quantity	1

Table 7: Rotator control / RF frontend power cables specifications

Manufacturer and Model	Jayflex J0205044
Datasheet link	http://www.jaycor.co.za/PDF/J0205044.pdf
Number of cores	8 cores per cable
	6 cores per cable – Rotator Control / Motor power
	2 cores per cable – DC power for RF frontend

Current handling (max)	3 A
Length	± 15 meters
Quantity	2

2.6 RADIO

The radio installed inside the vehicle cabin at the front passenger seat.

Table 8: Radio specifications

Manufacturer and Model	Tait TM8115
Input Voltage	12 VDC – Supplied by vehicle starter battery
Dimensions (WxHxD)	175 x 51 x 160 mm
Weight	1.5 kg

Figure 5: Tait TM 8115 Radio

3 CUSTOMER FURNISHED EQUIPMENT

SARAO will provide the customer furnished equipment (CFE) as in Sections 3.1 to 3.7.

3.1 RECEIVER

MESA Product Solutions RTA-3 receiver specifications

Table 9: RTA-3 Receiver specifications

Manufacturer and Model	MPS RTA-3 Receiver
Frequency range	70 MHz – 3 GHz
Power consumption	± 100 W
Input power	220 - 240 VAC
Form factor	2U
Dimensions (WHD)	428 x 87.38 (2U) x 450 mm
Weight	18 kg

Figure 6: RTA-3 Receiver

3.2 SERVER

Dell Server specifications:

Table 10: Server specifications

Manufacturer and Model	Dell PowerEdge R330
Power consumption	350 W
Input power	220 – 240 VAC
Temperature for Continuous operation	10°C – 35°C
Form factor	1U
Dimensions (WHD)	434 x 42.8 x 677.3 mm
Weight	13.8 kg

Figure 7: Dell PowerEdge R330

3.3 ROTATOR COMPUTER CONTROL INTERFACE

Yaesu Rotator computer control interface unit specifications:

Table 11: Computer control interface specifications

Manufacturer and Model	Yaesu GS-232A
Power consumption	12 VDC @ 110 mA
Input power	12 VDC
Dimensions (WHD)	110 x 21 x 138 mm
Weight	380 g

Figure 8: Yaesu GS232 Computer control interface unit

3.4 ETHERNET TO FIBRE CONVERTER

Oring Ethernet to Fibre converter specifications:

Table 12: Ethernet to Fibre converter specifications

Manufacturer and Model	Oring IMC-111FB-SS
Fibre mode	Single-mode
Fibre port	SC
Ethernet port	RJ45
Power consumption	2.2 W
Input power	12 – 48 VDC
Operating temperature	-40°C to 70°C
Dimensions (WHD)	26.1 x 95 x 70 mm
Weight	218 g

Figure 9: Fibre-Ethernet converter

3.5 RS232 TO FIBRE CONVERTER

Oring RS232 to Fibre converter specifications:

Table 13: RS232 to Fibre converter specifications

Manufacturer and Model	Oring ISC-1310FB-SC
Fibre mode	Single-mode
Fibre port	SC

Serial port	DB9 - Male and Terminal block
Power consumption	1.8 W
Operating temperature	-40°C to 70°C
Input power	12 – 48 VDC
Dimensions (WHD)	26.1 x 95 x 70 mm
Weight	192 g

Figure 10: RS232-Fibre converter

3.6 ETHERNET SWITCH

Oring switch specifications

Table 14: Ethernet switch specifications

Manufacturer and Model	Oring IES-1042FX-SS
Fibre mode	Single-mode
Fibre connector x 2 ports	SC
Ethernet port x 4 ports	RJ45
Power consumption	7 W
Input power	12 – 48 VDC
Operating temperature	-40°C to 70°C
Dimensions (WHD)	26.1 x 94.9 x 144.3 mm
Weight	382 g

Figure 11: 6-port Ethernet switch

3.7 RF FRONTEND

SARAO developed a RF frontend that must preferably mount directly onto the antenna at the top of the mast, in line with the receiver.

Table 15: RF frontend Supply Voltage and Power requirement

Power requirement	+32 VDC @ 300 mA
	+15 VDC @ 300 mA

The RF frontend has internal DC voltage regulators that supply the required voltages to the internal components.

