AISG Extension:

Remote eAntenna Extension

Revision History

DATE	ISSUE	NOTES
14 December 2012	1.0	Provisional release; by Liyue, Ma Xin and Stefan Feuchtinger
29 January 2013	2.1.0	First release; renamed Generic Upload and Generic Download as RAE Upload and RAE Download. Corrected errors of issue 1.0. Annexes annotated as normative or informative.

AISG Extension:
Remote eAntenna Extension
Standard No. AISG-ES-RAE v2.1.0

29th of January, 2013

1. Foreword

The Antenna Interface Standards Group (AISG) published the AISG standard to facilitate the introduction of antenna line products with remote control and monitoring facilities. The purpose of that standard is to ensure basic interoperability of antennas and control infrastructure. The AISG standard covers two basic types of Antenna Line Devices: Actuators capable of altering the electrical downtilt of the antenna and tower mounted amplifiers.
It has become evident that commercial antenna line devices are evolving beyond this set of capabilities. The AISG has decided to publish extensions to the basic standard rather than adding all possible branches to the core specification. For purposes of compliance, users should note that this entire Extension Standard is *optional*. However, once this Extension Standard is elected for inclusion in a device, the entire option becomes mandatory.

This extension to the AISG standard adds procedures for beam forming antennas (an example is shown in Annex E) that implement capabilities to store and send weighting factor data and other auxiliary information. Being able to store this antenna specific information in the antenna itself and making it retrievable by the base station will ensure the correct beam forming weighting is used by the base station, thereby avoiding unintentional use of wrong weighting factors that create false broadcast beam patterns resulting in network performance degradation.

2. Scope

This document contains extensions to layers 1, 2 and 7 of AISG specification, version 2.0 [1], for antennas implementing Remote eAntenna Extension (RAE).

3. References

This AISG extension standard incorporates provisions of other publications. These provisions are cited in the text and the referenced publications are listed below. Where references are dated, subsequent amendments or revisions of these publications apply only when specifically incorporated by amendment or revision of this AISG extension. For undated references, the latest edition of the publication applies.

1. AISG Version 2.0, "Control Interface for Antenna Line Devices"
2. 3GPP TS25.460 UTRAN Iuant Interface General Aspects and Principles Release 6
3. 3GPP TS25.461 UTRAN Iuant Interface Layer 1, Release 6
4. 3GPP TS25.462 UTRAN Iuant Interface Signalling Transport, Release 6
5. 3GPP TS25.463 UTRAN Iuant Interface Remote Electrical Tilting (RET), Release 6
6. NIMA TR8350.2 U.S. Department of Defense World Geodetic System 1984, Third Edition - Amendment 1
7. 3GPP TS25.466 UTRAN Iuant Interface: Application Part, Release 10

NOTE: The 3GPP references are to Release 6 unless otherwise indicated. These documents are referred to in AISG Version 2.0, although they may have been superseded.

4. Abbreviations

Where abbreviations or acronyms are used in this document they have the following meanings:

RAE	Remote eAntenna Extension
TCP	Time Consuming Procedure
WGS 84	World Geodetic System 1984

5. Terminology and Definitions

Where the following terms are used in this document, they have the meanings listed below.

Weighting Factor	A set of amplitude and phase settings for one RF port of a beam forming antenna. The amplitude is expressed in percent of the maximum power, ranging from 0 to 100. The phase is expressed in degrees, ranging from -180.0 to +179.9, expressed in phase value times 10.
Latitude	An angular measurement in degrees ranging from 0 degree at the equator, to +90 degrees at the North pole, and −90 degrees at the South pole, as specified by WGS 84 [6]. Latitude identifies a position on earth north or south of the equator and is reported in decimal degrees, with six decimal places of accuracy, and then multiplied by $1x10^6$ so that it may be represented by an integer.
Longitude	An angular measurement ranging from 0 degree at the prime meridian (Greenwich meridian) to +180 degrees eastward and −180 degrees westward, as specified by the WGS 84 [6] ellipsoid. Longitude identifies a position on earth east or west of the prime meridian and is reported in decimal degrees, to six decimal places of accuracy, and then multiplied by $1x10^6$ so that it may be represented by an integer.
Altitude	The elevation of a point or object from the surface of the WGS 84 [6] geoid. Altitude is reported in meters, to one decimal place of accuracy, and then multiplied by 10 so that it may be represented by an integer.
Antenna Pattern	A mathematical function or graphical representation of the radiation properties of the antenna as a function of space coordinates.

6. Layer 1

All definitions and specifications for RET devices in references [1], [2] and [3] regarding Iuant layer 1 apply to RAE devices that comply with this Extension Standard unless otherwise stated by requirements in this document.

6.1. DC supply

6.1.1. RAE DC power consumption

Devices complying with this extension standard shall have a maximum steady-state power consumption of less than 1 W.

6.1.2. RAE Power-up characteristics

Devices complying with this extension standard shall have a maximum power-up period of 3 seconds. After the power-up period, the device shall be fully functional.

6.2. Resumption of operation after interruption of power supply

Normal operation shall be resumed after restoration of the power supply following any interruption or voltage drop below the minimum operating voltage in accordance with [3]. All data stored in the RAE shall be retained when the supply voltage falls below the minimum operating voltage and during interruption of power supply.

6.3. RAEs not requiring continuous DC power

RAE may be left unpowered for extended periods, and normal operations shall be resumed as power is supplied.

Note: RAE is not required for the antenna to operate. When no DC power is supplied to the RAE, the antenna itself will work nonetheless.

7. Layer 2

All definitions and specifications for ALDs in references [1] and [4] regarding Iuant Layer 2 shall be valid for all ALDs included in this extension standard regardless of whether the device implements any other functionality.

Extended specifications for layer 2 are defined in the following chapter.

7.1. Device Type

Table 7.1.1 shows the additional device type for this Extension Standard:

Table 7.1.1: Device type

Device Type	Acronym	1-octet unsigned integer
Remote eAntenna Extension	RAE	0x31

8. Layer 7

The application layer includes the common elementary procedures as defined in [1] and [5] and is extended by AISG-specific procedures.

8.1. General Aspects

8.1.1. Geometry and Numbering

All RAE devices shall be defined as multiple subunit devices. Devices with single RAE units shall be implemented as multiple subunit devices with the number of subunits equal to 1. RAE subunit numbering shall start with 1.

