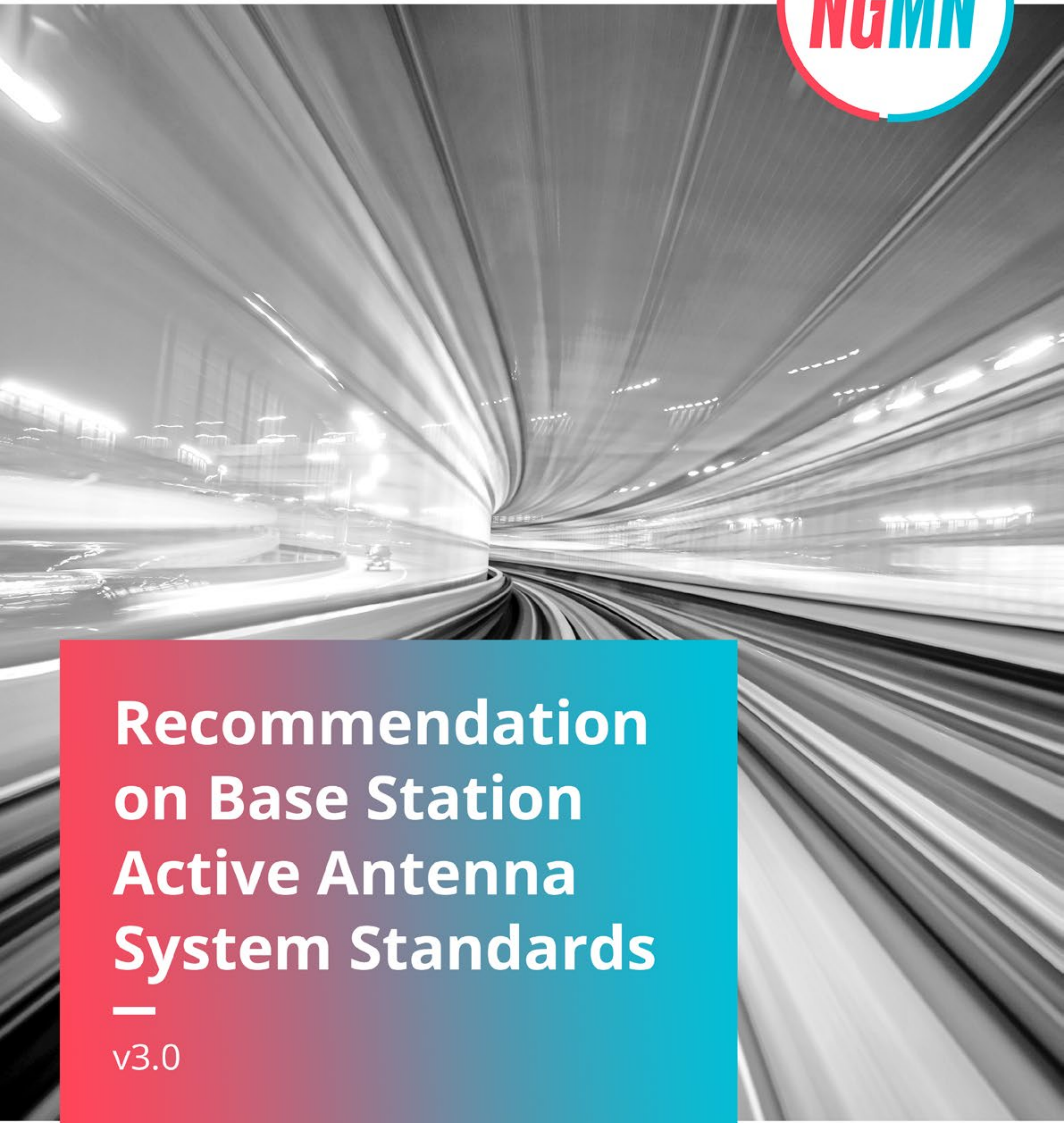

Recommendation on Base Station Active Antenna System Standards

v3.0

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RECOMMENDATION ON BASE STATION ACTIVE ANTENNA SYSTEM STANDARDS

by NGMN Alliance

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ABSTRACT

The current release of the publication provides recommendations on standards for parameters describing an Active Antenna Systems (AAS). Specifically, electrical, mechanical and Electromagnetic Field (EMF) exposure related parameters and a format for electronic data exchange are introduced.

DOCUMENT HISTORY

Date	Version	Author	Changes
07/09/2023	V 3.0	NGMN	• Added Section 7 "Hybrid Passive and Active Antenna Systems" • Added Annex B for description of Hybrid Passive and Active Antenna Systems • Completely revised the section relevant to Coordinate systems. The spherical polar coordinate system is adopted for descriptions within this WP, other coordinate systems are allowed for the descriptions of parameters. • Added Paragraph 3.3.5 – Dynamic Range • Added Paragraph 3.3.6 Minimum Configurable Total Output Power • Added paragraph 3.1.16 Front to Back • Appendix G revised and extended

CONTENTS

01 INTRODUCTION AND PURPOSE OF DOCUMENT

1.1 PREFACE

The main scope of the present document is to describe and capture the electrical and mechanical key performance parameters of Active Antenna System (AAS) and how to exchange this data electronically.

In addition, for the purpose of complying with RF-EMF exposure regulation requirements, mechanisms to monitor and limit the power radiated by AAS are described.

The topic related to Hybrid Passive and Active Antennas (HPAA) systems is addressed in section 7. An informative annex (see APPENDIX B 10) is provided in the current release of the WP to anticipate the matter of a typical deployment scenario for AAS.

Coordinate System approach has been revised. The Spherical Coordinate System (SPCS_Polar) is adopted for descriptions and explanations in the White Paper; other Co-ordinate Systems are described and allowed to be used, as an example for quantification of parameters or generation of the radiation patterns. The Coordinate System adopted for parameter quantification shall be indicated.

Information and data reported in this document are independent of frequency bands and duplex method (FDD/TDD). Reference to specific frequencies is indicated where relevant for the specification of the parameter or information to be reported.

The reader must be familiar with the NGMN BASTA document titled: “Recommendations on Base Station Antenna Standards” [1].

1.2 INTRODUCTION

Space Division Multiplexing Access (SDMA) technologies are widely considered in the industry to be key enablers for coping with increasing capacity demand. AAS are key technologies for SDMA in next generation mobile communication networks. Such systems allow dynamic beam steering by using multiple technology options (e.g. MIMO, M-MIMO, or beamforming etc.) whose influence on coverage, capacity and QoS is extensive. The purpose of this WP is to provide a comprehensive hands-on document for operating, validating and measuring AAS base stations.

In particular, the following topics are covered:

- Definitions of relevant AAS electrical and mechanical parameters
- EMF monitoring parameters
- A format definition for the electronic transfer of AAS specifications described in Section 3
- Recommended Test States that would allow operators to test antennas in lab or site
- Recommended 3D radiation pattern format

AAS Datasheet shall be written also in XML format according to the XML Schema Definition (XSD) that is provided together with the WP (see Section 17.1).

Furthermore, a format for antenna far-field radiation pattern file(s) is provided.

1.3 INTERPRETATION

In order to describe compliance with this document, certain words are used, while others indicate directive enforcement. Key words used in the paper are:

- Shall: indicates requirements or directives strictly to be followed in order to conform to this paper and from which no deviation is permitted.
- Shall, if supported: indicates requirements or directives strictly to be followed in order to conform to this whitepaper, if this requirement or directives are supported and from which no deviation is permitted.
- Should: indicates that among several possibilities, one is recommended as particularly suitable without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (should equals is recommended).
- May: is used to indicate a course of action permissible within the limits of this whitepaper
- Can: is used for statements of capability.
- Mandatory: indicates compulsory or required information, parameter or element.
- Optional: indicates elective or possible information, parameter or element

1.4 ABBREVIATIONS

The abbreviations used in this WP are written out in the following table.