The RF frontend connections listed in Table 16. Note that all the relevant cables to the front end will be required to rotate along with the antenna, since the frontend attaches to the latter.

Table 16: RF frontend connections

Connections	Interface
RF Input	N-type
RF Output	N-type
15V DC	Feed-Through Filter Connection
32V DC	Feed-Through Filter Connection
Optical Control x 2	SC

4 RECEIVER SYSTEM REQUIREMENTS

Procurement / Manufacturing and installation of the Receiver System to vehicle load bay shall include:

1. Procure / Manufacture a Shielded Enclosure for the vehicle load bay (Section 4.1).
2. Install the shielded enclosure. See Appendices for the proposed position.
3. Procure and install power filter/s for all the electrical interface/s.
4. Procure / Manufacture and install an entry interface panel that caters for the all RF and Fibre connections.
5. Procure and install the DC power supplies.
6. Distribute the AC power inside the SE.
7. Distribute the DC power inside the SE.
8. Install the Receiver, Server, Ethernet-Fibre converter, RS232-Fibre converter and Rotator computer control unit inside the shielded enclosure.

Appendix A shows a two-dimensional proposal for the load-bay layout and Appendix B shows a 3-dimesional representation of the former. Appendix C is a block diagram of the complete system, which serves as a recommendation for the integration strategy. Any changes made to these diagrams must be reviewed and approved by SARAO

4.1 RECEIVER SYSTEM SHIELDED ENCLOSURE

Procure / Manufacture and install a custom sized shielded enclosure to fit to the vehicle load bay, while accommodating the Power System SE. Generate a layout drawing of the load bay with the proposed shielded enclosure and upon approval by SARAO, manufacturing may commence.

1. The shielded enclosure (SE) manufactured out of aluminium to minimise weight.
2. Procure and install the appropriate power filter/s for all the electrical interface/s.
3. A hinged SE door is preferred, but if it is not practical, a removable door is another option.
4. Supply and fit a standard 19” equipment rack inside the SE for the RF equipment (10U preferred rack space).
5. The SE must have sufficient space for the following equipment:
    a. Receiver
    b. Server
    c. Rotator computer control unit
    d. Ethernet-Fibre converter
    e. RS232-Fibre converter
    f. Power and Data filters

6. Procure and install rails that will allow the SE to slide in and out of the vehicle load bay as illustrated in Appendix B.
7. Procure and install vibration support for the SE.
8. The SE must have sufficient ventilation. The air temperature inside the SE shall be less than 35°C, due to the Server Continuous operation specification shown in Table 10.
9. The SE must have sufficient protection against dust, because the Mobile RMS vehicle will mainly conduct measurements in and around the SARAO site in the Karoo, known to be dusty terrain.

4.2 SHIELDING EFFICIENCY

The Receiver System SE must provide the following effective shielding:

1. The SE must provide 80 dB of attenuation for frequencies from 70 MHz to 3 GHz.
2. The SE must provide 60 dB of attenuation for frequencies from 3 GHz to 18 GHz.

4.3 ENTRY PANEL

Procure / manufacture and install an entry panel with all the required interfaces for the load bay equipment SE.

1. The entry panel must have the following interfaces:
    a. N-type RF interface: 1 x Internally connected to the RTA-3 Receiver RF port
    b. N-type RF interface: 3 x Spare
    c. Fibre interface (1): 1 x 900 µm Fibre Waveguide interfaces*,
    Internally connected to the Ethernet-Fibre converter*
    d. Fibre interface (1): 1 x 900 µm Fibre Waveguide interfaces*,
    Internally connected to the RS232-Fibre converter*

** Alternatively, fibres (1) may pass via combined waveguides containing multiple cores or shielded connectors that satisfy the shielding-effectiveness requirements.

    e. Fibre interface (2): 2 x 900 µm Fibre Waveguide interfaces**,
    Internally connected to RTA-3 Receiver Fibre port
    f. Fibre interface (2): 2 x Spare 900 µm Fibre Waveguide interfaces**

** Alternatively, fibres (2) may pass via combined waveguides containing multiple cores or shielded connectors that satisfy the shielding-effectiveness requirements.

4.4 DC POWER DISTRIBUTION

Distribute DC electrical power inside the SE.