8.1.2. Parallel Procedure Handling for TCPs

The RAE device does not define any TCPs, and parallel procedure handling is not supported by the RAE.

8.2. Return and alarm codes

A table of return and alarm codes is given in [5].

8.3. Common Elementary Procedures for the Remote eAntenna Extension

To avoid prematurely exhausting the available space in the command table through the proliferation of extensions, certain codes defined for other devices are reused by this extension. This process is called “overloading”.

For devices compliant with this extension, the overloaded code shall refer to a member of the RAE procedure set defined herein, and not to the procedure assigned by the original specification.

This section defines those procedures that are defined by overloading existing procedure codes without any significant changes in the procedure initiation message, response message, and/or return code values. For clarity, only differences from the language of the referenced specification are elaborated for these procedures.

Table 8.3.1: Common elementary procedures

RAE Procedure	Overloads	Code Value	Requirement
RAESetDeviceData	TMASetDeviceData [1]	0x74	mandatory
RAEGetDeviceData	TMAGetDeviceData [1]	0x75	mandatory
RAEAlarmIndication	TMAAlarmIndication [1]	0x76	mandatory
RAEClearActiveAlarms	TMAClearActiveAlarms [1]	0x77	mandatory
RAEGetAlarmStatus	TMAGetAlarmStatus [1]	0x78	mandatory
RAEGetNumberOfSubunits	TMAGetNumberOfSubunits [1]	0x79	Mandatory

These commands shall be implemented as specified in the corresponding paragraphs of [1], except that the term “TMA” shall be replaced by “RAE”.

RAE device extends the table C.1 in [1] used for RAESetDeviceData and RAEGetDeviceData. The new field 0x10 is to store the altitude of the antenna installed. The new field 0x11 is to store the geographic location of the antenna installed. The new field 0x30 is to store test records.

Table 8.3.2: Assigned fields for additional data (extend field 0x10, 0x11, 0x30)

Field No.	Length (octets)	Format	Description
0x01	15	ASCII	Antenna model number
0x02	17	ASCII	Antenna serial number
0x03	2	16-bit unsigned	Antenna operating band(s)
0x08	2	16-bit unsigned	Antenna operating band(s)
0x09	2	16-bit unsigned	Antenna operating band(s)
0x04	8	4 x 16-bit unsigned	Beamwidth for each operating band in band order (deg), beginning with lowest band. The lowest band is transmitted within the first 16-bit value. (example: width for band I, width for band II)
0x05	4	4 x 8-bit unsigned	Gain [dBi] for each operating band in band order, expressed in gain value times 10, beginning with the lowest band. The lowest band is transmitted within the first 8-bit value. (example: gain for band I, gain for band III)
0x06	2	16-bit signed	Maximum supported electrical tilt [degree], expressed in tilt value times 10.
0x07	2	16-bit signed	Minimum supported electrical tilt [degree], expressed in tilt value times 10.
0x10	4	32-bit signed	Altitude [meters] of an antenna over sea level, expressed in altitude value times 10.
0x11	8	2x 32-bit Signed	Geographic location , including longitude and latitude, with the format as listed in Table 8.3.3
0x21	6	ASCII	Installation date
0x22	5	ASCII	Installer's ID
0x23	32	ASCII	Base station ID
0x24	32	ASCII	Sector ID
0x25	2	16-bit unsigned	Antenna bearing [degree], in the range of 0 – 359.9 degree, expressed as bearing value times 10
0x26	2	16-bit signed	Installed mechanical tilt [degree], expressed in tilt value times 10.
0x30	70	ASCII	Reserved for facility test record (key test parameters, such as PIM, and/or S-parameters for smart antennas)

Table 8.3.3: coding for Geographic location in field 0x11

Format	Description
32-bit signed	Longitude [10^{-6}degree] according to WGS 84 [6]
32-bit signed	Latitude [10^{-6}degree] according to WGS 84 [6]

8.4. Device-Specific Elementary Procedures for RAE

This section defines procedures that are defined by overloading existing procedures in [1] and [5] that include significant changes in the procedure message initiation, response, and/or return code values or formats. For clarity, these procedures are defined completely. No requirements from the overloaded procedure clauses in [1] or [5] shall be inferred unless re-stated in this Extension Standard.

A weighting factor file can be downloaded to a subunit of the RAE device by running the RAEDownload command. The RAEDownload command contains a parameter specifying the file type. Therefore, RAE devices can identify the files to be downloaded. An antenna pattern file is stored in each subunit in RAE device which can describe the properties of the antenna. The antenna pattern file shall be read-only.

In addition, files in RAE device can be queried by running the RAEGetNumberofFiles and RAEGetFileInformation command, and can be uploaded to the primary device by running RAEUploadFile command.

The RAE device shall store two weighting factors files. One is factory weighting factors file, and the other one is active weighting factors file. The factory weighting factors file is written in the factory, and cannot be changed remotely. The active weighting factors file is written in the factory identical to the factory weighting factors file, but can be read and updated remotely in the field. The active weighting factors file can be replaced by the factory weighting factors file remotely to revert to the initial pattern setting.

Table 8.4.1: RAE specific elementary procedures

RAE Procedure	Overloads	Code Value	Requirement
RAEResetFactoryWeightingFactors	TMASetMode [1]	0x70	Mandatory
RAEDownloadStart		0x43	Mandatory
RAEDownloadFile		0x44	Mandatory
RAEDownloadEnd		0x45	Mandatory
RAEGetNumberofFiles		0x46	Mandatory
RAEGetFileInformation		0x47	Mandatory
RAEUploadFile		0x48	Mandatory
RAEGetWeightingFactor	TMAGetGain [1]	0x73	Mandatory
RAEGetSupportedFunctions	TMAGetSupportedFunctions [1]	0x7A	Mandatory

8.4.1. RAE Download Start

Table 8.4.1.1: Elementary procedure RAE Download Start

Name: **RAEDownloadStart**				
Code: **0x43**	Issued by: **Primary device**	Procedure class: **1**	DownloadMode state: **No**	Power mode: **Low**

Table 8.4.1.2: Initiating message parameters and format for RAE Download Start

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**Unsigned integer**	**Weighting factors file type (0x04)**

Table 8.4.1.3: Response message parameters and format for RAE Download Start

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**ReturnCode**	**Return code OK**

Description:

On receipt of this initiating message the file download process shall be initiated. The download procedures can be applied to individual subunits of the device or to the device itself. To apply procedures to the device itself, the subunit number parameter shall be 0.