Table 1.1: Acronyms and abbreviations table

Abbreviation	Definition
3GPP	3rd Generation Partnership Project
AAS	Active Antenna System
AR	Angular Region
BBU	Base Band Unit
BERP	Broadcast Envelope Radiation Pattern
BS	Base Station
CPD	Cross-Polar Discrimination
DL	Down Link
EBB	Eigen Based Beamforming
EIRP	Equivalent Isotropic Radiated Power
EL	Elevation
EMF	Electromagnetic Field
ETSI	European Telecommunication Standards Institute
FF	Far-Field
FDD	Frequency Division Duplex
GoB	Grid of Beams
HPAA	Hybrid Passive and Active Antenna
HPBW	Half-Power Beamwidth
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronic Engineers
LHCP	Left-Handed Circular Polarization
MIK	Mechanical Installation Kit
M-MIMO	Massive MIMO
MIMO	Multiple Input/Multiple Output
MU-MIMO	Multi User MIMO
MTBF	Mean Time Between Failures
N/A	Not Available or Not Applicable
NGMN	Next Generation Mobile Network Alliance
NR	New Radio
O&M	Operation and Maintenance
PAS	Passive Antenna System
P-BASTA	Project Base Station Antennas
PCF	Polarization correlation factor
PDF	Probability Distribution Function
QoS	Quality of Service

Abbreviation	Definition
RDN	Radio Distribution Network
RF	Radio Frequency
RHCP	Right-Handed Circular Polarization
RXU	Receiver Unit
SPCS	SPherical Coordinate System
SPCS_Geo	SPherical Coordinate System Geographics
SPCS_CW	SPherical Coordinate System Clockwise
SPCS_CCW	SPherical Coordinate System Counterclockwise
SPCS_Polar	SPherical Coordinate System Polar
SDMA	Space Division Multiplexing Access
SI	System International
SU-MIMO	Single user MIMO
TDD	Time Division Duplex
TERP	Traffic Envelope Radiation Pattern
TR	Technical Report
TRX	Transceiver
TRXUA	Transceiver Unit Array
TXU	Transmitter Unit
TS	Technical Specification
UE	User Equipment
UL	Up Link
VNA	Vector Network Analyzer
WP	White Paper
XML	eXtensible Markup Language
XPD	see CPD

1.5 REFERENCES

[1] NGMN "Recommendations on Base Station Antenna Standards v12.0"

[2] IEEE Std. 145-2013 Standard definitions of Terms for Antennas

[3] 3GPP TS 38.104 NR; Base Station (BS) radio transmission and reception

[4] Antenna Interface Standards Group Base Standard AISG v3.0 v3.0.2.1

[5] Report ITU-R M.2334-0 (11/2014) Passive and active antenna systems for base stations of IMT systems

[6] Constantine A. Balanis, Antenna Theory: Analysis and Design, 4th Edition, ISBN: 978-1-118-64206-1 February 2016

[7] Simon Ramo, John R. Whinnery, Theodore Van Duzer, Fields and Waves in Communication Electronics, 3rd Edition ,ISBN: 978-0-471-58551-0, March 1994

[8] 3GPP TS 38.141-2 Base Station (BS) conformance testing. Part 2: Radiated conformance testing

[9] IEC TR 62232: 2022, Edition 3.0 - Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure (106/511/CD of 2019-12-20)

[10] 3GPP TS38.214; Technical Specification Group Radio Access Network; NR; Physical layer procedures for data (Release 17)

[11] 3GPP TS 37.105 V18.1.0 (2023-03), Technical Specification Group Radio Access Network; Active Antenna System (AAS) Base Station (BS) transmission and reception (Release 18)

[12] 3GPP TS 37.104 NR, E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception

[13] 3GPP TS 37.145-2 Active Antenna System (AAS) Base Station (BS) conformance testing, Part 2: radiated conformance testing

[14] IEC TR 62669: 2019 - Case studies supporting IEC 62232 - Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure

[15] B. Thors, A. Furuskär, D. Colombi, and C. Törnevik, "Time-averaged Realistic Maximum Power Levels for the Assessment of Radio Frequency Exposure for 5G Radio Base Stations Using Massive MIMO," IEEE Access, Vol. 5, pp. 19711-19719, September 18th, 2017

[16] P. Baracca, A. Weber, T. Wild, and C. Grangeat, "A Statistical Approach for RF Exposure Compliance Boundary Assessment in Massive MIMO Systems," International Workshop on Smart Antennas (WSA), Bochum (Germany), Mar. 2018, arxiv.org/abs/1801.08351

[17] IEC 60529 Degrees of Protection Provided by Enclosures (IP CODE)

[18] ETSI ES 202 706-1 V1.6.1 (2021-01), Environmental Engineering (EE); Metrics and measurement method for energy efficiency of wireless access network equipment; Part 1: Power consumption - static measurement method

[19] 3GPP TS 38.211 Physical channels and modulation

[20] AISG Standard Antenna Port Colour Coding V3.2., Antenna Interface Standards Group Antenna Port Colour Coding Standard AISG-APC v3.2.1, 7th of May, 2018

[21] ISO 8601 “Data Elements And Interchange Formats. Information Interchange. Representation Of Dates And Times (British Standard)”, 2004

Note: Where not specified, the latest version of the document apply.

02 DEFINITIONS

This section contains the definitions used throughout this WP.

2.1 PASSIVE AND ACTIVE ANTENNA SYSTEMS DEFINITION

Unless otherwise stated, definitions from [1] and [2] by IEEE and NGMN, respectively, applies.

The scope of this Section is to contribute to give a functional description of antenna systems for mobile cellular networks, setting the boundary between passive and active antenna systems

3GPP [3], in base station type BS-Type 1-C, clearly defines the interface between BTS and passive antenna namely as radio frequency (RF)-interface, Figure 2.1. However, a definition of passive antenna is not given and the antenna block is not shown in the diagram.

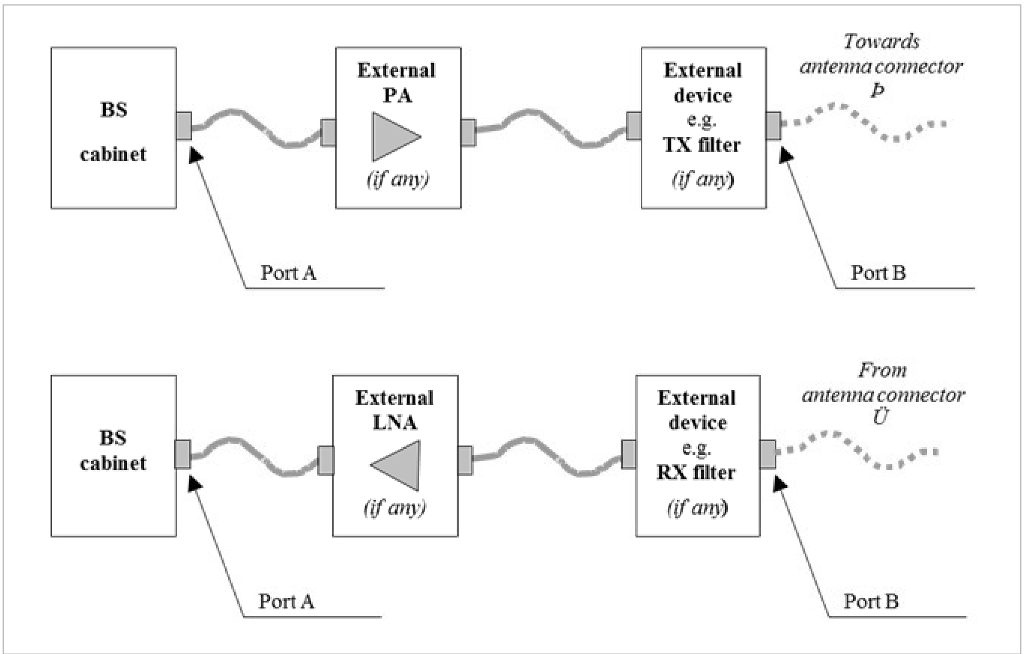


Figure 2.1: 3GPP BS-Type 1-C

A Passive Antenna is a device which performs the function to transform conducted RF signals to electromagnetic field over the air (to form radiation patterns) and vice versa, with assigned phases and amplitudes. It is composed of:

- NxM Antenna Array, with N≥1, M≥1
- Radio Distribution Network (RDN), optionally including Remote Electrical Tilt (RET) device

For instance, for the purpose of network planning, passive BTS antennas offer the possibility to setup a so called down tilt [1]. This means that PAS has the capability to point the radiation pattern within a range in the elevation plane for the purpose of coverage optimization. The down tilt adjustment is performed by sending commands remotely through the AISG interface [4]. Those drive Remote Electrical Tilt devices installed in the passive antenna which allow electromechanical adjustment of the phase shifter few times over the whole antenna lifetime [5].

