AA-MID SYSTEM REQUIREMENTS SPECIFICATION

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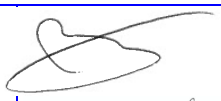
A. W. Gunst	AA domain specialist	SPDO	2011-11-15	
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LIST OF ABBREVIATIONS

AA-Mid ..... Aperture Array for mid-frequencies
AC ..... Alternating Current
ADC ..... Analogue to Digital Converter
ADD ..... Architectural Design Document
CI ..... Configuration Item
CMS ..... Configuration Management System
COAR ..... Consolidated Observation Action Register
CoDR ..... Concept Design Review
dB ..... Decibel
deg ..... degree
DRM ..... Design Reference Mission
DC ..... Direct Current
EM ..... Electro Magnetic
EMC ..... Electromagnetic Compatibility
EMI ..... Electromagnetic Interference
FAT ..... Factory Acceptance Test
FCA ..... Functional Configuration Audit
FMECA ..... Failure Modes, Effects and Critically Analysis
FOV ..... Field of View in squared degrees
GHz ..... Giga Hertz
Hz ..... Hertz
HFE ..... Human Factors Engineering
HPBW ..... Half Power Beam Width
HPC ..... High Performance Computing
IEC ..... International Electrotechnical Commission
IEEE ..... Institute of Electrical and Electronics Engineers
ITU ..... International Telecommunications Union
ICD ..... Interface Control Document
INCOSE ..... International Council on Systems Engineering
ISO ..... International Standards Organisation
Jy ..... Jansky
K ..... Kelvin
Kg ..... kilogram
km ..... kilometre
LEMP ..... Logistic Engineering Management Plan
LO ..... Local Oscillator
LOFAR ..... Low Frequency Array
m ..... metre
M&C ..... Monitoring and Control
MHz ..... Mega Hertz
MIL-STD .... Military Standard
MTBF ..... Mean Time Between Failures
MTTR ..... Mean Time To Repair
OAR ..... Observation Action Register
OEM ..... Original Equipment Manufacturer
OICD ..... Operator Interface Control Document
PAF ..... Phased Array Feed
PCA ..... Physical Configuration Audit
PDR ..... Preliminary Design Review
PEMP ..... Power Engineering Management Plan
PITF ..... Power Investigation Task Force
PPR ..... Pre-production Review
PrepSKA .... Preparatory phase for the SKA
RAM ..... Reliability, Availability and Maintainability
RAS ..... Radio Astronomy Service
RFI ..... Radio Frequency Interference
RMS ..... Root Mean Square
RQZ ..... Radio Quiet Zones
SAT ..... Site Acceptance Test
SEMP ..... System Engineering Management Plan
SI ..... Système International d'unités
SKA ..... Square Kilometre Array
SKADS ..... SKA Design Studies
SPDO ..... SKA Program Development Office
SRR ..... (Sub)System Requirements Review
SRS ..... System Requirements Specification
SS ..... Survey Speed
SSEC ..... SKA Science and Engineering Committee
STaN ..... Signal Transport and Networks
TBC ..... To Be Confirmed
TBD ..... To Be Determined
TBV ..... To Be Verified
TRR ..... Test Readiness Review
V ..... Volt
WBS ..... Work Breakdown Structure
WP ..... PrepSKA Work package

1 Introduction

This document covers the System requirements for the mid frequency Aperture Array for the SKA Phase 2, SKA_2. It is part of the systems engineering document set for the delta concept design review for SKA AA-mid.

The requirement sources are from the SKA_2 DRM [5] and the technical evaluations taking place.

Notes:

1. Comments are in *red italics*
2. TBDs etc are just in red
3. I have created the need for a "Technical Requirements" document that derives details of the system requirements for AAs given the parameters from the science and other requirements docs....
4. There needs to an Operations document to reference.
5. Some of the requirements will need to be fed back up to the System SRS
6. There is very little use of standards in the requirements – this needs to be fixed
7. Really this should be operating under ISO9001 quality standards
8. The references are now using Word's structure for them.

2 References

[1] Cloete, K., et. al., SKA System Requirements Specification, Rev. E, WP2-005.030.000-SRS-001, 2010-02-12.

[2] Stevenson, T. et. al., *SKA Phase 1 System Requirements Specification*, Rev. A, WP2-005.030.000-SRS-002, 2011-02-14.

[3] SKA Science Working Group, "*The Square Kilometre Array Design Reference Mission: SKA Phase 1*", report, v.1.3, January 2011.

[4] Dewdney, P.E. et. al., *SKA1: High Level System Description*, Rev. A., WP2-005.030.010-TD-002, 2011-02-14.

[5] SKA Science Working Group, "*The Square Kilometre Array Design reference Mission: SKA-mid and SKA-lo*", report, v.1.0.

3 Functional and performance requirements

These requirements cover AA-mid for SKA Phase 2. These requirements are specific to AA-mid and flow down from the science cases in the SKA DRM 1.0 [5].

3.1 Functional overview

The top level context diagram for the AA-mid Reception is shown in

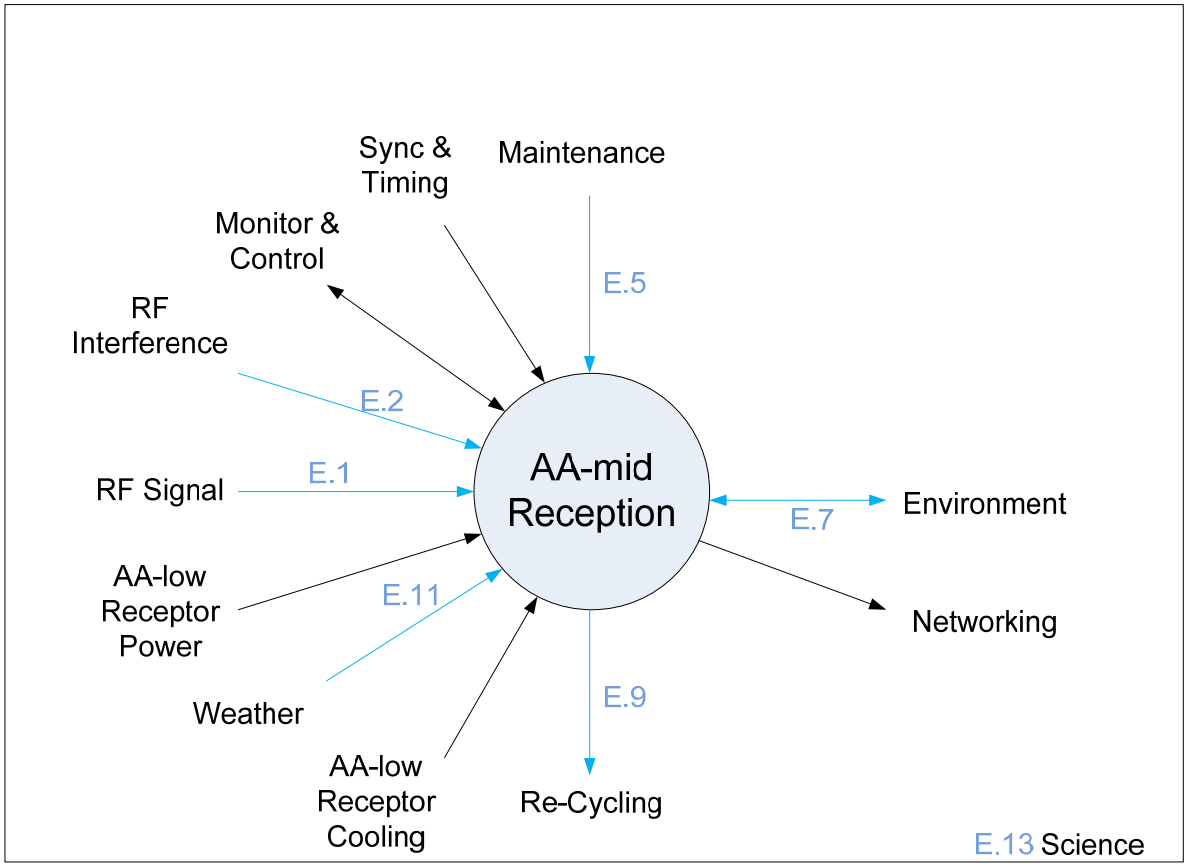

Figure 1, these are the same for all AAs in the SKA. This is part of the second level of the SKA context diagram as presented in [2]. From this figure it is clear that the AA-mid requirements are directly influenced by the following external aspects (blue arrows):

- RF Signal: the signal of interest received by the AA
- RF Interference: any human made disturbing signal which is also received by the AA and for which the system should be made robust
- Maintenance: the design of the AA reception system should take into account the affect it has on maintenance since the total amount of electronics in the field will be significant. Hence maintenance should be minimized and any extra investment to achieve that must be balanced against the reduction in maintenance cost.
- Environment: the environment of the AA poses extra requirements on primarily the mechanical design of the antenna element and receiver systems, installation of cables and bunkers necessary for the AA system. Examples of environmental influences are dust,

temperature (and its variation), humidity and soil composition. The soil composition has mechanical implications and a strong influence on the electrical grounding of the antennas.