The response time to this RAE Download Start procedure shall be less than 4 seconds.

Table 8.4.1.4: Return codes for RAE Download Start

OK	FAIL	Comment
	FormatError **Busy** **UnsupportedProcedure** **InvalidFileType**	

8.4.2. RAE Download File

Table 8.4.2.1: Elementary procedure RAE Download File

Name: **RAEDownloadFile**				
Code: **0x44**	Issued by: **Primary device**	Procedure class: **1**	DownloadMode state: **No**	Power mode: **Low**

Table 8.4.2.2: Initiating message parameters and format for RAE Download File

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**Less than, or equal to MaxDataReceiveLength**	**Vendor specific**	**File data, see Annex A**

Table 8.4.2.3: Response message parameters and format for RAE Download File

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**ReturnCode**	**Return code OK**

Description:

This elementary procedure is used once or several times to transfer file data from the primary device to the secondary device. A weighting factor file can only be downloaded to a subunit, not to the device itself.

The response time to this RAE Download File procedure shall be less than 4 seconds.

Table 8.4.2.4: Return codes for RAE Download File

OK	FAIL	Comment
	FormatError **Busy** **HardwareError** **InvalidFileContent** **InvalidProcedureSequence**	

8.4.3. RAE Download End

Table 8.4.3.1: Elementary procedure RAE Download End

Name: **RAEDownloadEnd**				
Code: **0x45**	Issued by: **Primary device**	Procedure class: **1**	DownloadMode state: **No**	Power mode: **Low**

Table 8.4.3.2: Initiating message parameters and format for RAE Download End

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**

Table 8.4.3.3: Response message parameters and format for RAE Download End

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**ReturnCode**	**Return code OK**

Description:

This elementary procedure indicates the end of a multi-message data transfer to the secondary device. The secondary device shall respond after verifying the received data.

If the download file is a weighting factors file, and if the file content is OK, the RAE device shall use the downloaded weighting factors as the new active weighting factors.

The response time to this RAE Download End procedure shall be less than 10 seconds.

Table 8.4.3.4: Return codes for RAE Download End

OK	FAIL	Comment
	FormatError **Busy** **HardwareError** **ChecksumError** **InvalidFileContent** **InvalidProcedureSequence**	

8.4.4. Get Number of Files

Table 8.4.3.1: Elementary procedure for RAE Get Number of Files

Name: **RAEGetNumberofFiles**				
Code: **0x46**	Issued by: **primary device**	Procedure class: **1**	DownloadMode state: **No**	Power mode: **Low**

Table 8.4.3.2: Initiating message parameters and format for RAE Get Number of Files

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**

Table 8.4.3.3: Response message parameters and format for RAE Get Number of Files

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**ReturnCode**	**Return code OK**
3	**1 octet**	**Unsigned integer**	**Number of files**

This command is used to query the number of files in the subunit.

Table 8.4.3.4: Return codes for RAE Get Number of Files

OK	FAIL	Comment
	FormatError **Busy** **HardwareError** **WorkingSoftwareMissing** **UnsupportedProcedure**	

Description:

The Get Number of Files procedures can be applied to individual subunits of the device or to the device itself. To get the device files, the subunit number parameter shall be 0.

8.4.5. Get File Information

Table 8.4.3.1: Elementary procedure RAE Get File Information

Name: **RAEGetFileInformation**				
Code: **0x47**	Issued by: **Primary device**	Procedure class: **1**	DownloadMode state: **No**	Power mode: **Low**

Table 8.4.3.2: Initiating message parameters and format for RAE Get File Information

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
1	**1 octet**	**Unsigned integer**	**File index**

Table 8.4.3.3: Response message parameters and format for RAE Get File Information

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**ReturnCode**	**Return code OK**
3	**1 octet**	**Unsigned integer**	**Weighting factor file (0x04)** **Antenna pattern file (0x05)**
4	**4 octets**	**Unsigned integer**	**File size**
5	**1 octet**	**Unsigned integer**	**Length of file name**
6	**Length of file name**	**ASCII**	**File name**

Description:

This command is used to query the file size and name. The file index is numbered from 1 upwards, and the maximum number equals the total number of files in the subunit.

Table 8.4.3.4: Return codes for RAE Get File Information

OK	FAIL	Comment
	FormatError **Busy** **HardwareError** **WorkingSoftwareMissing** **UnsupportedProcedure** **UnknownParameter**	

8.4.6. RAE Upload File

Table 8.4.6.1: Elementary procedure for RAE Upload File

Name: **RAE Upload File**				
Code: **0x48**	Issued by: **Primary device**	Procedure class: **1**	DownloadMode state: **No**	Power mode: **Low**

Table 8.4.6.2: Initiating message parameters and format for RAE Upload File

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**Unsigned integer**	**File index (see Annex D)**
3	**4 octets**	**Unsigned integer**	**Offset address of the data to be obtained**

Table 8.4.6.3: Response message parameters and format for RAE Upload File

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**ReturnCode**	**Return code OK**
3	**≤ MaxDataTransmitLength – 1 octet**	**Vendor specific**	**File content**

Description:

On receipt of the initiating message, the RAE shall return as many octets as possible of the file with the index “File index”, starting at “Offset”. The Upload File procedures shall be applied to individual subunits of the device.

NOTE: Query the file size and name before using the primary device to upload the file. Based on the file size, determine the maximum offset for file uploading and repeatedly transfer data. If the offset is 0 in the first time of data transfer, the offset for each successive data transfer is equal to the offset for the previous data transfer plus the size of the previous data transfer.

Table 8.4.6.4: Return codes for RAE Upload File

OK	FAIL	Comment
	FormatError **Busy** **HardwareError** **WorkingSoftwareMissing** **UnsupportedProcedure** **UnknownParameter**	

8.4.7. RAE Reset Factory Weighting Factors

Table 8.4.7.1: Elementary procedure RAE Reset Factory Weighting Factors

Name: **RAERestoreFactoryWeightingFactors**				
Code: **0x70**	Issued by: **Primary device**	Procedure class: **1**	DownloadMode state: **No**	Power mode: **Low**

Table 8.4.7.2: Initiating message parameters and format for RAE Reset Factory Weighting Factors

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**

Table 8.4.7.3: Response message parameters and format for RAE Reset Factory Weighting Factors

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**ReturnCode**	**Return code OK**

Description:

The RAE device shall overwrite the active weighting factors with the factory weighting factors for the addressed subunit.