The mechanical adjustment of the phase path is performed in the Radio Distribution Network (RDN) which is not defined in BS-Type 1-C. This is defined in BS-Type 1-H, Figure 2.2, as “the RDN is a linear passive network which distributes the RF power generated by the transceiver unit array to the antenna array, and/or distributes the radio signals collected by the antenna array to the transceiver unit array, in an implementation specific way”. The simplest implementation consists in a one-to-one TAB port to single antenna element connection.

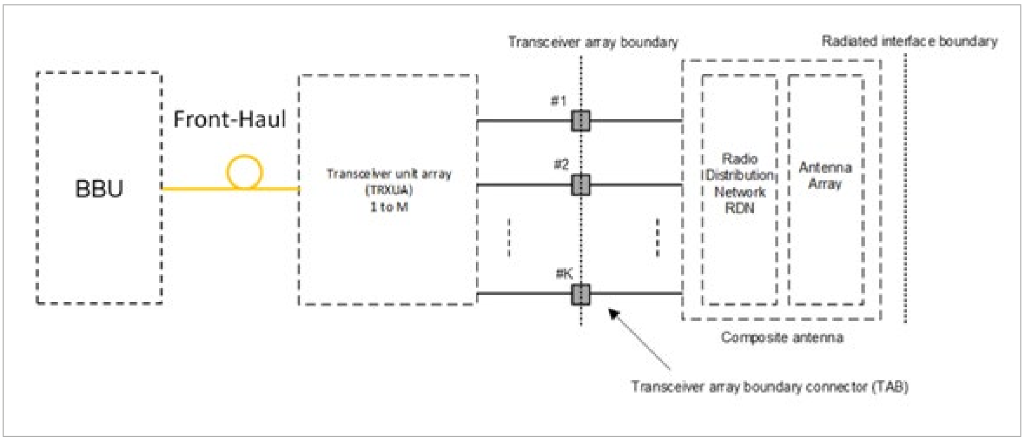


Figure 2.2: BS-Type 1-H and BBU

The RDN is passive - Figure 2.2 – and the RDN and Antenna Array form the so-called Composite antenna which can be still accessible via a radio frequency (RF)–Interface through the Transceiver Array Boundary (TAB) connector.

Following this definition path, the Composite antenna is a passive antenna. For instance, at the TAB conducted measurements of the Composite antenna can be performed. Through the TAB, the Composite antenna supports real time beam steering to enable SDMA applications.

Indeed, through the TRXUA the composite antenna can be fed with assigned phases and amplitudes at TAB resulting in different radiation patterns.

Precisely, the Base Band Unit (BBU) can handle multiple users by calculating the optimal phases and amplitudes also known as pre-coders in real time. Goal is to optimize network performance by load control and advanced interference management. This means that the BBU represents the core intelligence, the TRXUA and Composite antenna the supporting devices.

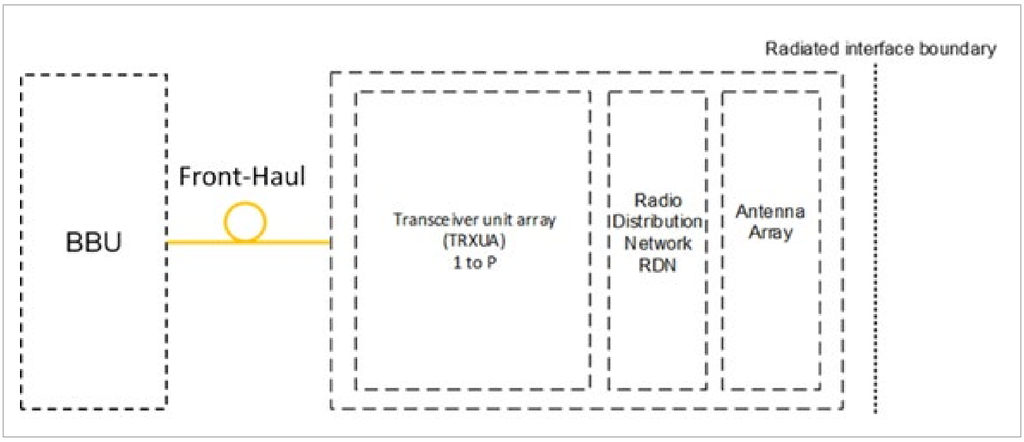


Figure 2.3: BS-Type 1-O and 2.O combined with BBU

In 3GPP BS-Type 1-O (at least 8 TRXUA) and 2-O - Figure 2.3 – TRXUA, RDN and AA are fully integrated. In this case conducted measurements for the Composite antenna are not possible. Only Over the Air (OTA) measurements through the Radiated interface boundary are possible as the RF-Interface is no longer available.

This is an AAS, which integrates TRXUA, RDN and Antenna Array together, and the interface to BBU is via a Front-Haul.
Similarly, to the BS-Type 1-H the AAS is the supporting device and the BBU is the core intelligence, Figure 2.3.

Summarizing, in BS-Type 1-C and 1-H, there is no passive antenna definition where the concept of Composite antenna as combination of RDN and Antenna Array is introduced. In BS-Type 1-O and 2-O, AAS is defined.

Here below a comprehensive definition of a Passive Antenna (PA) will be introduced, derived from the functional blocks introduced by 3GPP: Antenna Array, RDN and RET.
Basic concepts of passive antenna element and their combinations in Arrays will be reviewed and their functional relations discussed.

Passive Antennas basic definitions

Specifically considering radio waves, which are a type of electromagnetic (EM) radiation with wavelengths in the electromagnetic spectrum longer than infrared light (3kHz to 300GHz), one can derive a more practical definition of passive antenna element for telecommunication industry: a passive antenna element is a device which transforms radio frequency (RF) signals to radio waves and vice versa. The RF-Signals generator – TRXUA - is connected to the passive antenna element by an RF-interface. Figure 2.4 shows a function schematic of a passive antenna.

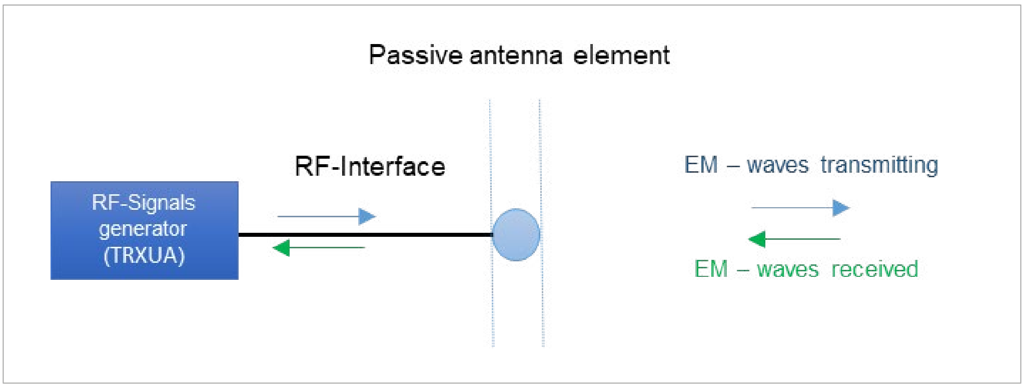


Figure 2.4: Passive antenna element functional block

Radio waves can be combined in patterns produced by multiple passive antenna elements properly distributed in space. For this reason, this definition is easily extendible to groups of passive antenna elements which are best represented by means of NxM-matrixes also called in common technical language "Array". Matrixes are linear operators which also transform the state of a system to another state.