- Re-cycling: since the SKA has a limited lifetime the usage of materials which can be re-cycled may be of relevance.
- Weather: the AA reception systems should be designed to withstand rain, lightning, earthquakes, hail, snow etc. dependent on the weather profile of the site.

In

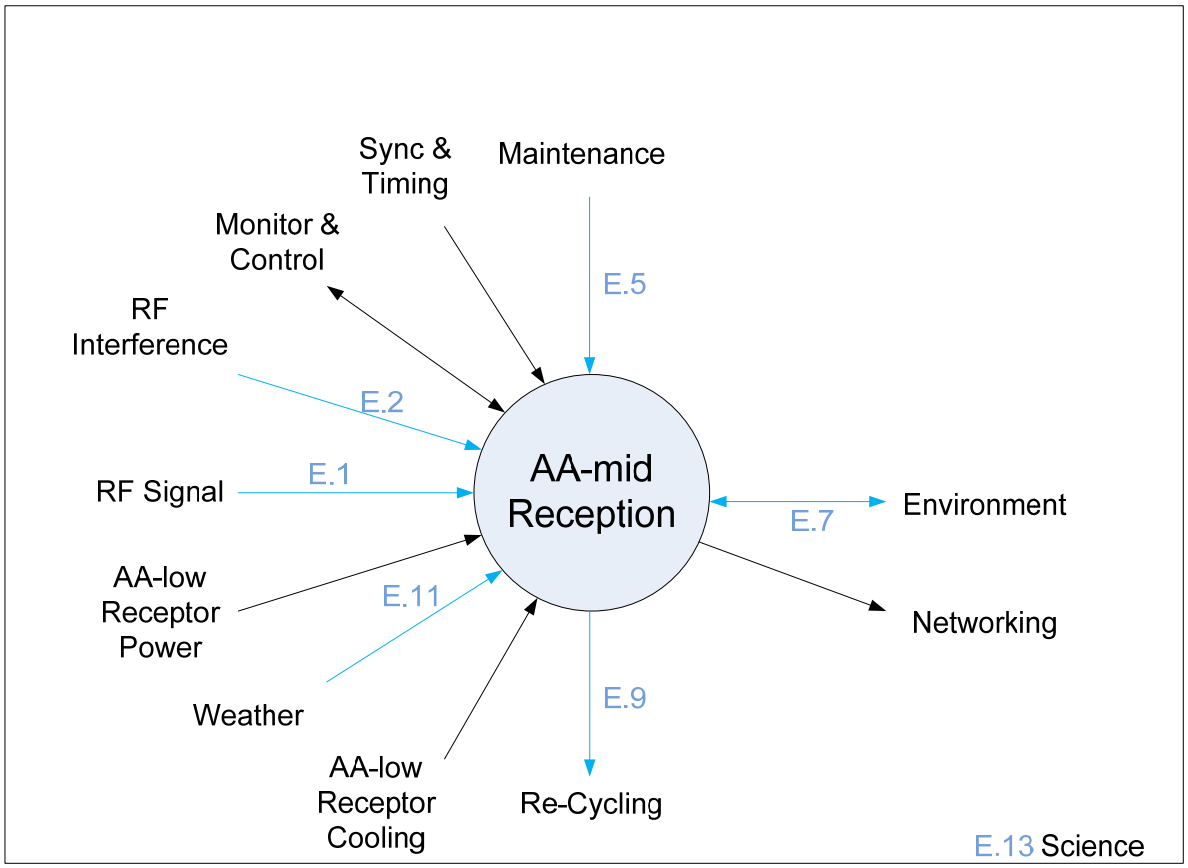

Figure 1 the internal SKA interfaces are shown in black. These interfaces are required for AA reception to work properly. The following internal interfaces are defined:

- Networking: via this interface the data from the AA reception system is transported to the central systems to be further processed.
- Monitor & Control: via this interface monitor information like status reports from all the subsystems in the AA reception system are communicated in one direction, while the control of the AA reception system is done in the other direction. Control of the AA reception system is necessary since there are many settings: beam steering, selecting the frequency bands, etc.
- Sync & Timing: via this interface the synchronization, timing and eventually LO signals are retrieved from a central system. For radio astronomical systems one of the most important aspects is to synchronize all AA reception systems with each other since the phase relation

between the AA stations is a primary parameter which should be retrieved. Typical signals required by the AA reception system are: clock signal to sample the analogue signal and a synchronisation signal e.g. a pulse per second signal to align all AA reception systems.

- AA Receptor Cooling: cooling is necessary primarily because the amount of signal processing required in the AA reception systems is significant and the environmental conditions are likely to be hot.
- AA Receptor Power: This interface is defined to power all the electronics in the AA Reception system.

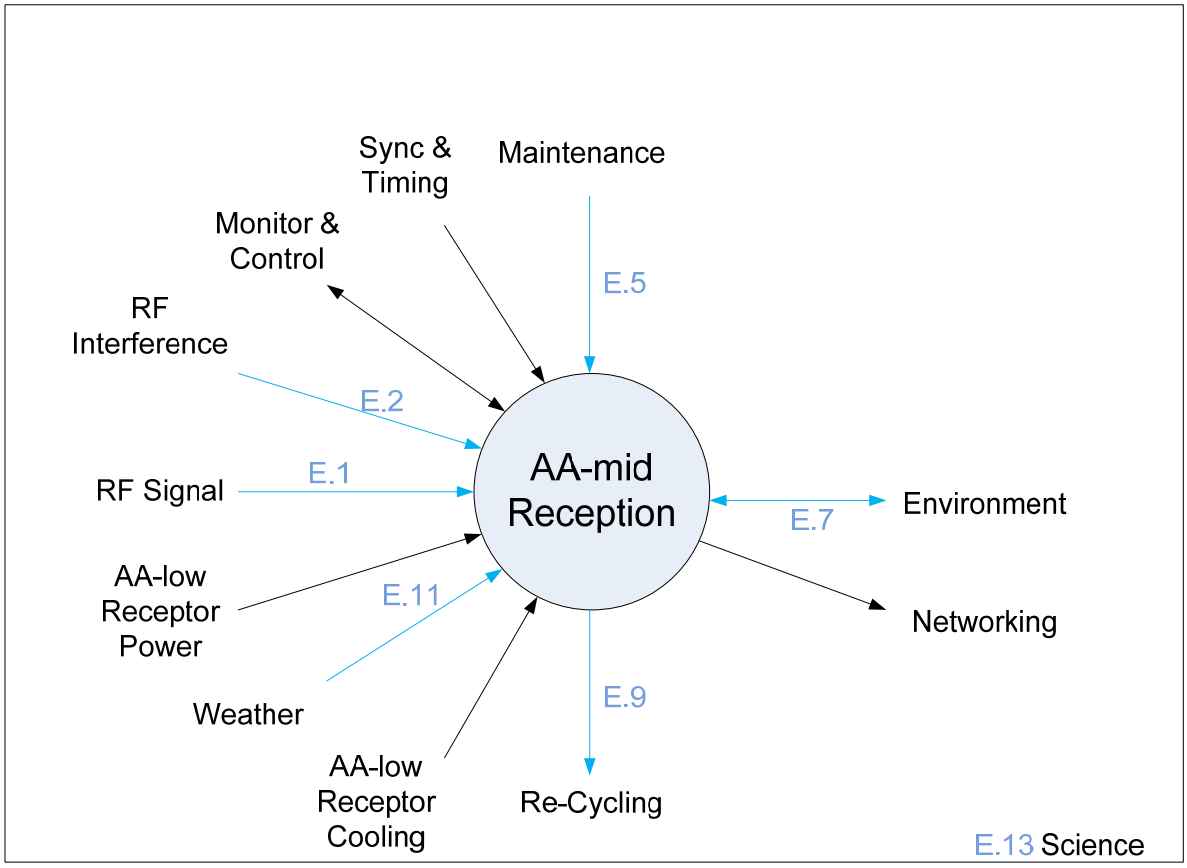

Figure 1 Context diagram of the AA Reception system (level 2)