1. Distribute DC power to the following equipment inside the SE:
    a. Rotator computer control interface unit
    b. Ethernet to Fibre converter

c. RS232 to Fibre converter

4.5 AC POWER DISTRIBUTION

Distribute AC electrical power inside the SE.

1. Use a protective conduit while routing electrical wiring external to the SE.
2. Distribute AC electrical power to the following equipment inside the SE:
    a. Receiver
    b. Server
    c. 2 x Spare AC electrical sockets
3. The distribution circuit must include an AC monitoring protection circuit.

4.6 RECEIVER INSTALLATION

Installation of the receiver inside the SE shall include:

1. Install the Receiver in 19” equipment rack.
2. Connect and route all interface cable/s to the relevant port/s.

4.7 SERVER INSTALLATION

Installation of the server inside the SE shall include:

1. Install the Server in 19” equipment rack.
2. Connect and route all interface cable/s to the relevant port/s.

4.8 ROTATOR COMPUTER CONTROL UNIT INSTALLATION

Installation of the Rotator computer control unit inside the SE shall include:

1. Install the Rotator computer control unit in 19” equipment rack.
2. Route the interface cable/s to the relevant port/s.
3. The interface cables need to exit the SE via the appropriate data line filters

4.9 ETHERNET-FIBRE CONVERTER INSTALLATION

Installation of the Ethernet-Fibre media converter inside the SE shall include:

1. Install the media converter in 19” equipment rack.
2. Connect and route all interface cable/s to the relevant port/s.

4.10 RS232-FIBRE CONVERTER INSTALLATION

Installation of the RS232-Fibre media converter inside the SE shall include:

1. Install the media converter in 19” equipment rack.
2. Connect and route all interface cable/s to the relevant port/s.

5 VEHICLE CABIN REQUIREMENTS

Procurement / Manufacturing and installation of the equipment vehicle cabin shall include:

1. Procure / Manufacture a shielded enclosure (SE) for the vehicle cabin
2. Populate the SE and install in the vehicle cabin below the front passenger seat.
3. Procure and install a power switch for the vehicle cabin equipment.
4. Demonstrate the operation of the complete System that includes both the vehicle load bay and cabin equipment.

5.1 VEHICLE CABIN SHIELDED ENCLOSURE

Procure and install a custom sized shielded enclosure for the vehicle cabin below the front passenger seat.

1. The SE manufactured out of aluminium to minimise weight.
2. The SE must have a removable lid.
3. Procure and install an appropriate power filter for the electrical interface.
4. The SE must have sufficient space for the Ethernet switch, Power filters and internal cabling.
5. Secure the Ethernet switch and all cabling inside the SE.
6. The SE must have sufficient ventilation. The air temperature inside the SE shall be less than the maximum operating temperature specification of the Ethernet switch shown in Table 14.
7. The SE must have sufficient protection against dust, because the Mobile RMS vehicle will mainly conduct measurements in and around the SARAO site in the Karoo, known to be dusty terrain.

5.2 SHIELDING EFFICIENCY

The Vehicle cabin SE must provide the following effective shielding:

1. The SE must provide 50 dB of attenuation for frequencies from 70 MHz to 3 GHz.
2. The SE must provide 40 dB of attenuation for frequencies from 3 GHz to 18 GHz.

5.3 ENTRY PANEL

Procure / manufacture and install an entry panel with all the required interfaces for the vehicle cabin SE.

1. The following interfaces are required:
    a. SC Fibre interfaces: 2 x 900 µm Fibre Waveguide interfaces*,
    Internally connected to the 2 x fibre ports of the Ethernet switch

** Alternatively, the fibres may pass via combined waveguides containing multiple cores or shielded connectors that satisfy the shielding-effectiveness requirements.

    b. Ethernet interface: 1 x Ethernet feed-through
    Internally connected to the Ethernet switch

c. DC Power filters: 2 x DC power filters

12VDC for the Ethernet switch

5.4 ETHERNET SWITCH INSTALLATION

Installation of the Ethernet switch inside the vehicle cabin SE shall include:

1. The vehicle starter battery may supply DC power to the media converter.
2. DC power routed from starter battery to the Radio Equipment is already available at the front passenger seat.
3. Route the interface cables to the relevant ports.