This means that Arrays, have the capability transform RF-signals distributed over all elements (Matrixes entries) to radio waves to form combined radiation patterns. Similarly, to the single passive element, the passive Array is connected to the RF-Signals generation via an RF-interface. Also, in this case the RF-Signals are distributed over the passive antenna elements via a RDN, Figure 2.3.

Arrays can be best described by classical antenna theory [6]. For the purpose of a functional description and without losing on generality – radio waves are linear - we consider a uniform linear Array [6], Figure 2.5. By observing the antenna radiation pattern in the far field region, waves from antenna element can be treated as plane waves, and the rays theory applies.

In this setup N is the number of elements, d the spacing between the elements, θ the radiation pattern direction which can be changed by properly choosing the phase difference between the radiating elements and superimposing the elements patterns into the far-field region [6], Figure 2.5(a). As an example, in Figure 2.5(b), it is shown the change of radiation pattern when increasing linearly the number of elements when all the passive antenna elements use the same phase/amplitude.

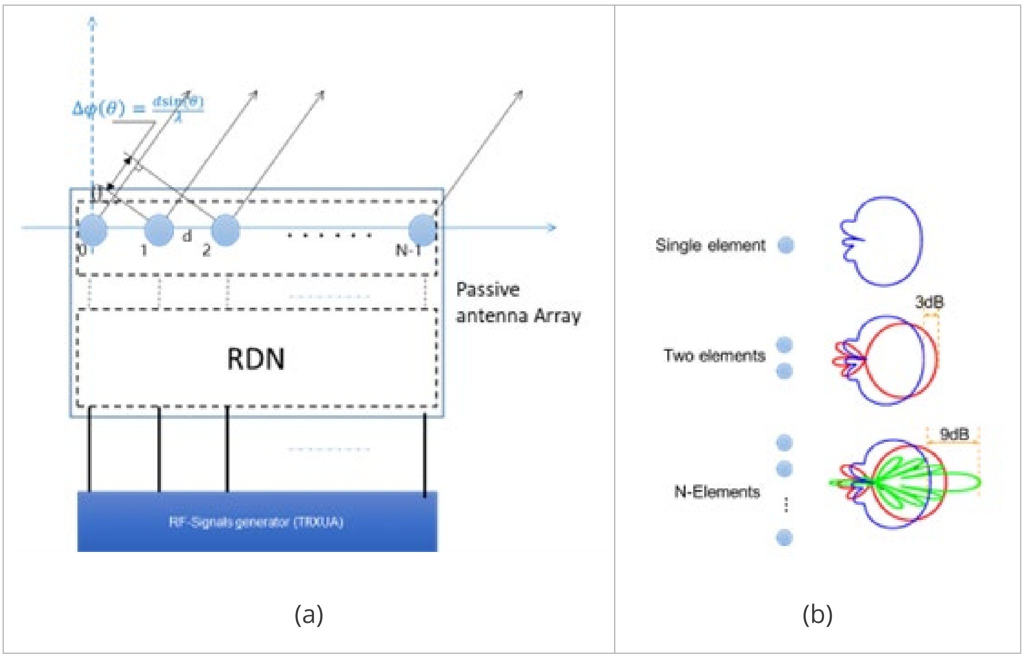
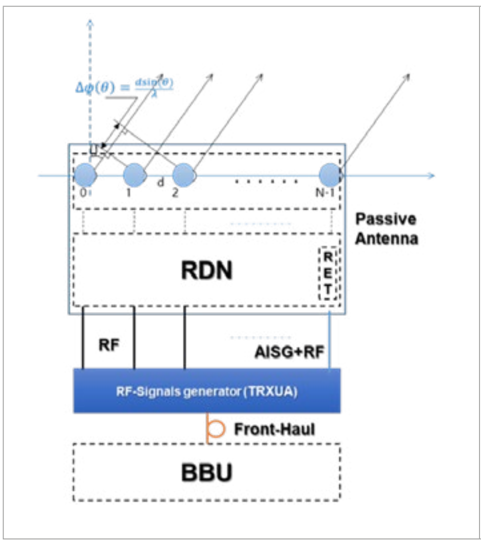


Figure 2.5: (a) Passive Antenna Array. (b) Example of radiation pattern changing when increasing the number of radiating elements

For the functional view point the passive antenna array is composed by the antenna array and RDN. In the case shown in Figure 2.5(a) then, the RDN is simply composed by RF- transmission lines connecting one to one the passive antenna elements of the array to the RF-signals from/to the TRXUA thought an RF-Interface. This concept, considering the linearity, can be extended to more complex RDN architectures in which, for design purposes, hardware coded phase and amplitudes distribution can be implemented, multiple antenna elements can be grouped, etc. Also, in this case the RDN functionality is identical, linear and reciprocal.

Along this path a passive antenna array is device which supports the function to transform the RF-signals from/to the TRXUA through an RF-interface with assigned phases and amplitudes to radiation patterns and vice versa. Similarly, to BS-Types discussed above, the BBU handles multiple users and calculates phase and amplitudes in real time to minimize the interference in the network, Figure 2.6.



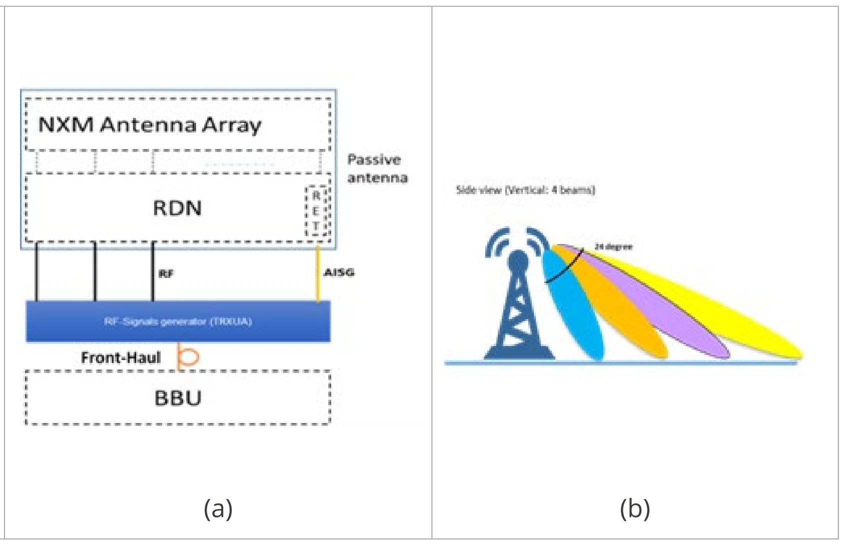


Figure 2.6: Passive Array with TRXUA and BBU

Figure 2.7: (a) Passive Antenna with integrated RET device. (b) Down Tilt example

As was mentioned in the introduction, for the case of passive BTS antennas, it is convenient to offer the possibility to change the down tilt value for the goal of optimizing network performance [5], Figure 2.7(b). The down tilt adjustment is implemented by Remote Electrical Tilt devices controlled over the AISG interface [4]. The RET is controlling the phase shifters according to AISG input - see Figure 2.7(a).

The RET device, combined with the RDN, supports the functionality to change the effective physical path of the RF-signals, affecting therefore the elevation beam pointing direction to allow coverage planning. This is a hardware functionality which enables the RDN to be reconfigured for several coverage scenarios.

2.2 ANTENNA REFERENCE COORDINATE SYSTEM

2.2.1 CARTESIAN COORDINATE REFERENCE SYSTEM – CCRS_CARTESIAN

The Cartesian Coordinate Reference System (CRS) adopted in this White Paper is shown in Figure 2.8.