The response time to this RAE Reset Factory Weighting Factors procedure shall be less than 10 seconds.

Table 8.4.7.4: Return codes for RAE Reset Factory Weighting Factors

OK	FAIL	Comment
	FormatError **Busy** **HardwareError** **InvalidFileContent** **UnsupportedProcedure**	

8.4.8. RAE Get Weighting Factor

Table 8.4.8.1: Elementary procedure RAE Get Weighting Factor

Name: **RAEGetWeightingFactor**				
Code: **0x73**	Issued by: **Primary device**	Procedure class: **1**	DownloadMode state: **No**	Power mode: **Low**

Table 8.4.8.2: Initiating message parameters and format for RAE Get Weighting Factor (field number between 0x01 and 0x0A)

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**Unsigned integer**	**Field number; value between 0x01 and 0x0A**

Table 8.4.8.3: Initiating message parameters and format for RAE Get Weighting Factor (field number equal to 0x0B)

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**Unsigned integer**	**Field number; value equal to 0x0B**
3	**2 octets**	**Unsigned integer**	**Electrical tilt [degree], expressed in tilt value times 10.**
4	**2 octets**	**Unsigned integer**	**Broadcast beam width [degree].**
5	**2 octets**	**Unsigned integer**	**Frequency band min [MHz].**
6	**2 octets**	**Unsigned integer**	**Frequency band max [MHz].**

Description: For values of field 2 between 0x01 and 0x0A, the subunit will return antenna information data according to Table A.1.

For values of field 2 equal to 0x0B, the subunit will return the weighting factor data (3 x N octets) for the specified electrical tilt, the specified beamwidth and the specified frequency band according to Table A.2.

Table 8.4.8.4: Response message parameters and format for RAE Get Weighting Factor

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**Return code**	**Return code ok**
3	**See Annex A**	**See Annex A**	**Field value, See Table A.1 ; also see Table 8.4.8.5**

Table 8.4.8.5: Interpretation of RAEGetWeightingFactor Response

Octet number	Description
1	**Amplitude [%] of port 1**
2	**Phase[degree] low octet of port 1**
3	**Phase[degree] high octet of port 1**
...	**...**
3 x N – 2	**Amplitude [%] of port N**
3 x N – 1	**Phase[degree] low octet of port N**
3 x N	**Phase[degree] high octet of port N**

Description:

The response format in table 8.4.8.5 is used for field 0x0B. The amplitude is expressed in percent of the maximum power, ranging from 0 to 100. The phase is expressed in degrees, ranging from -180.0 to +179.9, expressed in phase value times 10.

Table 8.4.8.6: Return codes for RAE Get Weighting Factor

OK	FAIL	Comment
	FormatError **Busy** **HardwareError** **WorkingSoftwareMissing** **UnsupportedProcedure** **UnknownParameter**	

8.4.9. RAE Get Supported Functions

On receipt of the initiating message, the secondary device shall respond with the function flags and parameters indicating the supported functionality of the addressed RAE.

Table 8.4.9.1: Elementary procedure RAEGetSupportedFunctions

Name: **RAEGetSupportedFunctions**				
Code: **0x7A**	Issued by: **Primary device**	Procedure class: **1**	DownloadMode state: **No**	Power mode: **Low**

Table 8.4.9.2: Initiating message parameters and format for RAEGetSupportedFunctions

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**

Table 8.4.9.3: Response message parameters and format for RAEGetSupported Functions

Number	Length	Type	Description
1	**1 octet**	**Unsigned integer**	**Subunit number**
2	**1 octet**	**Return code**	**Return code: OK**
3	**1 octet**	**Unsigned integer**	**Function Flags**

Table 8.4.9.4: Return codes for RAEGetSupportedFunctions

OK	FAIL	Comment
	FormatError **HardwareError** **WorkingSoftwareMissing**	

Table 8.4.9.5: Function Flags for RAEGetSupportedFunctions

Bit	7 to 6	5	4	3	2	1	0
Function	**Reserved**	**Antenna Pattern file Function**	**Installed mechanical tilt sensor Function**	**Antenna bearing sensor Function**	**Height sensor Function**	**Location sensor Function**	**Weighting Factor Function**

On receipt of the initiating message, the RAE shall respond with the function flags and parameters indicating the supported functionality of the addressed RAE unit.

Bits are numbered from 0...7, bit number 0 set to 1 represents the value 0x01. Bit number 1 set to 1 represents the value 0x02. Bit number 2 set to 1 represents the value 0x04. Bit number 3 set to 1 represents the value 0x08. Bit number 4 set to 1 represents the value 0x10. Bits number from 0 to 4 set to 1 represents the value 0x1F. Bit value 0 represents function is not supported. Bit value 1 represents function is supported. Reserved bits shall be set to zero.

Annex A: Assigned fields for smart antenna information - including weighting factors (Normative)

Table A.1: antenna information structure

Field No.	Length (octets)	Format	Description
0x01	24	ASCII	Weighting factors information
0x02	24	ASCII	Weighting factors Version
0x03	1	8-bit unsigned	The number of electrical tilt sample points: P
0x04	2 x P	16-bit signed	<min electrical tilt (deg)> , ... ,< max electrical tilt (deg)>, expressed in tilt value times 10
0x05	1	8-bit unsigned	The number of broadcast beam widths: L
0x06	2 x L	16-bit signed	< broadcast Beam width 1(deg)> , ... ,< broadcast Beam width L(deg)>
0x07	1	8-bit unsigned	The number of frequency bands: M
0x08	4 x M	2 x 16-bit unsigned	< frequency band 1 low (MHz), frequency band 1 high (MHz)> , ... ,< frequency band M low (MHz), frequency band M high (MHz)>
0x09	1	8-bit unsigned	The number of RF ports: N
0x0A	2	16-bit signed	Antenna advanced parameters, e.g. space between antenna columns(mm)
0x0B	3 x N	8-bit unsigned, 16-bit signed	< Amplitude (|P|*100), Phase(0.1 deg)> , ... , < Amplitude (|P|*100), Phase(0.1 deg)>, (see Table A.2)