5.5 POWER SWITCH FOR VEHICLE CABIN EQUIPMENT

Procure and install a power switch for the vehicle cabin equipment.

1. The switch must turn off the DC power to the SE as well as the Radio Equipment while doing sensitive measurements.
2. The switch must be easily accessible by the user from the front passenger seat.

5.6 DEMONSTRATE THE COMPLETE SYSTEM

Demonstrate the operation of the complete Receiver System that includes the all the equipment installed in the vehicle load bay as well as the vehicle cabin.

6 VERIFICATION

6.1 VERIFICATION DEFINITIONS

Table 17: Verification definitions

A	Analysis	An element of verification that uses established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures to provide evidence that stated requirements are met
D	Demonstration	An element of verification that involves the actual operation of an item to provide evidence that the required functions were accomplished under specific scenarios - The items may be instrumented and performance monitored
I	Inspection	An element of verification that is generally non-destructive and typically includes the use of sight, hearing, smell, touch, and taste; simple physical manipulation; and mechanical and electrical gauging and measurement
T	Test	An element of verification in which scientific principles and procedures are applied to determine the properties or functional capabilities of items

6.2 VERIFICATION CROSS REFERENCE

The traceability between the requirement in sections 4 to 5 and the verification methods specified in section 6.1 listed in Table 18.

Table 18: Verification Cross Reference

Requirement Number & Name	Verified by:
4.1 Receiver System Shielded Enclosure	Inspection
4.2 Shielding Efficiency	Test
4.3 Entry Panel	Inspection
4.4 DC Power distribution	Inspection
4.5 AC Power distribution	Inspection
4.6 Receiver installation	Inspection
4.7 Server installation	Inspection
4.8 Rotator computer control unit	Inspection
4.9 Ethernet-Fibre converter installation	Inspection
4.10 RS232-Fibre converter installation	Inspection
5.1 Vehicle cabin shielded enclosure	Inspection
5.2 Shielding Efficiency	Test
5.2 Entry panel	Inspection
5.4 Ethernet switch	Inspection
5.5 Power switch for vehicle cabin equipment	Demonstration
5.6 Demonstrate the complete System	Demonstration