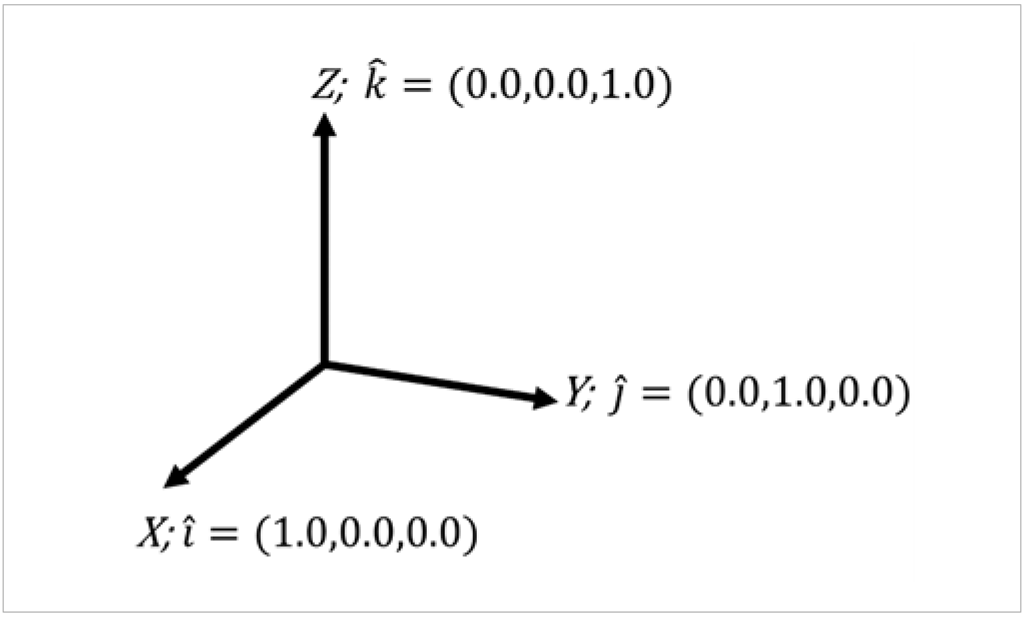


Figure 2.8: The Cartesian Coordinate System (CCRS) adopted in this White Paper

Relations between vectors of the coordinate system are:

$$\hat{\imath} \cdot \hat{\jmath} = \hat{\imath} \cdot \hat{k} = \hat{\jmath} \cdot \hat{k} = 0.0 \tag{2.1}$$

$$\hat{\imath} \times \hat{\jmath} = \hat{k} \tag{2.2}$$

$$\hat{\imath} \times \hat{k} = -\hat{\jmath} \tag{2.3}$$

$$\hat{\imath} \times \hat{k} = \hat{\imath} \tag{2.4}$$

The antenna is oriented to the CCRS_Cartesian as shown in Figure 2.9.

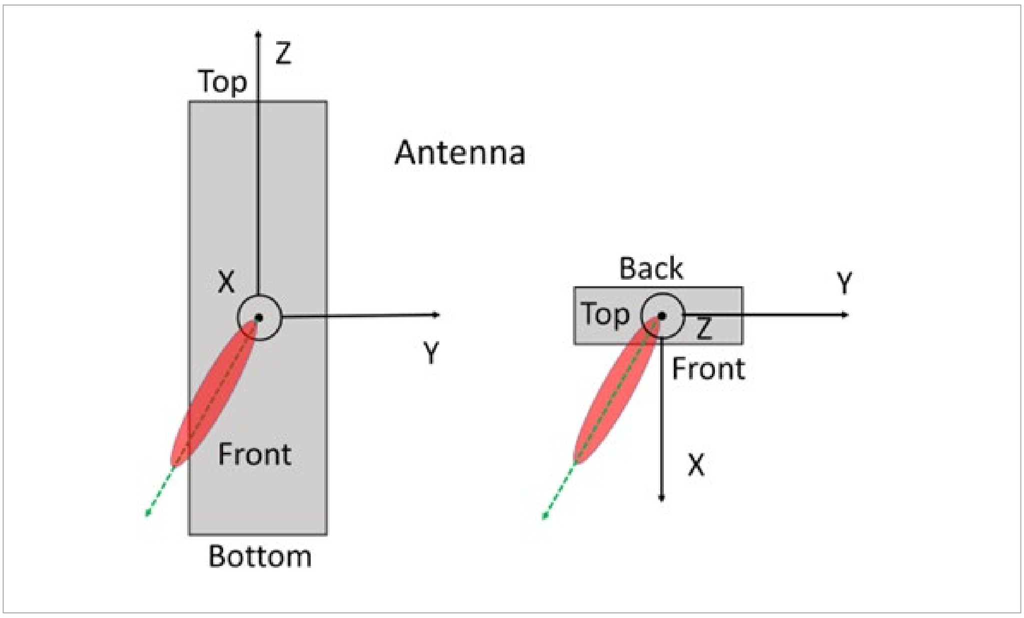


Figure 2.9: Antenna Positioning and Orientation in the CCRS_Cartesian

By considering the minimum parallelepiped including the antenna, with the front side corresponding to the half space where is located the maximum of the radiation, then:

- The top of the antenna corresponds to the positive Z axis
- The bottom of the antenna corresponds to the negative Z axis
- The front of the antenna is directed toward the positive X Axis
- The back of the antenna is directed toward the negative X Axis
- The sides of the antenna are directed toward the Y axis

2.3 SPHERICAL COORDINATE SYSTEMS

2.3.1 GENERAL

Associated to the CCRS_Cartesian there is a spherical coordinate system for representing points on a spherical surface for describing parameters and properties of the antenna. There can be multiple options to represent the angular coordinates, each one has pros and contra depending on the usage. The following criteria is adopted for describing angles in this White paper:

- The Spherical Polar Coordinate System (SPCS_Polar) is adopted in the body of the White Paper, see section 2.3.2.
- Other Spherical Coordinate System are available, described in the following sections, that can be adopted for specific uses, like the representation of the antenna's radiation pattern, see Annex G.
- The Spherical Coordinate System CRS for describing specific parameter or features in the Radiation Pattern file format (see Section 15) and XML data file (see Section 16) must be declared.

- To avoid ambiguities in the usage of different coordinate system, the following terminology convention is adopted:

- With the term “Elevation” or “Elevation Coordinate” is intended the angular coordinate that scans the sphere, on a half-circle, from the positive Z axis to the Negative Z axis or vice versa. The positive direction and limits are specific of the adopted SPCS. The symbol used for identifying the elevation direction is the Greek symbol ϑ or Θ or the term “Theta” or “theta”; where required the symbol or the term is complemented with a subscript indicating univocally the SCPS at which symbol or term is referred to.

- With the term “Azimuth” or “Azimuthal Coordinate” is intended the angular coordinate that scans the sphere on a circle at constant Z. The positive direction and limits are specific of the adopted SPCS. The symbol used for identifying the azimuth direction is the Greek symbol φ or Φ or the term “Phy” or “phy”; where required the symbol or the term is complemented with a subscript indicating univocally the SPCS at which symbol or term is referred to.

- With the term “radius” is intended the radius of the sphere centered at the origin of the SPCS. The radius starts from the center of the SPCS and ends to the point on the sphere’s surface. The symbol used for identifying the radius direction is the symbol r or R or the term “Radius” or “radius”; where required the symbol or the term is complemented with a subscript indicating univocally the SPCS at which symbol or term is referred to.

- A point P(x,y,z) on the sphere’s surface is represented by its elevation and azimuthal coordinates and radius: P(x,y,z) = P(r,ϑ,φ) = P(Radius,Θ,Φ) = P(radius,Theta,Phy) or any combination of symbols and terms. The same point can have different values for radius, elevation and azimuthal coordinates depending on the convention used by the adopted SPCS.

- Angles are expressed in degrees: a number followed by the symbol “°” or followed by the term “degs”. If the symbol or the term is missing the angle is intended in degrees.

- Other information relevant to specific usages of the adopted SPCS can be included in the extra information set specific for the XML (see Annex H) or 3drp.json (see Section 15 and Section 16).

In this White Paper the adopted SPCS is the Polar Coordinate System [6][7], as indicated in 2.3.2, indicated with the term SPCS_Polar, for describing angles in the body of this document.