Note: The weighting factor file contains one set of weighting factors for each of the L x M x N combinations of broadcast beam widths, frequency bands and electrical tilt value. The amplitude value P refers to the far field power level in W normalized to the maximum value in the pattern

Table A.2: weighting factors data relation

		frequency band 1			.....			frequency band M		
		port 1	**.....**	**port N**	**port 1**	**.....**	**port N**	**port 1**	**.....**	**port N**
min electrical tilt	**Beam width 1**	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	.....	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	Beam width L	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
electrical tilt 1		**frequency band 1**			**.....**			**frequency band M**		
		port 1	.....	port N	port 1	.....	port N	port 1	.....	port N
	Beam width 1	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	.....	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	Beam width L	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
.....		**frequency band 1**			**.....**			**frequency band M**		
		port 1	.....	port N	port 1	.....	port N	port 1	.....	port N
	Beam width 1	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	.....	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	Beam width L	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
max electrical tilt		**frequency band 1**			**.....**			**frequency band M**		
		port 1	.....	port N	port 1	.....	port N	port 1	.....	port N
	Beam width 1	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	.....	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	Beam width L	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude	Amplitude
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase

NOTE: Electrical tilts are sampled discretely in table A.2. If the electrical tilt required by primary device is not in table A.2, then RAE shall calculate and report a value according to the data in table A.2.

Annex B: Procedure sequence for file download and get weighting factor (Normative)

B.1 Procedure sequence for set weighting factors to a secondary device

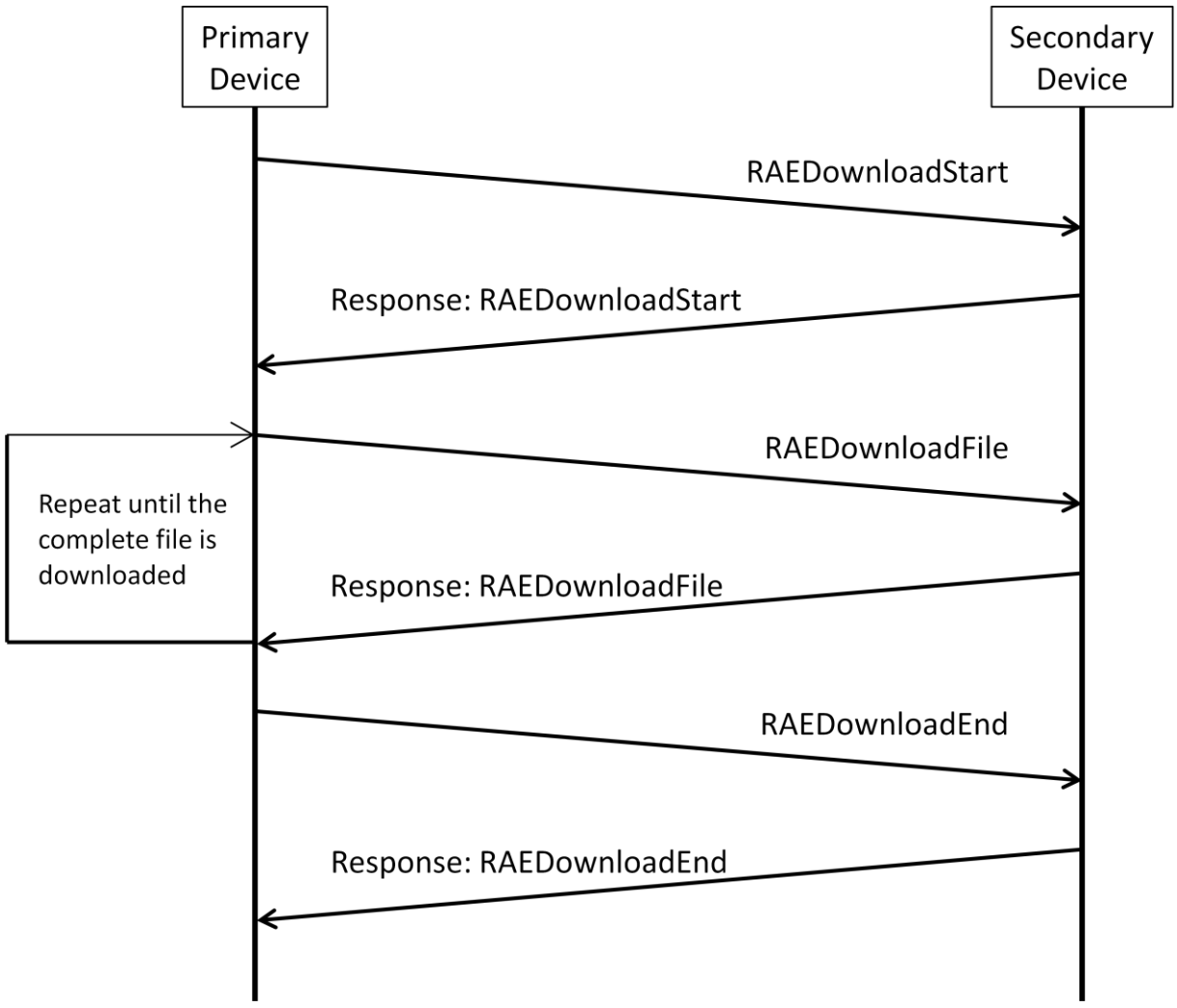

Figure B.1: Procedure sequence for RAE Download File

The data content of the RAE Download File message is implementation specific but it is recommended to support a file validity feature that shall minimize the risk of downloading faulty or invalid file.