Considering in more detail the AA-mid Reception context diagram of

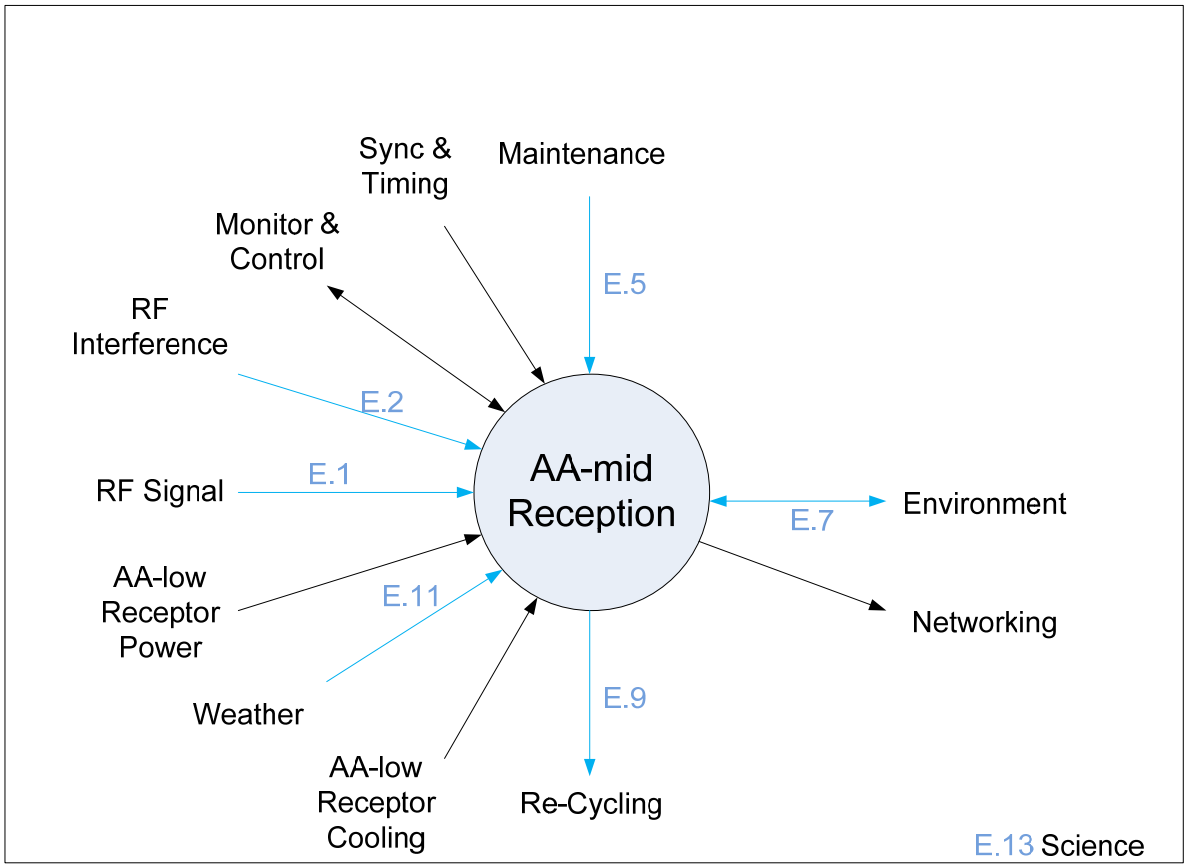

Figure 1 results in the third level context diagram presented in Figure 2.

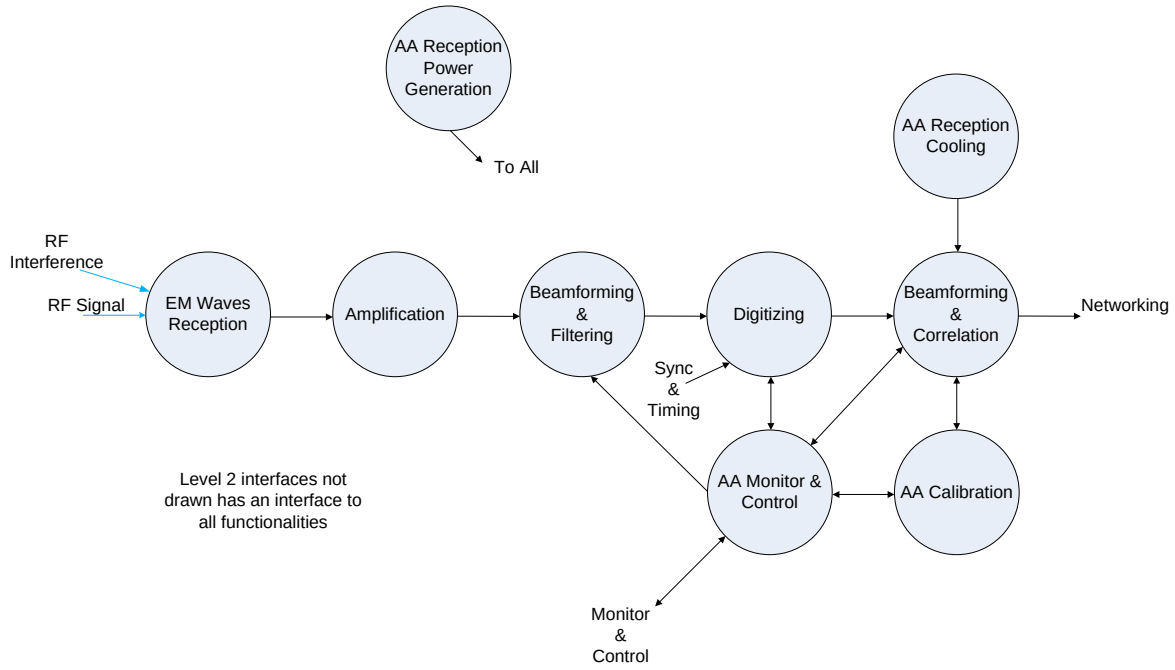

Figure 2 Context diagram of the AA Reception system at level 3

As shown in Figure 2 the primary functions of the SKA_1 AA-mid reception system are:

1) **EM waves reception**: the electromagnetic radiation is converted into the electrical domain.

2) **Amplification**: this boosts the signal for digitisation and reduces the noise contribution of later stages.

3) **Beamforming & Filtering**: adds optionally multiple antenna elements with an analog beamformer and filters out the frequencies outside the AA-mid specification. In practice multiple amplifier and filtering stages will be implemented.

4) **Digitizing**: the analogue signal is sampled and quantized.

5) **Beamforming & Correlation**: in the beamforming phase the signals of multiple receptors are combined in order to make beams on the sky. A correlation function is required to calibrate all the individual receiver chains with each other to compensate for gain and phase variations between them as a function of time.

6) **AA Calibration**: calculates the gain and phase differences between receiver chains and uses the output of the correlation functionality as an input.

7) **AA Monitor & Control**: translates high level system control information to specific commands for the AA hardware and software. The monitor information from the software and hardware is transmitted to the SKA Monitor & Control system. This system also enables local control of the AA station for maintenance and troubleshooting activities.

8) **AA Reception Power Generation**: power is generated or retrieved from a central node.

9) **AA Reception Cooling**: maintains the temperature of all parts of the AA-mid station within specification limits.

3.2 AA-mid spectral characteristics

The spectrum to be observed with SKA_1 AA-mid is specified.

3.2.1 Operating Frequency

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1110	**Electromagnetic frequency range.** AA-mid shall be able to measure electromagnetic radiation in a frequency range from:	Essential		Test
	400 MHz to 1450 MHz		Lower boundary from Section 16.4.2 and 17.4 in [5]. The higher boundary is from Section 12.4.1 [5], 1450 MHz is taken since neutral hydrogen is at 1421 MHz.	

3.2.2 Instantaneous Bandwidth

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1120	**Instantaneous bandwidth.** AA-mid shall have a minimum instantaneous bandwidth of:	Essential		Test
	1000 MHz		[5] Section 1.4, fractional bandwidth ~ 1	

3.2.3 Spectral Flatness

Identification	Requirement	Applicability	Parent	Verification/ Comments
AAM_REQ_1130	**Spectral ripple.** The passband ripple over the band, after calibration:	Essential		Test
	Maximum +/- 1 % (TBD). *Note that this is not the analogue system, but after digitisation and processing. The only characteristics*		[2] SYS_REQ_1190	The parent is not very specific.

	the analogue chain requires is to deliver a signal within bounds to the ADC, stability and be capable of measurement for calibration.			