2.3.2 SPCS_POLAR

The center of the SCS_Polar is placed at the (0.0, 0.0, 0.0) position of the CCRS_Cartesian, as shown in Figure 2.10.

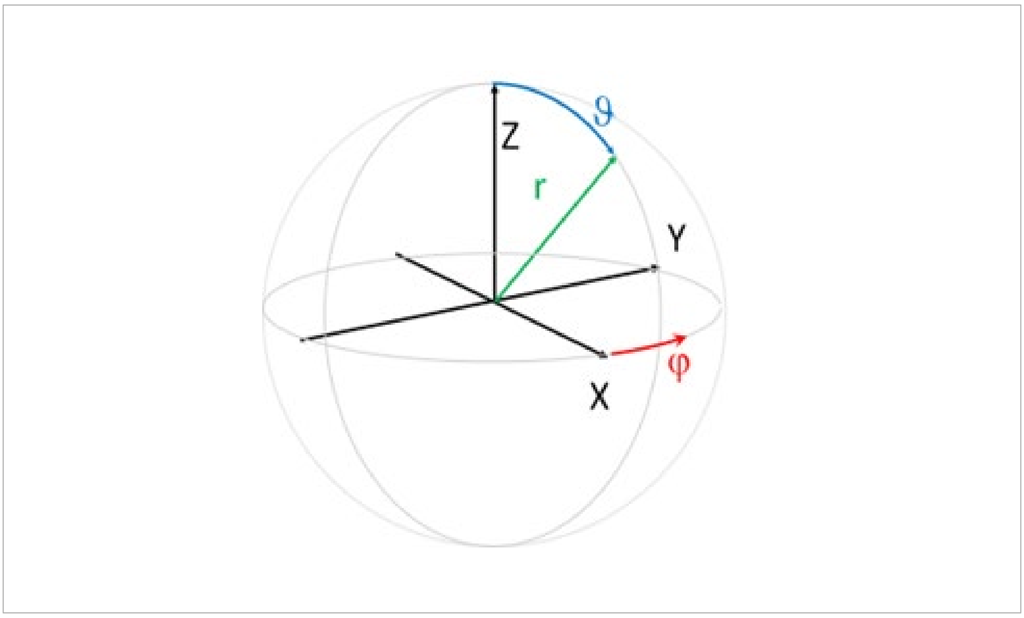


Figure 2.10: The Polar Coordinate System SPCS_Polar

In the SCS_Polar system

- r is the distance from the CRS centre to the point on the sphere, see the green arrow in Figure 2.10
- the ϑ angular coordinate ranges from 0.0° to 180.0° starting from the Positive Z axis toward the Negative Z axis (see the blue arrow in Figure 2.10). This coordinate is referenced as elevation
- The φ angular coordinate ranges from 0° to < 360° starting from the X axis counter clockwise looking downward from the Z Positive Axis (see the red arrow on Figure 2.10). This coordinate is referenced as azimuth.

The cartesian coordinates of a point on the sphere are given by

$$x = r \sin\vartheta \cos\varphi$$

$$y = r \sin\vartheta \sin\varphi$$

$$z = r \cos\vartheta \qquad (2.5)$$

2.3.3 SPCS_CW (CLOCKWISE)

The SPCS_CW is shown in Figure 2.11, it has the centre at the (0.0, 0.0, 0.0) position of the CCRS_Cartesian.

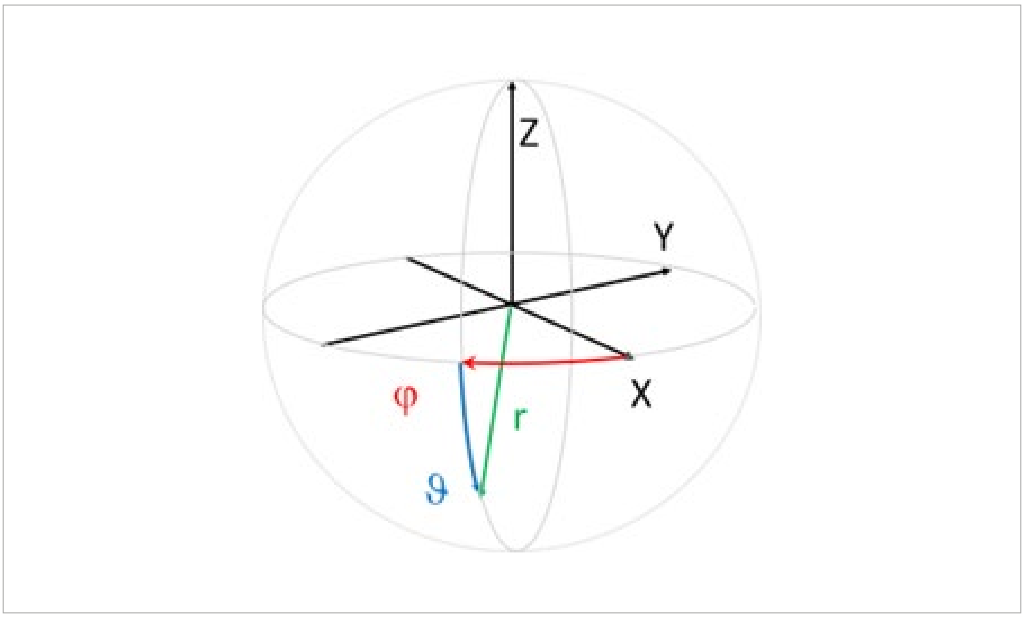


Figure 2.11: Antenna Reference Coordinate System SPCS_CW

In the SPCS_CW system:

- r is the distance from the SPCS_CW center (see the green arrow in Figure 2.11)
- the ϑ angular coordinate ranges from -90.0° to 90.0° starting from the Positive Z axis toward the Negative Z axis (see the blue arrow in Figure 2.11). This coordinate is referenced as elevation; the elevation coordinate assumes the value 0° on the XY plane at Z = 0.
- The φ angular coordinate ranges from 0° to < 360° starting from the X axis clockwise looking downward from the Z Positive Axis (see the red arrow in Figure 2.11).

The cartesian coordinates of a point are given by

$$x = r \sin(\vartheta + 90.0) \cos(360.0 - \varphi)$$

$$y = r \sin(\vartheta + 90.0) \sin(360.0 - \varphi)$$

$$z = r \cos(\vartheta + 90.0) \tag{2.6}$$

2.3.4 SPCS_CCW (COUNTERCLOCKWISE)

The SPCS_CCW is shown in Figure 2.12, it has the centre at the (0.0, 0.0, 0.0) position of the CCRS_Cartesian.

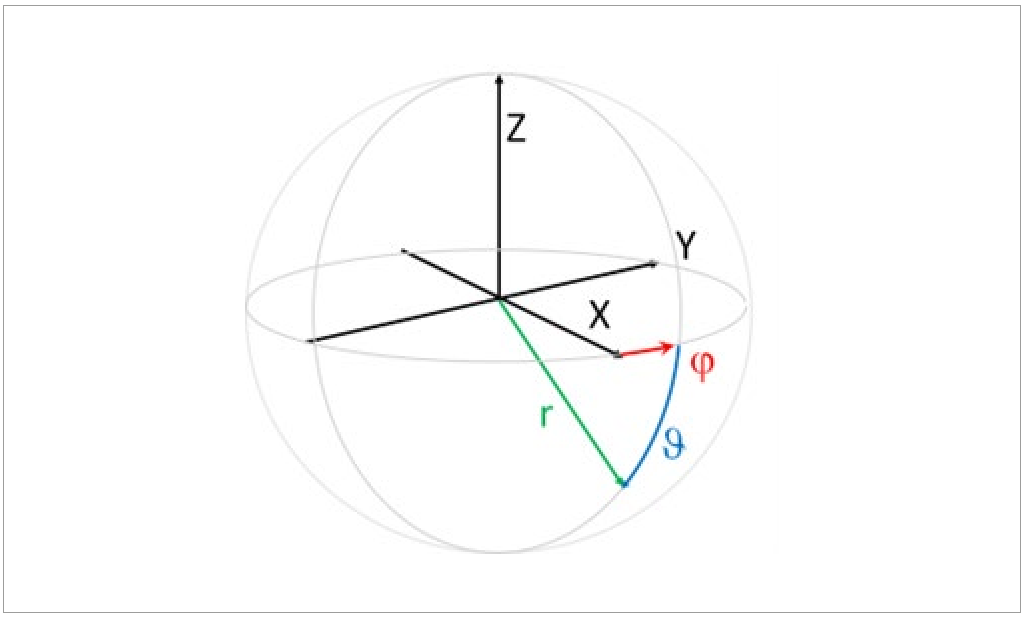


Figure 2.12: Antenna Reference Coordinate System SPCS_CCW

In the SPCS_CCW system

- r is the distance from the SPCS_CCW center (see the green arrow in Figure 2.12)
- The ϑ angular coordinate ranges from -90.0° to 90.0° starting from the Positive Z axis toward the Negative Z axis (see the blue arrow in Figure 2.12). This coordinate is referenced as elevation; the elevation coordinate assumes the value 0° on the XY plane at Z = 0.
- The φ angular coordinate ranges from 0° to < 360° starting from the X axis counterclockwise looking downward from the Z Positive Axis (see the red arrow in Figure 2.12).