B.2 Procedure sequence for Get Weighting Factors from a secondary device

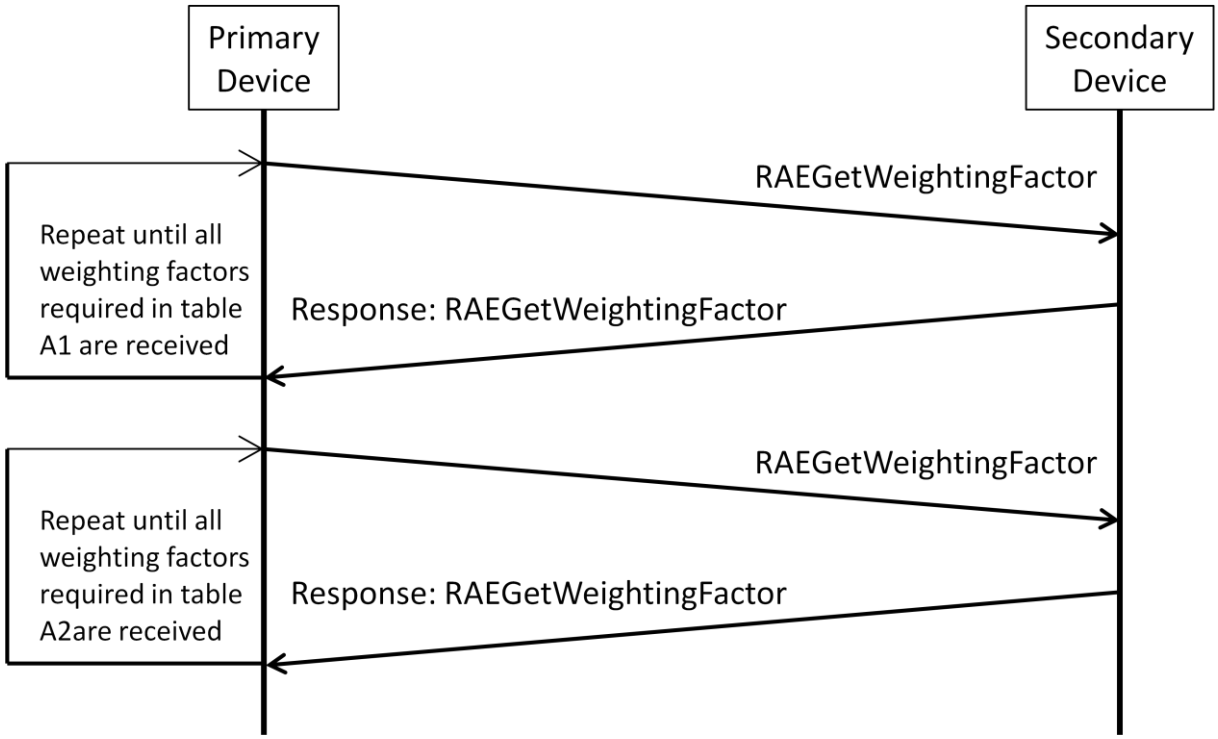

Figure B.2: Procedure sequence for Get Weighting Factors

First, the primary device shall send the command RAEGetWeightingFactor with field number 0x01 to 0x0A to the secondary device. The secondary device shall return the corresponding field number and field value, see Table A.1.

Then, the primary device shall send the command RAEGetWeightingFactor with field number 0x0B and include the electrical tilt, broadcast beam width and frequency band for which the weighting factors are inquired. The secondary device shall return the field number and the weighting factors.

B.3 Example for getting antenna weighting factors

The antenna weighting factors data in Table 2.1 are shown as part in table B.1 and table B.2, table B.1 and table B.2 are stored in the RAE device. A base station shall send RAEGetWeightingFactor command with field 0x01~0x0A to query the weighting factors information after the base station has connected to the RAE, then the RAE shall return the information highlighted in the table below:

The weighting factors of a broad range TD Smart Antenna @65°Broadcast Beam width

Vendor name	**Vendor x**								
Electrical tilt	**0°**								
Broadcast Beam width: 65°									
Frequency Range/port		**Port 1**	**Port 2**	**Port 3**	**Port 4**	**Port 5**	**Port 6**	**Port 7**	**Port 8**
1880M~1920M	**Amplitude |P|**	**0**	**0.45**	**1.00**	**1.00**	**0**	**0.45**	**1.00**	**1.00**
	Phase	**0**	**0**	**0**	**179.0**	**0**	**0**	**0**	**179.0**

TD_Smart_Antenna

Ver001

3 electrical tilt sample points: 0.0°, 3.0°, 6.0°

3 broadcast Beam widths: 30°, 65°, 90°

2 frequency bands: 2010~2025MHz, 1880~1920MHz

8 RF ports

70 mm space between antenna columns

The base station can check the antenna with the information above:

To query e.g. the weighting factors value of 0 deg tilt, 65 deg broadcast beam width, 1880~1920MHz frequency band, the base station will send RAEGetWeightingFactor command with field 0x0B and the field values 0, 65, 0x80, 0x07. The RAE will look up table B.2 and return the values: 0, 0, 45, 0, 100, 0, 100,1790, 0, 0, 45, 0, 100, 0, 100, 1790.

Table B.1: Weighting factors file structure

Field No. (Normative)	Length (octets) (Informative)	Format (Informative)	Description (Informative in HEX format)
0x01	24	ASCII	54 44 5F 53 6D 61 72 74 5F 41 6E 74 65 6E 6E 61 5F 48 75 61 77 65 69 00
0x02	24	ASCII	56 65 72 30 30 31 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0x03	1	8-bit unsigned	03 P
0x04	6	16-bit signed	00 00 1E 00 3C 00
0x05	1	8-bit unsigned	03 L
0x06	6	16-bit signed	1E 00 41 00 5A 00
0x07	1	8-bit unsigned	02 M
0x08	8	2 x 16-bit unsigned	DA 07 E9 07 58 07 80 07
0x09	1	8-bit unsigned	08 N
0x0A	2	16-bit unsigned	46 00
0x0B	3 x N x (L x M x P)	8-bit unsigned, 16-bit signed	See table B.2

Table B.2: Weighting factors data relation (HEX format)

		2010~2025MHz			1880~1920MHz							
		port 1	.....	port 8	port 1	port 2	port 3	port 4	port 5	port 6	port 7	port 8
0.0deg	30 deg	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	65 deg	Amp	Amp	Amp	0	2D	64	64	0	2D	64	64
		Phase	Phase	Phase	00 00	00 00	00 00	FE 06	00 00	00 00	00 00	FE 06
	90 deg	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
		frequency band 1			**1880~1920MHz**							
		port 1	**.....**	**port 8**	**port 1**	**port 2**	**Port 3**	**Port 4**	**Port 5**	**Port 6**	**Port 7**	**Port 8**
3.0deg	30 deg	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	65 deg	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	90 deg	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
		frequency band 1			**1880~1920MHz**							
		port 1	**.....**	**port 8**	**port 1**	**port 2**	**Port 3**	**Port 4**	**Port 5**	**Port 6**	**Port 7**	**Port 8**
6.0deg	30 deg	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	65 deg	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase
	90 deg	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp	Amp
		Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase	Phase

B.4 Antenna Pattern Introduction

Antenna Pattern Information can be stored in the RAE device.