7 APPENDICES

7.1 APPENDIX A

Proposed 2-dimensional layout for the Mobile RMS vehicle load bay

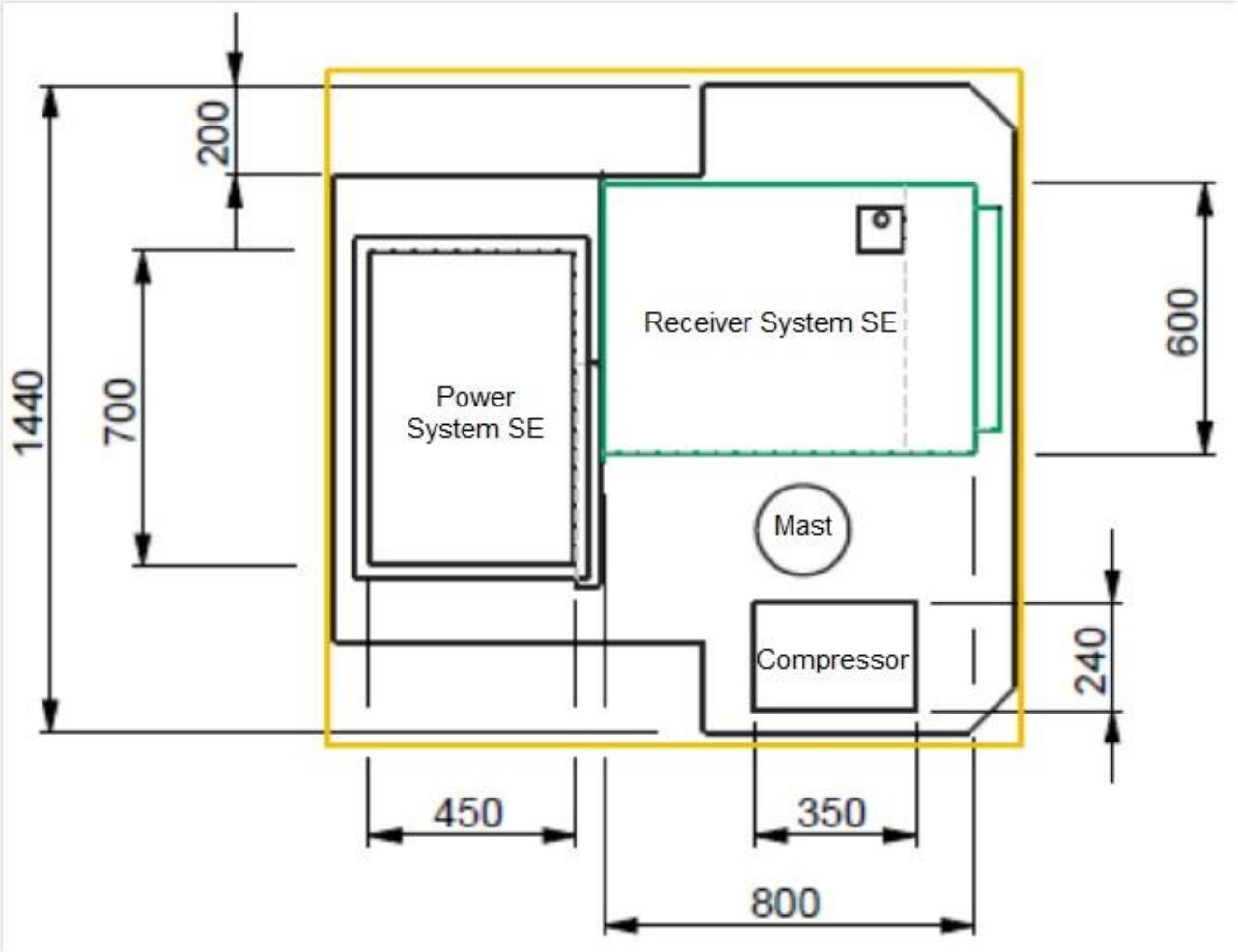

Figure 12: Proposed 2D layout

7.2 APPENDIX B

Proposed 3-dimensional layout for the Mobile RMS vehicle load bay, with the Receiver SE rail system extended to allow access to power-system SE.