3.2.4 Spectral Passband Slope

Identification	Requirement	Applicability	Parent	Verification/ Comments
AAM_REQ_1135	**Spectral passband slope.** The passband slope over the band should be:	Essential		Test
	Maximum x dB (TBD). *Note that this is the analogue system, prior to digitisation. This can be calibrated out but decreases the Signal to Noise Ratio.*			

3.2.5 Spectral Resolution

The following requirements are for the AA-mid station only. This is when using frequency domain beamforming and is necessary to meet the size and spacing of the elements. The spectral filter must also transmit the data such that the correlator may further subdivide the data into much narrower bands required for correlation. The final required SKA spectral resolution should be made by the central systems.

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1140	**Spectral resolution.** The AA-mid station shall have a minimal spectral resolution over the full instantaneous bandwidth (TBV):	Essential		Test
	1MHz (TBD) [5] Table 12.2 requires resolution before correlation of 3 kHz			

3.2.6 Spectral Dynamic Range

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1150	**Spectral dynamic range.** SKA shall have a minimum spectral dynamic range at the output of the correlator of:	Essential		Test
	62 dB		[1] Paragraph 3.3.5, changed 1400 to	

			1450 MHz to enable surveys of neutral hydrogen at 1421 MHz.	

3.2.7 Clipping

The dynamic range of the element (or Tile) up to digitisation is partly set by the effective number of bits, ENOB, of the digitiser. This is a measure of the ability to cope with interference and large astronomical signals; it is *not* a measure of the dynamic range of the array itself or the images that get produced after processing.

It is not practical to expect to precisely digitise every possible interference signal, however, statistically the amount of observing time lost due to clipping can be determined.

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1160	**Clipping.**	Essential		Test
	The dynamic range of the ADC's shall be such that no clipping will occur for 95% (TBC) of the time.		[2] SYS_REQ_5430 The parent requirement needs some changes since it specifies no clipping	
AAM_REQ_1165	Clipping data should be marked in the data stream	Essential	[2] SYS_REQ_5430	

3.3 AA sensitivity, FOV and survey speed

3.3.1 Sensitivity

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1210	**Sensitivity (A_{eff}/T_{sys}).** The AA receptor system shall have a minimum sensitivity for scan angles of maximal 45 degrees (TBD) of:	Essential		Test
	10,000 m^2/K expressed in Stokes I. This is equivalent with the sensitivity which is required for one polarisation.		[5] Section 18, Table 18.2 (DRM Chapters 6, 7, 8, 15 and 17)	

3.3.2 Instantaneous Field of View

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1220	**Instantaneous field of view.** The SKA shall achieve a minimum total FOV (that can be synthesized from multiple beams) of:	Essential		Test
	100 square degrees			

The field of view is derived from the survey speed and sensitivity.

3.3.3 Survey Speed

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1230	**Survey speed.** AA-mid shall have a survey speed ($m^4\ K^{-2}\ deg^2$):	Essential		Test
	$10^{10}\ m^4K^{-2}deg^2$		[5] Section 12.4.2	

3.4 Spatial Characteristics

3.4.1 Baseline Requirements

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1310	**Baseline.** The maximum baseline is:	Essential		Test
	180 km (TBD)		[4]	

3.4.2 Sky Coverage

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1320	**Sky coverage.**	Desirable		Test
	$6000deg^2$ (TBD)			

3.4.3 Scan Angle

This requirement is derived from the sky coverage.

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1330	**Scan angle.** The scan angle is defined from zenith. The maximum scan angle for SKA shall be at least:			Test
	45 degrees (TBD)	Desirable		

3.4.4 Core filling factor

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1340	**Core filling factor.** The filling factor of the core should be at least:	Essential		Analysis
	? %			

3.4.5 Station Side Lobes

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1350	**Station side lobes.** The integral of all station side lobes should be smaller than	Essential		Analysis
	? dB compared with the main lobe.			

3.5 Systematic Errors

3.5.1 Coherence Loss

Any coherence loss in the system introduced should be below the value specified below. An example of a coherence loss effect is the beam squint which is caused by a beamformer using phase shift. Since only one phase shift setting per sub-band or channel can be set an error arises at the edges of the sub-band or channel. The error causes coherence loss in the beamformer and should stay below the specified value.

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1410	**Coherence loss.**	Essential		Test

	The coherence loss of each subsystem in the SKA should be lower than:			
	1% (TBD)		Should be derived from the imaging requirement if possible.	

3.5.2 Positioning Error

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1420	**Position error.** The position error of the all antenna elements from the specified position should be smaller than:	Essential		Test
	TBD Note that this will depend on the array configuration used e.g. random may be very tolerant of errors – calibrate out.		LOFAR uses λ/40	

3.5.3 Orientation Error

The orientation of the elements is considered within one array. Array to array orientation is the subject of the System SRS (2). It is necessary to orientate the elements for consistency of polarisation, however, it may be easier to calibrate out detailed errors.

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1430	**Orientation error.** The orientation error of the antenna elements from the specified orientation should be smaller than:	Essential		Test
	TBD This will depend on the ability to calibrate individual elements		LOFAR uses 1 degree	

3.6 Temporal Characteristics

The stability of the analogue systems directly impacts the calibration requirements and their regularity. They need to be traded off together.

3.6.1 Gain Stability

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1510	**Gain stability.** The gain stability of each SKA receiver chain which is digitized should be smaller than:	Essential	Should be derived from a calibration requirement if possible.	Test
	Stability per ˚C: 0.5% (TBD)			
	over 24 hours: 0.5% (TBD) RMS at a constant temperature			

3.6.2 Phase Stability

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1520	**Phase stability.** The phase stability of each SKA receiver chain which is digitized should be smaller than:	Essential	Should be derived from a calibration requirement if possible.	Test
	Degree per ˚C: 0.5 deg (TBD)			
	over 24 hours: 0.5 deg (TBD) RMS at a constant temperature			

3.6.3 Beam Stability

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1530	**Beam stability.** The SKA shall have a maximal RMS stability in the HPBW of:	Essential	Should be derived from a calibration requirement if possible.	Test
	over 24 hours: TBD % RMS with a zenith pointing direction			
	TBD % RMS (TBD) with a zenith pointing direction if one receiver chain is failing in the full band for SKA			

3.6.4 Smoothness

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1530	**Smoothness.** Any variation in the SKA system shall be smoother than:	Essential	Should be derived from a calibration requirement if possible.	Test
	0.01% per second (TBD)			
	0.1%/Hz (TBD) over the instantaneous bandwidth This needs much more thought.....			

3.6.5 Tracking Accuracy

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1540	**Tracking accuracy.** The beam pointing accuracy should be such that:	Essential	(2) SYS_REQ_1980	Test
	A point source remains within TBD% of the HPBW of the beam. Presumably this requirement is due to the frequency dependant nature. Even so, it may well be that a figure in degrees for the AA-mid is better.			

3.6.6 Beam Switching Agility

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1550	**Beam switching agility.** The beam switching time includes the distribution of the command from the control centre. A beam should be re-pointed to a predefined position in:	Essential	TBD	Test
	TBD secs.			

3.6.7 Maximal Observation Period

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1560	**Maximal Observation Period.** The AA subsystem shall be designed so that a deep field observed. The requirement is maintain noise limited sensitivity.	Essential	(2) SYS_REQ_1430	Test
	Capable of 1000 hr integration time			

3.6.8 Temporal Resolution

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1560	**Temporal resolution.** The AA subsystem shall have an attainable time resolution of at least:	Essential		Test
	50 µs		[5] Paragraph 16.4.4	

3.7 Polarisation Characteristics

3.7.1 Beam Polarization Stability

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1610	**Beam polarization stability.** The polarisation properties of the beams shall be stable enough to enable their calibration to:	Essential	(2) SYS_REQ_1710	Test
	<0.5 % (TBD) This needs to be better specified in dB, which will be the scientific requirement. It needs to be derived into something that can be built and tested.			

3.7.2 Beam Polarization Purity

Identification	Requirement	Applicability	Parent	Verification

AAM_REQ_1640	**Beam polarization purity.** The isolation between both polarisations shall be at least:	Essential		Test
	40 dB (TBD)		See [5] Paragraph 17.4.5	

3.8 Imaging Characteristics

3.8.1 UV Coverage

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_1710	**UV coverage.** SKA shall have a:	Essential	UV coverage is not defined good at the moment	Analysis

3.8.2 Imaging Dynamic Range

STATION DYNAMIC RANGE This has to be translated into AA station requirements. The imaging is a system wide requirement dominated by the post processing – the tech requirements of the AA station is determined here.

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_1720	**Imaging dynamic range.** SKA 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:	Essential		Test
	74 dB		[5] Paragraph 6.4.5	

3.9 Monitoring and Control

Monitoring and Control is a central system responsible for acquiring and monitoring data and for control of the SKA systems. The requirements in this section reflect the consequent requirements for the AA reception subsystems.