Table B.3: Antenna Pattern data format

port x		frequency point 1				
		Azimuth 0°	Azimuth 1°	…	Azimuth 358°	Azimuth 359°
	min electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
	…	…	…	…	…	…
		…	…	…	…	…
	max electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
		frequency point …				
		Azimuth 0°	Azimuth 1°	…	Azimuth 358°	Azimuth 359°
	min electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
	…	…	…	…	…	…
		…	…	…	…	…
	max electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
		frequency point f				
		Azimuth 0°	Azimuth 1°	…	Azimuth 358°	Azimuth 359°
	min electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
	…	…	…	…	…	…
		…	…	…	…	…
	max electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase

Note: This pattern information is a 2D pattern in different frequency points and electrical tilts, which contains the amplitude and phase. The angle of the electrical tilt is an integer ranging from the minimum supported electrical tilt to the maximum supported electrical tilt as given in table 8.3.2. The azimuth value is form 0° to 359°, and the step size of azimuth is 1°.

B.5 Antenna Pattern File format for reference

Antenna Pattern Information can be stored in the RAE device. As shown in table B5.1, each pattern is mapped to a specific frequency point of port x. The amplitude value E refers to the linear far field strength (V/m) normalized to the maximum value in the pattern

Table B5.1: Antenna Pattern data format < Amplitude (|E|*100), Phase (0.1 deg)>

port x		frequency point 1				
		Azimuth 0°	Azimuth 1°	…	Azimuth 358°	Azimuth 359°
	min electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
	…	…	…	…	…	…
		…	…	…	…	…
	max electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
		frequency point …				
		Azimuth 0°	Azimuth 1°	…	Azimuth 358°	Azimuth 359°
	min electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
	…	…	…	…	…	…
		…	…	…	…	…
	max electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
		frequency point f				
		Azimuth 0°	Azimuth 1°	…	Azimuth 358°	Azimuth 359°

	min electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase
	…	…	…	…	…	…
		…	…	…	…	…
	max electrical tilt	Amplitude	Amplitude	…	Amplitude	Amplitude
		Phase	Phase	…	Phase	Phase

This pattern is a 2D pattern in different frequency points and electrical tilts, which contains amplitude and phase. The sample points of the electrical tilt values are integer values ranging between the min electrical tilt and max electrical tilt of the antenna as referenced in table A.1, field 0x04. The azimuth value ranges from 0°to 359°, and the step length of azimuth is 1°. As shown below, 0°direction of azimuth is the antenna reference axis x.

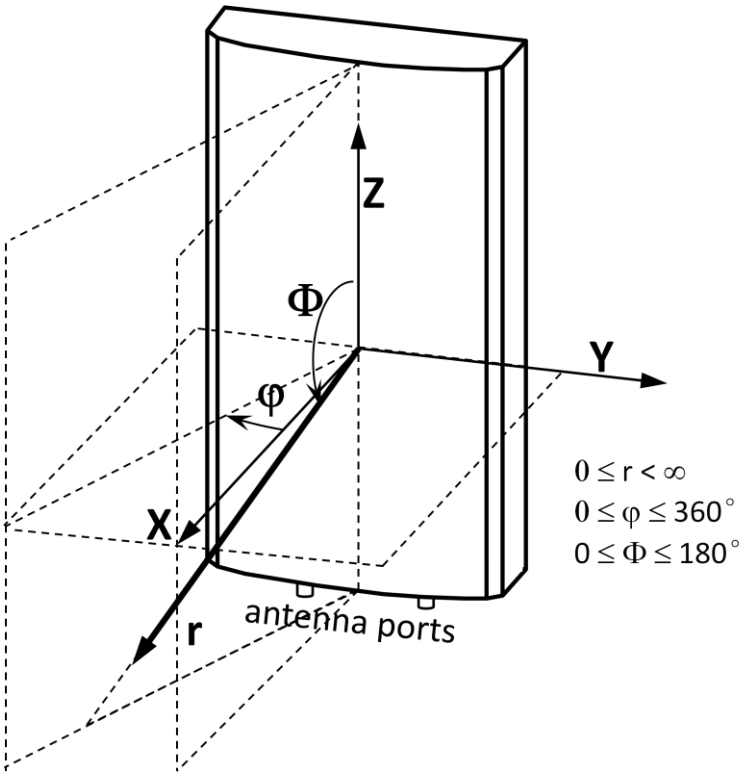

Figure B5.1: Antenna spherical coordinates

Pattern structure

An antenna pattern of port x is described above. According to binary storage format, the pattern structure includes two parts, as shown in Table B5 2.

Table B5.2: Pattern file structure

Pattern Name
Pattern Version
Port X
Operating Band of Port X
Number of Frequency Points
Frequency Point Values
Number of Electrical Downtilt sample points
Electrical Downtilt Values
Pattern Data (Amplitude and Phase)

Pattern File Format

A antenna pattern file may contain one or more port patterns. Figure B.5.3 shows, an entire pattern file format for reference, ach pattern from port 1 to port N has the same structure as described above.

Table B.5.3: Pattern file format

Pattern File Name
Pattern File Version
Pattern File Type
Pattern Information Number N
Port 1 Pattern offset address
…
Port N Pattern offset address
Port 1 Pattern
…
Port N Pattern

Annex C: A sample of a broadcast beam weighting factors file (Informative)

Weighting factors file structure

The structure of the weighting factors file is a black-box for the primary device, and the file structure is flexible for every RAE device. However, RAE devices must comply with the commands of the RAE specific protocol. Based on the commands of the RAE specific protocol, the primary device can get the weighting factors by communicating with the RAE device.