The cartesian coordinates of a point are given by

$$x = r \sin(\vartheta + 90.0) \cos\varphi$$

$$y = r \sin(\vartheta + 90.0) \sin\varphi$$

$$z = r \cos(\vartheta + 90.0) \tag{2.7}$$

2.3.5 SPCS_GEO (GEOGRAPHICAL)

The SPCS_Geo is shown in Figure 2.13, it has the center at the (0.0, 0.0, 0.0) position of the CCRS_Cartesian.

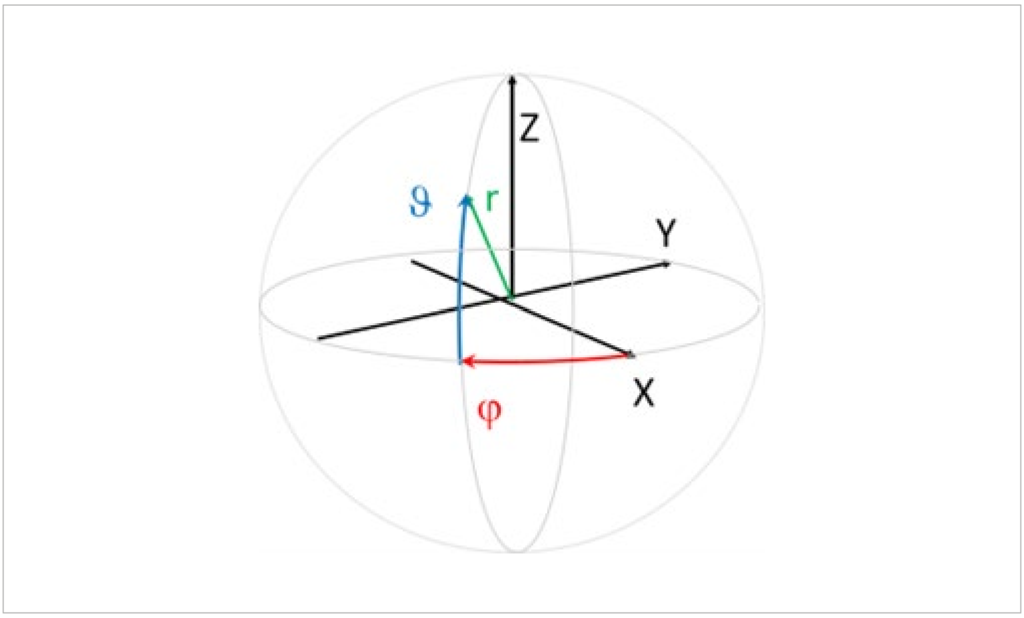


Figure 2.13: Antenna Reference Coordinate System SPCS_Geo

In the SPCS_Geo system

- r is the distance from the SPCS_Geo center (see the green arrow in Figure 2.13)
- the ϑ angular coordinate ranges from 90.0° to -90.0° starting from the Positive Z axis toward the Negative Z axis (see the blue arrow in Figure 2.13). This coordinate is referenced as elevation; the elevation coordinate assumes the value 0° on the XY plane at Z = 0.
- the φ angular coordinate ranges from 0° to < 360° starting from the X axis clockwise looking downward from the Z Positive Axis (see the red arrow in Figure 2.13).

The cartesian coordinates of a point are given by

$$
\begin{aligned}
x &= r \sin(90.0 - \vartheta) \cos(360.0 - \varphi) \\
y &= r \sin(90.0 - \vartheta) \sin(360.0 - \varphi) \\
z &= r \cos(90.0 - \vartheta)
\end{aligned}
\tag{2.8}
$$

2.3.6 RELATION BETWEEN SPCS, RELATION WITH BASTA PA 12.0 AND BASTA AA 2.0

The following Table 2.1 reports the angular relation between the SPCS

Table 2.1: Relations between angles among SPCSs described in Section 2.3

To From	SPCS_Polar	SPCS_CW	SPCS_CCW	SPCS_Geo
SPCS_Polar	—	$\vartheta_{SCS\ Polar} = \vartheta_{SCS\ CW} + 90$ $\varphi_{SCS\ Polar} = 360 - \varphi_{SCS\ CW}$	$\vartheta_{SCS\ Polar} = \vartheta_{SCS\ CCW} + 90$ $\varphi_{SCS\ Polar} = \varphi_{SCS\ CCW}$	$\vartheta_{SCS\ Polar} = 90 - \vartheta_{SCS\ Geo}$ $\varphi_{SCS\ Polar} = 360 - \varphi_{SCS\ Geo}$
SPCS_CW	$\vartheta_{SCS\ CW} = \vartheta_{SCS\ Polar} - 90$ $\varphi_{SCS\ CW} = 360 - \varphi_{SCS\ Polar}$	—	$\vartheta_{SCS\ CW} = \vartheta_{SCS\ CCW}$ $\varphi_{SCS\ CW} = 360 - \varphi_{SCS\ CCW}$	$\vartheta_{SCS\ CW} = -\vartheta_{SCS\ Geo}$ $\varphi_{SCS\ CW} = \varphi_{SCS\ Geo}$
SPCS_CCW	$\vartheta_{SCS\ CCW} = \vartheta_{SCS\ Polar} - 90$ $\varphi_{SCS\ CCW} = \varphi_{SCS\ Polar}$	$\vartheta_{SCS\ CCW} = \vartheta_{SCS\ CW}$ $\varphi_{SCS\ CCW} = 360 - \varphi_{SCS\ CW}$	—	$\vartheta_{SCS\ CCW} = -\vartheta_{SCS\ Geo}$ $\varphi_{SCS\ CCW} = 360 - \varphi_{SCS\ Geo}$
SPCS_Geo	$\vartheta_{SCS\ Geo} = 90 - \vartheta_{SCS\ Polar}$ $\varphi_{SCS\ Geo} = 360 - \varphi_{SCS\ Polar}$	$\vartheta_{SCS\ Geo} = -\vartheta_{SCS\ CW}$ $\varphi_{SCS\ Geo} = \varphi_{SCS\ CW}$	$\vartheta_{SCS\ Geo} = -\vartheta_{SCS\ CCW}$ $\varphi_{SCS\ Geo} = 360 - \varphi_{SCS\ CCW}$	—

The following Table 2.2 reports the back compatibility of symbols with coordinate system used in BASTA PA WP12.0 [1] and BASTA AA WP 2.0

Table 2.2: Summary of symbol back compatibility with BASTA PA WP 12.0 and BASTA AA WP 2.0

Angle name	Mathematical symbol	Definition	Identifier for use in data file	Value along x-axis (deg)	Direction from x-axis as seen from coordinate origin (Antenna backside)
3GPP Phi	ϕ or φ	CCW around z-axis	phi	0	left
3GPP Theta or elevation downtilt	Θ	Downwards from xy-plane at constant 3GPP-Phi	Theta	0	down
Azimuth	AZ = Φ	AZ = Φ = − ϕ	Azimuth or Phi	0	right
Elevation	EL	EL = − Θ	Elevation	0	up
phi	ϕ or φ	Identical to 3GPP-Phi	phi	0	left
theta	θ	θ = 90° + Θ	theta	90	down

2.4 ANGULAR REGION

An Angular Region (AR) is defined as an elevation aperture and an azimuth aperture. Within the AR, the spherical angles vary as follows:

$$\vartheta_{start} \leq \vartheta \leq \vartheta_{end}$$

$$\varphi_{start} \leq \varphi \leq \varphi_{end}$$

Note: in other contexts, outside current document the AR concept can also be denoted as "Segment" or "Angular Segment" [9].