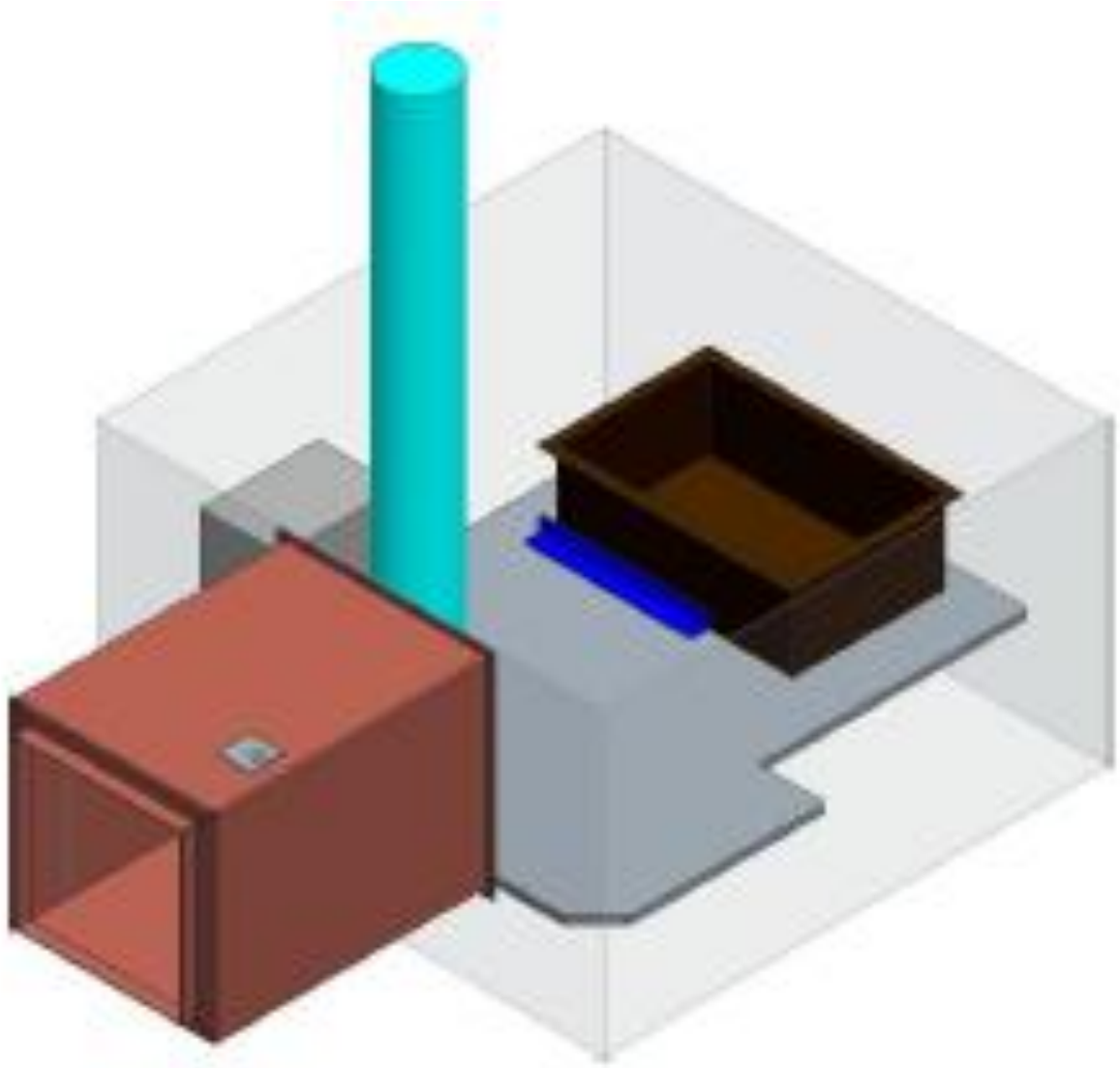

Figure 13: Proposed 3D layout

7.3 APPENDIX C

Mobile RFI Monitoring System Block diagram

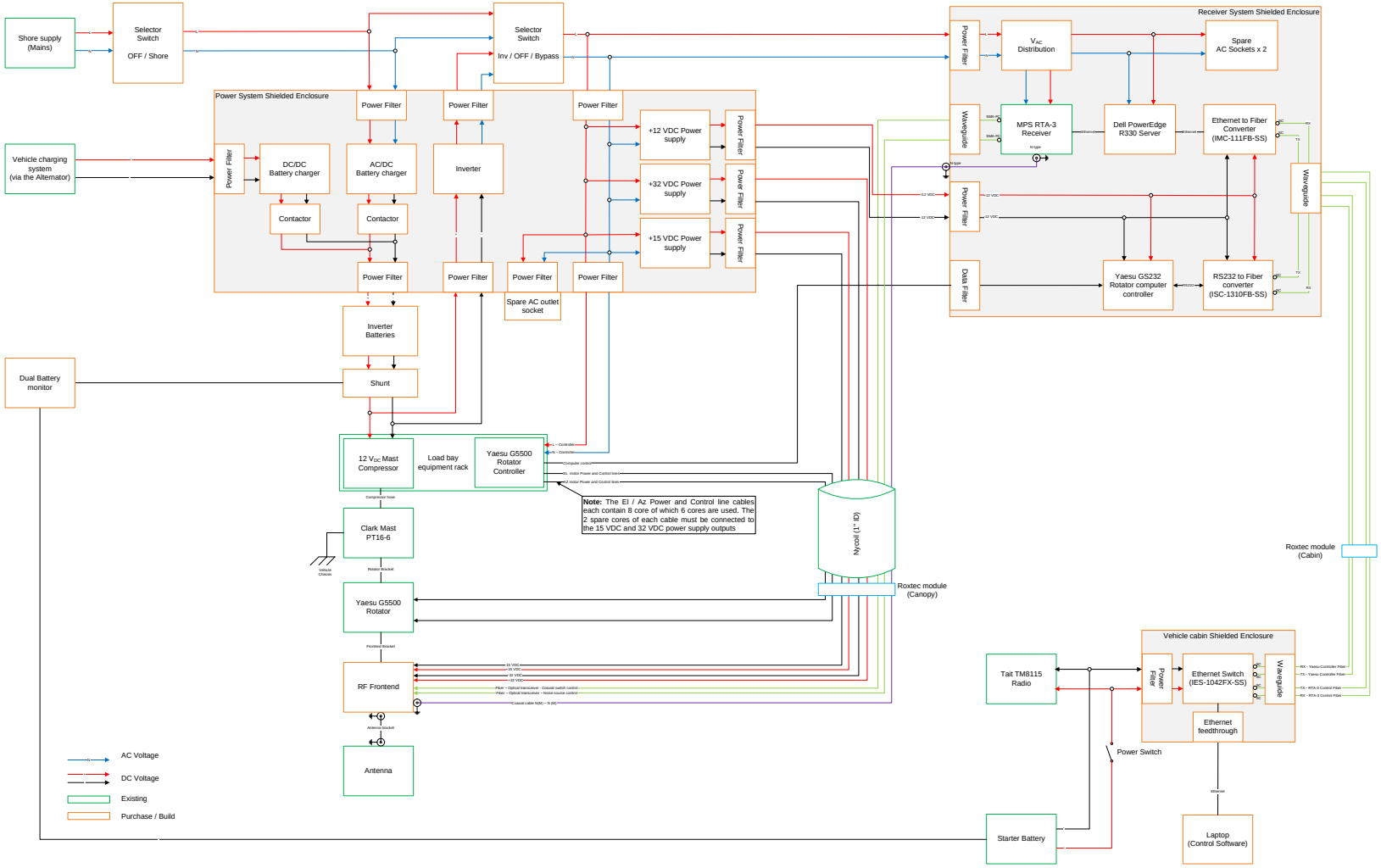

Figure 14: Block diagram of Mobile RMS

Specification - RFI Bakkie, Receiver system

Adobe Sign Document History 12/10/2018

Created:	12/10/2018
By:	Carel van der Merwe (carel@ska.ac.za)
Status:	Signed
Transaction ID:	CBJCHBCAABAAvhlS7B7BUJiS__5kIw6EZjCmFZ-W_daS

"Specification - RFI Bakkie, Receiver system" History

Document created by Carel van der Merwe (carel@ska.ac.za)
12/10/2018 - 4:48:36 AM PST- IP address: 105.186.92.225

Document emailed to Ashley Kotze (akotze@ska.ac.za) for signature
12/10/2018 - 4:50:37 AM PST

Document viewed by Ashley Kotze (akotze@ska.ac.za)
12/10/2018 - 5:07:39 AM PST- IP address: 66.249.93.211

Document e-signed by Ashley Kotze (akotze@ska.ac.za)
Signature Date: 12/10/2018 - 5:08:35 AM PST - Time Source: server- IP address: 196.24.39.242

Document emailed to Antheun Botha (antheun@ska.ac.za) for signature
12/10/2018 - 5:08:35 AM PST

Document viewed by Antheun Botha (antheun@ska.ac.za)