The structure of the weighting factors file which we designed includes two primary parts: The weighting factor header and the weighting factor data. It is shown as follow:

Table C1: Example of the weighting factors file structure

Weighting factors file name
Weighting factors file version number
Number of electrical downtilt entries
Number of broadcast beam width entries
Number of frequency bands
Number of RF ports
Antenna advanced parameters: space between antenna columns
Specified electrical downtilt values
Specified broadcast beam width values
Specified frequency bands
Weighting Factors Data

Weighting factors information

In the example, weighting factors file information include:

Weighting factors file name: HW_TD_WT_DEMO
Weighting factors file version number: Ver001
Number of electrical downtilt entries: 4
Number of broadcast beam width entries: 2
Number of frequency bands: 3
Number of RF ports: 8
Antenna advanced parameters: space between antenna columns: 70 mm
Specified electrical downtilt values: 0, 40, 70, 90 (0.1 deg)
Specified broadcast beam width values: 30, 65 deg
Specified frequency bands: 1880~1920, 2010~2025, 2500~2690 MHz
Weighting factors data

Rules of data storage

Little endian order is used for storage, octet align without pad data.

The weighting factors data consist of an amplitude value (1 octet) and a phase value (2 octets). The weighting factors table is four-dimensional, comprising electrical downtilt, broadcast beam width, frequency band number and RF port number as the dimensions.

The four-dimensional weighting factor data is sequential for storage in the weighting factors file.

For example, in the weighting factor file, the data Amplitude[i][j][k][l](1Octet) is stored in octet at the position of data[t], and the Phase[i][j][k][l](2Octets) is stored at the position of data[t+1](low part) and data[t+2](high part). The parameter i, j, k and l represent the 4 dimensions of downtilt, beam width, frequency and port number. The value of t is computed as:

t = HEAD+[(i*beam_num*freq_num+j*freq_num+k)*port_num+l]*3(Octet)

Note: beam_num, freq_num and port_num are the total number of broadcast beam width entries, number of frequency band entries and number of RF ports, and HEAD is the length of the weighting factor file head.

In this given example, the HEAD is 78 Octet, and the Weighting Data are 4x2x3x8x3octets=576 Octet, the complete file size is 654 Octet.

Parse weighting factors file (Example)

Weighting factor header

1: Weighting factors file name: HW_TD_WT_DEMO

2: Weighting factors file version number: Ver001

3: Number of electrical downtilt entries: 4
Number of broadcast beam width entries: 2
Number of frequency bands: 3
Number of RF ports: 8
Antenna advanced parameters: space between antenna columns [mm]: 70 (46 HEX).

4: Specified electrical downtilt values [0.1 deg]: 0, 40, 70, 90

5: Specified broadcast beam width values [deg]: 30, 65 [1E HEX, 41 HEX]

6: Specified frequency bands [MHz]: 1880~1920, 2010~2025, 2500~2690

Weighting factor data (Normalized power amplitude in [%], phases in [deg]

7: Weighting factors data for downtilt 0 (0.1 deg), broadcast beam width 30 deg, frequency band 1880~1920 MHz.

Amplitude	68	100	100	65	68	100	100	65
Phase	0	-10	20	30	0	-10	20	30

8: Weighting factors data for downtilt 0 (0.1 deg), broadcast beam width 30 deg, frequency band 2010~2025 MHz.

Amplitude	61	100	100	60	61	100	100	60
Phase	0	0	20	-20	0	0	20	-20

9: Weighting factors data for downtilt 40 (0.1 deg), broadcast beam width 65 deg, frequency band 2500~2690 MHz.

Amplitude	35	65	100	100	35	65	100	100
Phase	0	-1720	60	100	0	-1720	60	100

10: Weighting factors data for downtilt 90 (0.1 deg), broadcast beam width 65 deg, frequency band 2500~2690 MHz.

Amplitude	32	63	100	100	32	63	100	100
Phase	0	-1780	0	30	0	-1780	0	30

Annex D: File Types for RAE Upload and Download Procedures (Normative)

Table D.1: File Types for Secondary Devices

Code	Name	Comment	Download Mode State
0x04	Weighting Factors File	Contains data that have no operational impact within the secondary device.	
0x05	Antenna Pattern File	Contains the antenna radiation pattern data	

Note: RAE uses file types 0x04 and 0x05. Other file types are described for sake of completeness.

Annex E: Example of a beam forming antenna (Informative)

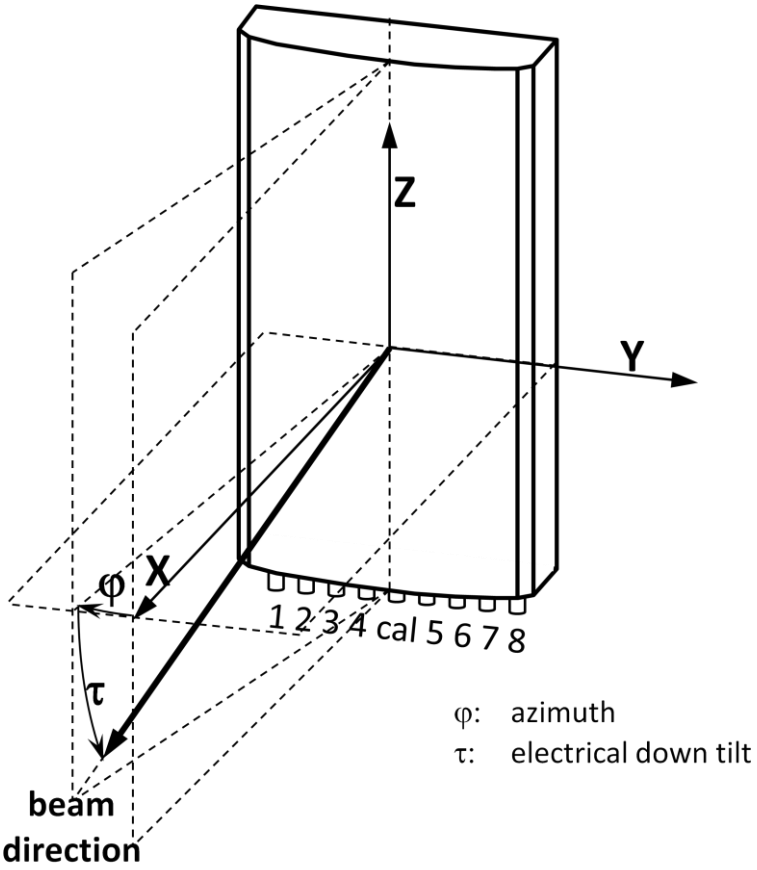

Figure E.1: Smart Antenna with 8 RF ports and 1 calibration port

Note: When using a beam forming antenna, the base station needs to be configured with the right weighting factor information to form the desired beam.