3.9.1 M&C Monitoring Data

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2110	**M&C monitoring data.** AA subsystems shall provide monitoring data to the monitoring and control function (for performance monitoring and closed-loop control functions) This will need substantial expansion.	Essential	(2) SYS_REQ_2220	Demo

3.9.2 M&C Calibration Information

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2120	**M&C calibration information.** Individual AA subsystem calibration information shall be available to the measurement function. This will need substantial expansion.	Essential	(2) SYS_REQ_2250	Demo

3.9.3 Subsystem M&C Action

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2130	**Subsystem M&C action.** AAs shall report completion of actions to M&C	Essential	(2) SYS_REQ_2420	Demo

3.9.4 Autonomous Control

This is to provide maintenance and troubleshooting capabilities. All the functions available centrally will be available at a local station interface e.g. power up and down, parameter setting and reporting and other diagnostic tools.

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2140	**Autonomous Control.** The AA station shall be capable of coming under local control and not interacting with the overall SKA.		(2) SYS_REQ_3620	Demo

3.9.5 Calibration

The calibration of the AAs is important to their operation. The details of the scheme used needs to be defined: they could be calibrated using external sources; astronomically while not observing or during observations using a separate beam.

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_1620	**Calibration update rate.** External Calibration measurements shall be necessary at a rate of:	Essential	(2) SYS_REQ_1720 This depends on the required precision and the rate gain and phase are changing as a function of time.	Test
	<1 hour For AAs this would mean using artificial sources. Maybe this should be showing observation time lost from recalibration...			
AAM_REQ_1630	**Real-time calibration.** The AA reception system shall provide instrumental real-time calibration functions.	Essential	(2) SYS_REQ_2760	Demo

3.10 Observational modes

3.10.1 Beam Forming Mode

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2210	**Beam forming mode.** The AA reception system shall provide a beam forming mode	Essential	(2) SYS_REQ_2710 – SYS_REQ_2740	Demo

3.10.2 Aggregate Mode

The AA performance is defined by the data rate that is transmitted to the correlator. The concept of maximum bandwidth beams is useful for explaining the capability of the AAs. However, considerable scientific benefit is available by adjusting the number of beams as a function of frequency such that a large amount of sky can be observed over a narrow bandwidth or less sky over a wide bandwidth. The total data rate from the array is the limiting factor. Further, the data rate could be used differently by adjusting the number of bits per sample. This exchange of bandwidth and beams is called “Aggregate Mode”.

Identification	Requirement	Applicability	Parent	Verification

AAM_REQ_2220	**Aggregate mode.** SKA shall provide an aggregate mode in which bandwidth is exchanged for spatial coverage.	Essential	(2) SYS_REQ_2750	Demo
AAM_REQ_2225	**Selectable number of bits per sample.** The number of bits per sample used should be selectable within the constraints of a constant total output data rate. This needs a scientific reason for providing it e.g. pulsar observations	Desirable	TBD	Demo

3.11 Data Products

3.11.1 Total output data rate

The output data rate, station to correlator, defines the survey capabilities of the array. It also determines the requirements of the correlator and post processor. The aggregate data rate for all the AA-mid stations is constant for a given sensitivity and survey speed, however many stations are used.

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2305	**Data rate.** The aggregate data rate of all AA-mid stations should be:	Essential	TBD	Demo
	Total data rate: TBD This is a function of sensitivity and survey speed			

3.11.2 Beam Products

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2310	**Beam products.** AA-mid shall be capable of communicating the beam products as a voltage time series over the observed FoV.	Essential	(4) Paragraph 5.4.6	Demo

3.11.3 Data Product Types

Identification	Requirement	Applicability	Parent	Verification

AAM_REQ_2320	**Data product types.** The AA shall produce recordable intermediate data products. for example pulsar voltage time series and RFI statistics. What is this? This is not really anything new about AAs this is all derived from the beams. RFI data is not an intermediate data product. Perhaps clipping data, calibration correction, beamformer weights.	Essential	(2) SYS_REQ_2820	Demo

4 Operational requirements

4.1 General

4.1.1 Up-time

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_2410	**Up-time.** AA-mid shall be designed to be operated continuously, other than for regular maintenance. This needs qualification – what about maintenance?	Essential	(2) SYS_REQ_3110	Demo

4.1.2 Reconfiguration Time

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2420	**Reconfiguration time.** Reconfiguration time for AA-mid from one observational mode to another:	Essential	(2) SYS_REQ_3150	Demo
	<5 minutes (TBC) Assumes all software applications are present at their designated location			

4.2 Start-up and Shut-down

4.2.1 Start-up Sequence

Identification	Requirement	Applicability	Parent	Verification

AAM_REQ_2430	**Start-up sequence.** The start-up of AA-mid functions shall follow a pre-defined sequence taking not longer than:	Essential	(2) SYS_REQ_3170	Test
	Hot start: 10 minutes This is a restart			
	Cold start: 24 hours A cold start is defined as requiring.....			

4.2.2 Shut-down Sequence

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2430	**Shut-down sequence.** The AA stations will use a controlled shut down process.	Essential	(2) SYS_REQ_3190	Test

4.2.3 AA-mid Autonomous Shut-down

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2440	**AA autonomous shut down.** An AA-mid station shall be capable of autonomously detecting conditions requiring station shut down e.g. power anomalies, over temperature, cooling failure etc and then shutting down and reporting the condition to the central M&C systems. This implies a separately powered M&C system that is kept alive – what if that needs powering down?		(2) SYS_REQ_3190	Test

4.2.4 Start-up and Shut-down Individual Antenna Systems

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2440	**Start-up and shut-down individual AA-mid stations.** It shall be possible to start-up or shutdown individual AA-mid stations and communicate status to the M&C systems.	Essential	(2) SYS_REQ_3180	Test

4.2.5 Start-up and Shut-down Dependencies

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2450	**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).	Essential	(2) SYS_REQ_3220	Inspection

4.2.6 Subsystem Shut-down

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2460	**Start-up and shut-down dependencies.** The shutdown of pre-defined parts of AA-mid stations shall have no (TBC) impact on SKA_1 operations after appropriate re-calibration performed automatically. This cannot be completely true – e.g. sensitivity will be lost or gained – just qualify with "significantly?	Essential	(2) SYS_REQ_3230	Test

4.2.7 Initial Check-out

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2470	**Initial check-out.** AA-mid shall be designed to enable an operational readiness check, including redundancies, prior to commencement of any SKA_1 operations (initial check-out).	Essential	(2) SYS_REQ_3240	Test

4.2.8 Operational Readiness Check

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2480	**Operational readiness check.** The AA-mid operational readiness check shall take:	Essential	(2) SYS_REQ_3250	Test
	>5 minutes.			

4.3 Failure Management

4.3.1 General

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3310	**Personnel safety.** As far as possible, no single failure in AA-mid shall lead to personnel safety hazards. *This seems very mild – surely it should cope with some level of anticipated further failure modes. Suggestion: take single out and change to: "as far as reasonable, no failures ..."*		(2) SYS_REQ_3310	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3320	**Failure propagation.** Failures in the AA-mid subsystems shall not lead to failures in other AA subsystems or other SKA systems.		(2) SYS_REQ_3320	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3330	**Operator command safety.** No single operator command for AA-mid shall cause catastrophic, serious, or major consequences.		(2) SYS_REQ_3330	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3340	**Voltage transient consequences.** No voltage-transients or "cut-off" of electrical power shall lead to catastrophic or serious consequences in AA-mid. This includes voltage transients applied to the input of the receivers.		(2) SYS_REQ_3340	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3350	**Operator command absence.** The absence of operator commands shall not cause catastrophic or		(2) SYS_REQ_3350	

	serious consequences.			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3360	**Single-point failures.** Single-point-failures in the AA-mid shall be listed in the design and operational documentation.		(2) SYS_REQ_3360	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3370	**Single-point failure justification.** Each-single-point failure listed for the AA-mid shall be justified, and assessed against alternative design(s) where this single-point-failure would not occur, if possible.		(2) SYS_REQ_3370	

4.3.2 Detection and Reporting

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3520	**Status report availability time.** The availability of a status report of the functioning of AA-mid shall be in:		(2) SYS_REQ_3520	
	≤5 seconds This is too generic a request, how much status, in what detail etc?			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3530	**Status report request.** The status report of a subsystem shall show the functioning of the subsystem at or after the operator request has been submitted to the system.		(2) SYS_REQ_3530	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3540	**Status report scope.** The status report shall display the status of a sub-system, together with the system time the status was determined.		(2) SYS_REQ_3540	