12/10/2018 - 7:23:27 AM PST- IP address: 66.249.93.206

Document e-signed by Antheun Botha (antheun@ska.ac.za)
Signature Date: 12/10/2018 - 7:24:10 AM PST - Time Source: server- IP address: 105.246.64.251

Document emailed to Braam Otto (botto@ska.ac.za) for signature
12/10/2018 - 7:24:11 AM PST

Document viewed by Braam Otto (botto@ska.ac.za)
12/10/2018 - 7:24:31 AM PST- IP address: 66.249.93.210

Document e-signed by Braam Otto (botto@ska.ac.za)
Signature Date: 12/10/2018 - 7:25:11 AM PST - Time Source: server- IP address: 196.192.165.14

Document emailed to Carel van der Merwe (carel@ska.ac.za) for signature
12/10/2018 - 7:25:12 AM PST

Document viewed by Carel van der Merwe (carel@ska.ac.za)

12/10/2018 - 9:02:14 PM PST- IP address: 66.249.93.206

Document e-signed by Carel van der Merwe (carel@ska.ac.za)

Signature Date: 12/10/2018 - 9:02:33 PM PST - Time Source: server- IP address: 105.186.92.225

Signed document emailed to Antheun Botha (antheun@ska.ac.za), Braam Otto (botto@ska.ac.za), Ashley Kotze (akotze@ska.ac.za), and Carel van der Merwe (carel@ska.ac.za)

12/10/2018 - 9:02:33 PM PST