4.3.3 Diagnosis and Recovery

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3610	**System interrogation reply.** Each AA-mid station shall have the capability to answer an operator interrogation. *Is this what is meant or is it sub-system?*		(2) SYS_REQ_3610	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3670	**Autonomous recovery.** AA-mid shall be able to recover autonomously in case of failures that are classified as minor or negligible. *Where the classification of failures and what is meant by recovery?*		(2) SYS_REQ_3670	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3680	**Effect of disabled units.** The AA-mid design shall ensure that disabled units do not corrupt the observational data in the remaining system.		(2) SYS_REQ_3680	

4.3.4 Lifetime

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3710	**Continuous operation period.** AA-mid shall be designed for a continuous operational periods of:		(2) SYS_REQ_3710	
	6 months After this time maintenance may be necessary, e.g. exchange/cleaning of air-conditioning filters.			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3720	**Minimum life time.** The AA subsystem shall be designed		(2) SYS_REQ_3720	

	for a minimum life time (including initial installation, testing and commissioning period) of:			
	TBD years			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3725	**Support equipment life-time.** AA-mid support equipment shall be designed to maintain SKA_1 for:		(2) SYS_REQ_7960	
	12 (TBC) years.			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3730	**Availability.** The average availability of all AA-mid subsystems during the operational period shall be:		(2) SYS_REQ_3730	
	> 90% (TBC). Availability is defined here as being available for scheduled observations in at least one of the supported operational modes. *This is far too loose. What level of subsystem? Board – the array would never be in use. The station? This would take into account redundancy of elements*			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3740	**Upgradeability** AA-mid shall be upgradable. *This is again far too vague. Anything is upgradeable to a trivial extent. This should be defined...*		(2) SYS_REQ_3740	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3750	**Life-time extension.** Large scale maintenance and/or an upgrade shall give the possibility to reach a life time of:		(2) SYS_REQ_3750	
	50 years (TBC). *The level of maintenance needs to be*			

	specified, could e extreme in this spec.			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3760	**Reusability.** Reusability of AA-mid equipment shall be ensured through design and can be by refurbishment and maintenance where this has been demonstrated as being cost effective.		(2) SYS_REQ_7940	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3770	**Spare parts.** AA-mid spare parts shall have a storage life consistent with availability and use during the full operational lifetime of the SKA_2 equipment to which it applies. *This should be SKA overall*		(2) SYS_REQ_7950	

4.3.5 Reliability

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7420	**Field return rate.** The field return rate of equipment, during installation and the first year full usage, shall be:		(2) SYS_REQ_7420	
	<0.5% (TBC). *Where did this figure come from? 0.5% of what? All like equipment?*			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7810	**Equipment reliability.** The reliability of AA-mid equipment to meet its performance requirements over a period of 10 years shall be:		(2) SYS_REQ_7810	
	>99.4 % (TBC). *This is a very confusing specification. Does it mean <6 boards out of a thousand work for 10 years (an MTBF of >1000years)? Or is it the overall*			

	station being kept up to performance through maintenance?			

4.4 Maintenance

Identification	Requirement	Applicability	Parent	Verification
~~AAM_REQ_3840~~	~~**Data loss due to power outage**~~ **This spec does not apply to AA-mid – it is a system parameter, there is no significant data stored locally.** ~~The AA subsystem 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.~~		(2) ~~SYS_REQ_3840~~ ~~This requirements needs to be rewritten in order to be feasible for the AA subsystems~~	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3850	**Autonomous restart after power outage.** AA-mid shall have the capability to restart autonomously and without failures, after an outage in external power supply. *How does this vary from AAM_REQ_3670?*		(2) SYS_REQ_3850	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3860	**System availability after restart.** AA-mid shall be available within 5 minutes (TBC) after restart. *How does this vary from AAM_REQ_2480?*		(2) SYS_REQ_3860	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3870	**Software/firmware re-installation.** All software / firmware in AA-mid shall be capable of being re-installed		(2) SYS_REQ_3870	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3880	**Software/firmware upgrades.** It shall be possible to replace all software / firmware configuration items in AA-mid through software-upgrades.		(2) SYS_REQ_3880	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3890	**Software code identification.** Software configuration items shall provide unambiguous identification to allow the maintenance of a configuration management database.		(2) SYS_REQ_3890	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3910	**Software code identification response time.** The software identification requests shall be available to the operator within:		(2) SYS_REQ_3910	
	10 seconds (TBC) *Why the urgency?*			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_3920	**AA maintenance functions.** The AA-mid shall include functions that allow maintenance of hardware and software. *This is far too wholly! What maintenance etc.*		(2) SYS_REQ_3920	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7820	**Tools and test equipment.** The AA-mid design shall require and specify a minimum number of special tools and test equipment to perform assembly, integration and repair and maintenance activities.		(2) SYS_REQ_7820 (2) SYS_REQ_9110	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7830	**Inaccessible hardware maintenance.** Inaccessible hardware or structures shall require no maintenance during operation and should have built in test capability when applicable.		(2) SYS_REQ_7830	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7840	**Test and repair instructions.** Test and repair instructions shall be written for fault detection and maintenance of the AA-mid equipment.		(2) SYS_REQ_7840	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7850	**Maintenance team size.** It should be possible to execute regular maintenance jobs with not more than two (2) people per job.		(2) SYS_REQ_7850	

4.5 Disposal Phase

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_4110	**Environmental rule compliancy.** The AA-mid design shall be fully compliant to all environmental rules applicable to the SKA site. *This requirement should be much more specific*		(2) SYS_REQ_4110	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_4120	**Lasting environmental effects.** AA-mid shall be designed to have no lasting adverse environmental effects on the facility and site. *This requirement should be much more specific*		(2) SYS_REQ_4120	

5 Engineering Design Constraints

This chapter specifies the design constraining requirements for engineering.

5.1 Materials and Processes

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7110	**Materials, Parts and Processes lists.** Each subsystem supplier of AA-mid shall establish, collect, review and deliver materials, parts and processes lists including all the Materials, Parts and Processes intended for use in the SKA by his suppliers and himself. They shall reflect the current design at the time of issue. *This all reads very muddled – should be part of a quality system*		(2) SYS_REQ_7110	

Identification	Requirement	Applicability	Parent	Verification
AAM_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).		(2) SYS_REQ_7130	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7140	**Product manufacturing.** Products should be manufactured as much as possible in a factory.			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7150	**Product assembly.** Products which needs to be assembled at the site should be constructed as simple as possible to minimize the construction time.			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7160	**Product testing.** Products should be tested as much as			

	possibly in the factory instead of testing at site.			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7170	**Product sealing.** Products exposed directly to the environment (like antenna elements) should be fully sealed before shipping to the site.			

5.2 Marking

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7210	**Part identification.** Each part, material or product shall be identified with a unique and permanent part or type number. *Needs to be more specific how far down the hierarchy the identification is necessary (board level, cables, connectors, ...)*		(2) SYS_REQ_7210	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7220	**Marking method.** Method of marking shall be compatible with the nature of the item and its use.		(2) SYS_REQ_7220	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7230	**Documentation marking.** Identification numbers shall be marked on documentation and, where possible, on all items.		(2) SYS_REQ_7230	

5.3 Power and other utilities

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7330	**Limiting excessive currents.** AA-mid equipment circuitry shall be protected against excessive currents by a current limiting device, which		(2) SYS_REQ_8160	

	shall not itself produce excessive currents. *What is this? Is this on the interfaces against lightning or other problems – if so, say so.*			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7340	**Power surge protection.** AA-mid subsystems shall be protected against power transients and surges.		(2) SYS_REQ_8170	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7350	**Polarity mis-connection protection.** AA-mid equipment circuitry shall be protected against the effects of inadvertent wrong polarity connections. (TBC) *This needs to be specified at what level and if it really needs to be done. This could use substantially more power due to diode drops etc.*		(2) SYS_REQ_8180	

5.4 Accessibility and testability

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7880	**Self-test capability.** The AA-mid subsystem design for both hardware and software shall provide self-test capabilities.		(2) SYS_REQ_7880	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7890	**Servicing point making.** All servicing and test points shall be clearly marked using TBD labelling standards.		(2) SYS_REQ_7890	

5.5 Transportability and storage

Identification	Requirement	Applicability	Parent	Verification

AAM_REQ_7910	**Handling heavy equipment.** AA-mid parts, test equipment or supporting equipment with a mass exceeding 25 kg shall be provided with provisions for handling and transportation. *Warnings?*		(2) SYS_REQ_7910	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7920	**Disassembly for transport.** It shall be possible to disassemble AA-mid equipment for transportation or storage as necessary.		(2) SYS_REQ_7920	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7930	**Long term storage.** It shall be possible to store AA-mid equipment (spare parts) for 10 years without any degradation of its function or performance.		(2) SYS_REQ_7930	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7935	**Special storage.** If special storage facilities are needed they shall be supplied as part of the spares procurement.		(2) SYS_REQ_7935	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_7940	**Packing density.** Packing density for transportation should be designed as an optimised cost/performance requirement.		TBD	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_7950	**Packing method.** All products should be packed prior to transportation such that it can withstand (1) rigours transportation, (2) transport vibration and (3) movement. Perhaps this should be specified more quantative in G's for example.		TBD	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_7960	**Large equipment size.** The volume of large equipment which cannot be disassembled should be driven by standard shipping container guidelines.		TBD	

5.6 Array Deployment

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8000	**Antenna element deployment time.** The time to assemble and deploy the antenna elements should be minimized to ? minutes per antenna element.		TBD	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8010	**Antenna element deployment.** The AA array design and deployment should be able for installation on a site with a local flatness tolerance of ? cm over ? m.		TBD	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8020	**Antenna positions.** Each individual antenna position should be measured and known within ? mm in three dimensions in the ITRF coordinate system.		TBD	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8030	**Antenna orientation.** Antenna elements should be designed such that they can be rotated quick and simple.		TBD	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8040	**Antenna fixation.** Antenna elements should be designed such that they can be simple and effectively fixed to the ground.		TBD	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8050	**Housing heights.** Any housing near the antenna field should not be in the line of sight of θ =x degrees above horizon. The following relation should hold: $h < d.tan(\theta)$, wherein h is the height and d is the distance of the housing to the nearest antenna.		TBD	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8060	**Burying cables and fibres.** If possible cable and fibre burying should be avoided as much as possible. Does not seem a good requirement I think.		TBD	

5.7 Electronic Design Requirements

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8100	**Device junction temperature.** The device junction temperature of the main devices should be kept below x degrees Celsius to increase lifetime. Should follow from the RAMS analysis. Don't know if you should put this as a requirement.		TBD	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8110	**Design for upgradability.** The AA low design should be made such that future upgrades are able to process the full bandwidth of each antenna element, assuming the cost impact is small.		TBD	

6 External Interface Requirements

External Interfaces are defined as interactions or communications with the world outside an AA-mid station. These are represented as blue arrows in

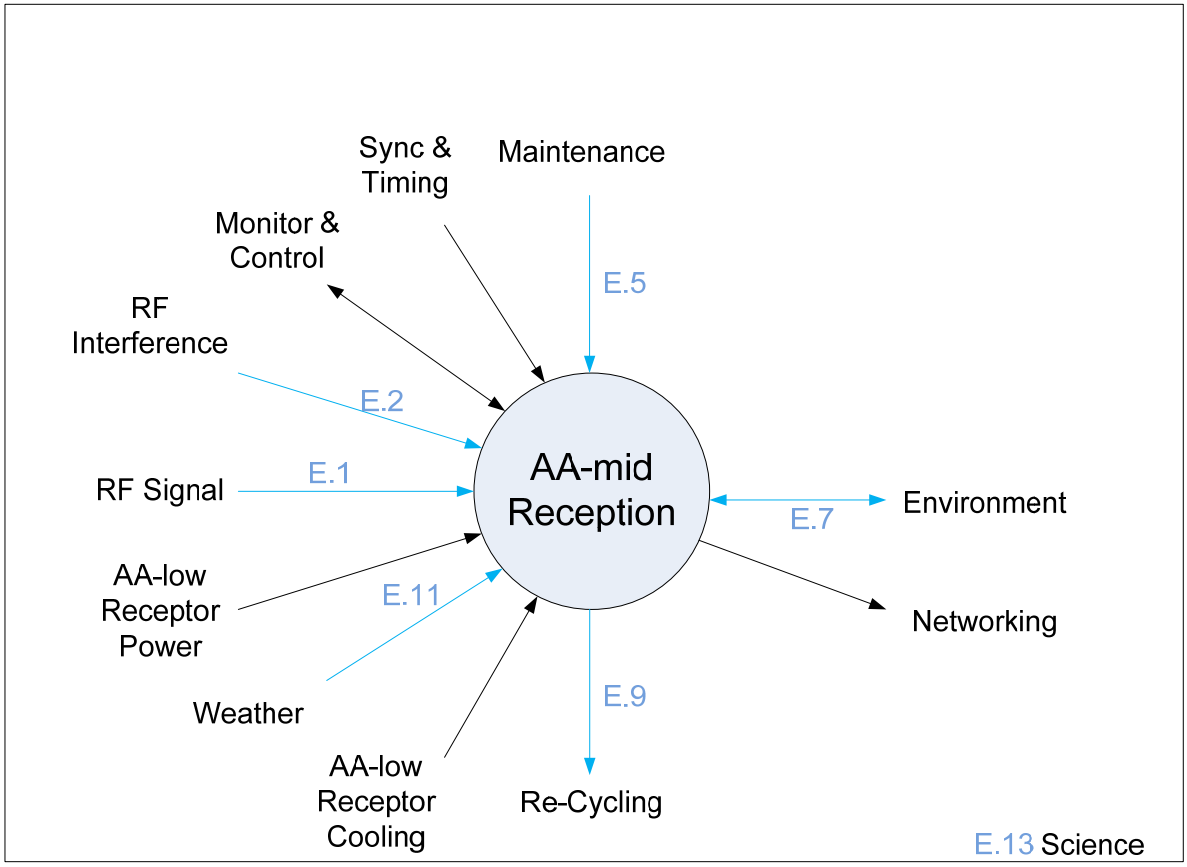

Figure 1.

6.1 RF Signal

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8300	**RF signal.** The input signal of each AA-mid station has the following characteristics in the band 70-450MHz:		The input for this requirement is the spectrum measured at the selected site.	
	TBD dBm: 24 hours average power			
	TBD dBm: Peak power			

6.2 RF Interference

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8400	**Damaging interference levels.** The AA-mid subsystem shall not be damaged by RFI signals of less than:		(2) SYS_REQ_5410	
	TBD V/m			

6.3 Maintenance

The requirements for maintenance are listed in the operational requirements section (Section 4.4).

6.4 Re-Cycling

Currently no re-cycling requirements are formulated.

6.5 Environment

6.5.1 General

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5120	**Compliancy with local environment.** The design of the AA-mid shall be appropriate (TBD) for operation in the natural environment for the geographical deployment location of the SKA. *This requirement should be made more specific*		(2) SYS_REQ_5120	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5130	**Transportation conditions.** AA-mid equipment shall be designed for the the mode of transport being used (road, air, sea, etc.) between place of manufacturing and final installation on the SKA site (including packaging requirements). *This requirement should be made more specific e.g. use proper standards etc*		(2) SYS_REQ_5130	

6.5.2 Site and infrastructure requirements

Identification	Requirement	Applicability	Parent	Verification
~~AAM_REQ_5220~~	~~**Facilities and equipment intrusion.**~~ **This is a system wide requirement and not specifically AA-mid: delete it**		(2) ~~SYS_REQ_5220~~	

	~~AA-mid equipment and operating facilities shall be adequately protected against intrusion by unauthorized persons or by "larger" wandering animals.~~ ~~This requirement should be made more specific~~			

6.5.3 Contamination and precipitation

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5230	**Precipitation.** AA-mid shall be able to operate with maximal 1% (TBD) degradation of the performance during any type of precipitation (TBD). *The original requirement is too stringent. Precipitation like snow will always have some influence. Need to determine reasonable acceptable degradation and define it.* *Shouldn't this be with 6.6 Weather?*		(2) SYS_REQ_5230	

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_5240	**Pollution and contamination protection.** AA-mid shall be adequately protected against performance degradation caused by contaminating particles (dust, sand etc), polluted air or any precipitation. *This requirement should be made more specific*		(2) SYS_REQ_5240	

6.5.4 Electro Magnetic Compatibility

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5420	**EM immunity.** AA-mid shall not be susceptible to RFI signals, in-band or out-band, other than via the receptors. *(What does this mean??)* *This requirement should be made more specific with numerical values*		(2) SYS_REQ_5420	

	otherwise this lead to an overdesign by putting all equipment in a Faraday cage.			

Identification	Requirement	Applicability	Parent	Verification
AAM_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.		(2) SYS_REQ_5610	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5620	**EMC compatibility marking.** All "off-the-shelf" equipment applied within the AA-mid subsystem shall posses as a minimum the host country EMC marking, including electrical and electronic supporting and infrastructural equipment. *Needs to be more specific when the site is selected.*		(2) SYS_REQ_5620	

Identification	Requirement	Applicability	Parent	Verification
AAM_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)		(2) SYS_REQ_5630	

Identification	Requirement	Applicability	Parent	Verification
AAM_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. *This needs to be properly fleshed out.*		(2) SYS_REQ_5640	

6.5.5 Self-generated RFI environment

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_2910	**Self-generated RFI susceptibility.** Interference due to self-generated RFI shall not degrade the performance of the instrument by greater than 1% by any measure (TBC). *This is a wild guess....*		(2) SYS_REQ_2910	

6.5.6 Grounding

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5810	**Safety ground.** Electrical safety ground shall be designed according to the regulations imposed by the local government. *This should be made more specific as soon the site is selected.*		(2) SYS_REQ_5810	

6.5.7 Corrosion

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5820	**Corrosion protection.** AA-mid equipment and buildings shall be protected against corrosion. *Specify the standard...*		(2) SYS_REQ_5820	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5830	**Corrosion protection in air flows.** AA-mid electronics and connectors in areas with a higher air flow (for cooling) or outdoor environment shall be additionally protected against corrosion. *Specify the standard...*		(2) SYS_REQ_5830	

6.6 Weather

6.6.1 Climatic Requirements

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5310	**Humidity.** AA-mid equipment shall be able to withstand moisture and humidity levels up to:		(2) SYS_REQ_5310	
	100 % RH. *For how long? Operating?*			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5320	**Allowable air temperature range.** AA-mid equipment shall be able to withstand (non-operating if necessary) an outside air temperature within the range of:		(2) SYS_REQ_5320	
	-15 ºC (TBC) to +60 ºC (TBC). *For how long...?*			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5330	**Air temperature operation range.** AA-mid equipment shall be able to operate within specification if the outside air temperature is within the range of		(2) SYS_REQ_5330	
	-5 ºC (TBC) to +50 ºC (TBC).			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5340	**Wind velocities.** AA-mid shall be able tolerate wind velocities up to:		(2) SYS_REQ_5340	
	Survival: 160 km/hr (TBC)			
	Normal operation: 40 km/hr (TBC).			

6.6.2 Lightning

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5710	**Lightning discharge susceptibility.** AA-mid 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. *This needs considerable study, there may be elements of the array destroyed and still carry on.*		(2) SYS_REQ_5710	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5720	**Lightning protection.** AA-mid 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).		(2) SYS_REQ_5720	

6.6.3 Seismicity

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_5910	**Earthquakes.** AA-mid equipment and buildings shall be protected against earthquakes with a magnitude up to:		(2) SYS_REQ_5910	
	Richter 3.8 (TBC).			

7 Internal Interface Requirements

Internal interfaces are defined as interactions or communications with the SKA system outside the AA-mid subsystems. These are represented as black arrows in

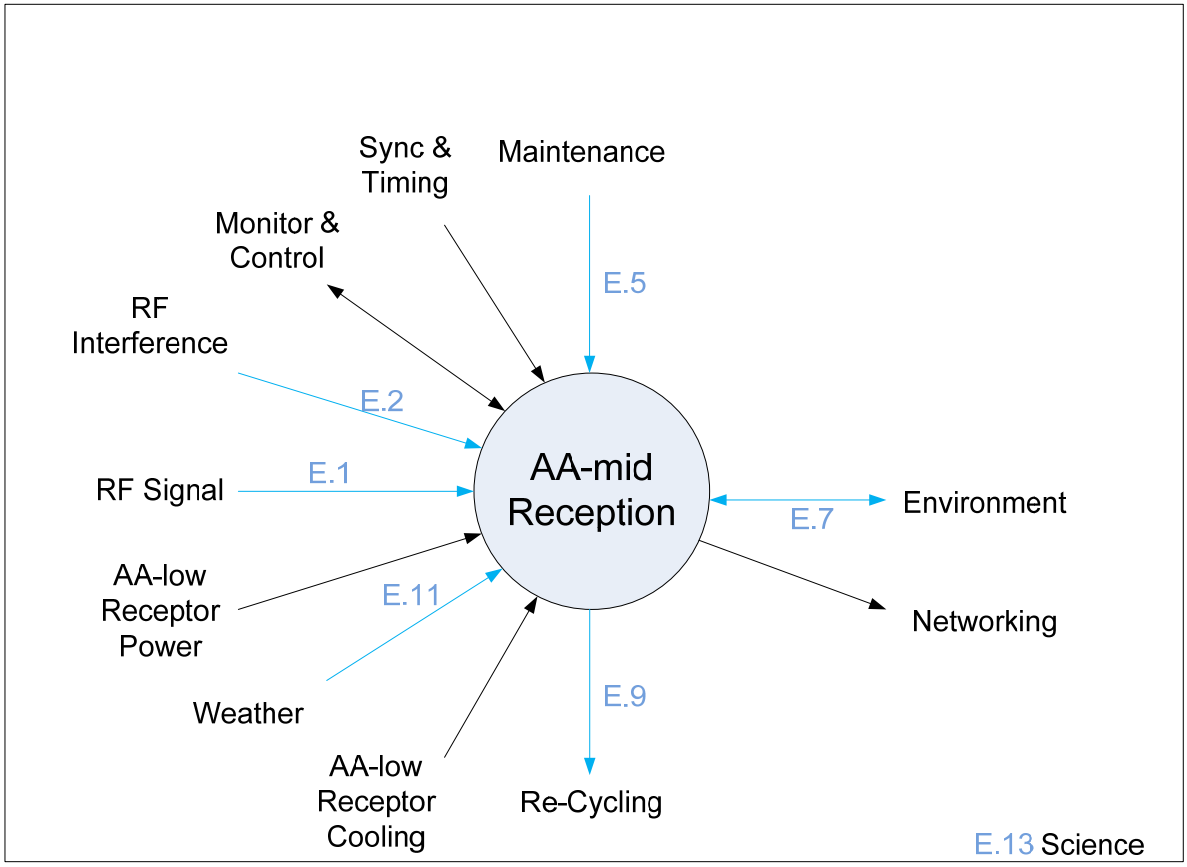

Figure 1.

7.1 AA Receptor Power

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8110	**Supply power.** The power supplied to AA-mid shall have the following characteristics (TBC):		(2) SYS_REQ_8110	
	Voltage: 380 V +/- 10%			
	Phases: Three			
	Frequency: 50 Hz +/- 1 Hz			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_7320	**Power consumption.** The power consumption of all equipment at an AA-mid station shall be:		(2) SYS_REQ_7320	
	<TBD kVA. *A biggy ....*			

7.2 Sync and Timing

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8140	**Subsystem time standard.** Each AA-mid station shall maintain an internal time standard with an accuracy of:		(2) SYS_REQ_8140	
	TBD nanoseconds. *Needs to discuss "stand-alone" and drift rate etc.*			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8150	**Central time standard.** All AA-mid stations shall synchronize their internal time standards to the central timing standard with an accuracy of		(2) SYS_REQ_8150	
	TBD nanoseconds.			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8160	**Synchronisation signal.** A synchronisation signal (tick or pulse) is distributed to each AA station and has the following characteristics:		This will be derived from the Signal Transport and Networks domain.	
	Voltage: TBD V *This is rubbish, it will be an optical signal over fibre.*			
	Rise time: TBD ps *It will probably not be done this way*			
	TBD s pulse with a width of TBD s			

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8170	**Clock signal.** This looks wrong – surely it will be a locally generated signal that is synchronised with the above The central clock is distributed to each AA-mid station and has the		This will be derived from the Signal Transport and Networks domain.	

	following characteristics:			
	Voltage of TBD V			
	Frequency of TBD MHz			
	Jitter of TBD ns			
	Long term stability of TBD			

7.3 Network

Ident	Requirement	Applicability	Parent	Verification
AAM_REQ_8200	**Data time-tagging.** All aperture arrays shall time-tag received and processed data with the accuracy of their internal time standard.		[1] SYS_REQ_8210	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8210	**Data packetizing.** All AA-mid observation data shall be packetized according to the SKA standard written in [TBD].		TBD	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8220	**Data interface.** The data interface of AA-mid to the central processing has the following characteristics:		This will follow from the Signal Transport and Network domain.	
	TBD			

7.4 Monitor and Control

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8500	**M&C protocol.** The M&C protocol used to interface with the AA-mid is TBD		This is driven by the M&C domain.	

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8510	**M&C interface.** The electrical characteristics of the M&C protocol for the AA-mid station are:		This is driven by the M&C domain.	
	TBD			
	TBD			

7.5 AA Receptor Cooling

Identification	Requirement	Applicability	Parent	Verification
AAM_REQ_8600	**Cooling capacity.** The required cooling capacity for each AA-mid station requires:			
	TBD kW			
	TBD			
	TBD			