An example on how to divide the served sector into ARs is shown in Figure 2.14 and Figure 2.15, and in Table 2.3, for an AAS covering a sector of ±60º in azimuth range and from -5º to +20º in elevation range.

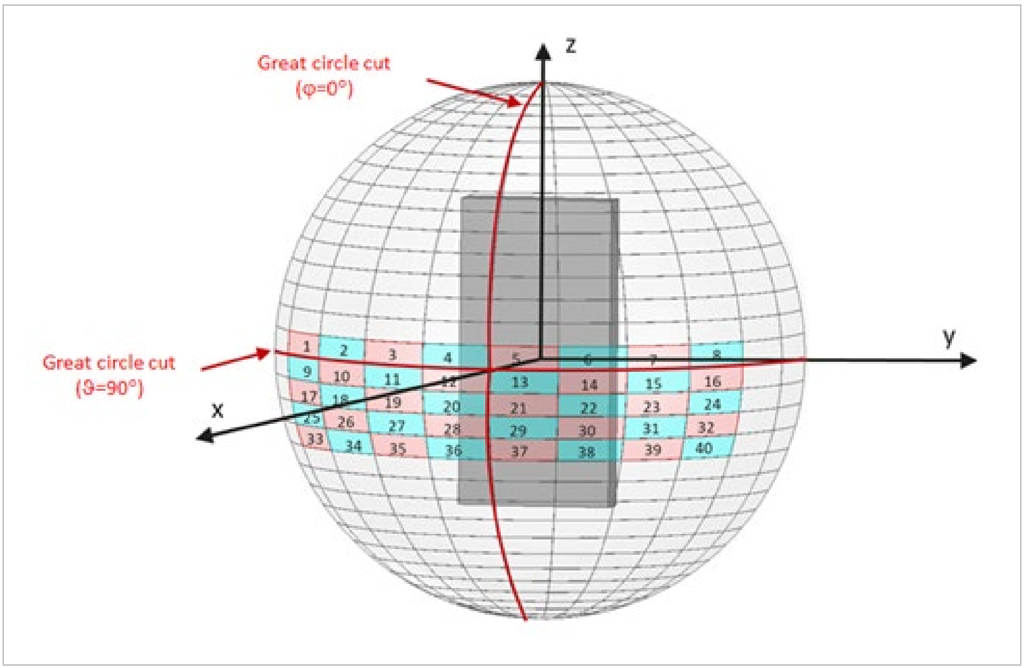


Figure 2.14: Example of sector divided into ARs

Table 2.3: AR tabular description of the example given in Figure 2.14

	SPCS_Polar				SPCS_CW				SPCS_CCW				SPCS_Geo			
Angula Region ID	Azimuth Range		Elevation Range		Azimuth Range		Elevation Range		Azimuth Range		Elevation Range		Azimuth Range		Elevation Range	
	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
1	300	315	85	90	45	60	-5	0	300	315	-5	0	45	60	90	95
2	315	330	85	90	30	45	-5	0	315	330	-5	0	30	45	90	95
3	330	345	85	90	15	30	-5	0	330	345	-5	0	15	30	90	95
4	345	360	85	90	0	15	-5	0	345	360	-5	0	0	15	90	95
5	0	15	85	90	345	360	-5	0	0	15	-5	0	345	360	90	95
6	15	30	85	90	330	345	-5	0	15	30	-5	0	330	345	90	95
7	30	45	85	90	315	330	-5	0	30	45	-5	0	315	330	90	95
8	45	60	85	90	300	315	-5	0	45	60	-5	0	300	315	90	95
9	300	315	90	95	45	60	0	5	300	315	0	5	45	60	85	90
10	315	330	90	95	30	45	0	5	315	330	0	5	30	45	85	90
11	330	345	90	95	15	30	0	5	330	345	0	5	15	30	85	90
12	345	360	90	95	0	15	0	5	345	360	0	5	0	15	85	90
13	0	15	90	95	345	360	0	5	0	15	0	5	345	360	85	90
14	15	30	90	95	330	345	0	5	15	30	0	5	330	345	85	90
15	30	45	90	95	315	330	0	5	30	45	0	5	315	330	85	90
16	45	60	90	95	300	315	0	5	45	60	0	5	300	315	85	90
17	300	315	95	100	45	60	5	10	300	315	5	10	45	60	80	85
18	315	330	95	100	30	45	5	10	315	330	5	10	30	45	80	85
19	330	345	95	100	15	30	5	10	330	345	5	10	15	30	80	85
20	345	360	95	100	0	15	5	10	345	360	5	10	0	15	80	85
21	0	15	95	100	345	360	5	10	0	15	5	10	345	360	80	85
22	15	30	95	100	330	345	5	10	15	30	5	10	330	345	80	85
23	30	45	95	100	315	330	5	10	30	45	5	10	315	330	80	85
24	45	60	95	100	300	315	5	10	45	60	5	10	300	315	80	85
25	300	315	100	105	45	60	10	15	300	315	10	15	45	60	75	80
26	315	330	100	105	30	45	10	15	315	330	10	15	30	45	75	80
27	330	345	100	105	15	30	10	15	330	345	10	15	15	30	75	80

	SPCS_Polar				SPCS_CW				SPCS_CCW				SPCS_Geo			
28	345	360	100	105	0	15	10	15	345	360	10	15	0	15	75	80
29	0	15	100	105	345	360	10	15	0	15	10	15	345	360	75	80
30	15	30	100	105	330	345	10	15	15	30	10	15	330	345	75	80
31	30	45	100	105	315	330	10	15	30	45	10	15	315	330	75	80
32	45	60	100	105	300	315	10	15	45	60	10	15	300	315	75	80
33	300	315	105	110	45	60	15	20	300	315	15	20	45	60	70	75
34	315	330	105	110	30	45	15	20	315	330	15	20	30	45	70	75
35	330	345	105	110	15	30	15	20	330	345	15	20	15	30	70	75
36	345	360	105	110	0	15	15	20	345	360	15	20	0	15	70	75
37	0	15	105	110	345	360	15	20	0	15	15	20	345	360	70	75
38	15	30	105	110	330	345	15	20	15	30	15	20	330	345	70	75
39	30	45	105	110	315	330	15	20	30	45	15	20	315	330	70	75
40	45	60	105	110	300	315	15	20	45	60	15	20	300	315	70	75

Note: In general, if irregular or more complex shapes of ARs are used, appropriate textual description and an elevation-azimut plane drawing is required.

2.5 EIRP

Equivalent (or Effective) Isotropically Radiated Power (EIRP) in a direction is the total radiated power if the radiation intensity the device produces in that direction would be radiated isotropically. Hence, EIRP is a farfield parameter like the radiation intensity. The System International (SI) unit of EIRP is W.

Radiation intensity [1] I(ϑ,φ), is the power radiated per unit solid angle and the SI unit is Watt per steradian (W/sr).

In formula,

$$EIRP(\vartheta,\varphi) = 4\pi I(\vartheta,\varphi) \qquad (2.9)$$

where the solid angle of the full sphere (4π sr) is used.

EIRP is defined as the directive antenna gain (G) multiplied by the net power accepted by the antenna (P_accepted), see e.g. [1]. Gain is radiation intensity divided by the radiation intensity of an isotropic radiator radiating the accepted power [1], i.e.,

$$G(\vartheta,\varphi) = \frac{I(\vartheta,\varphi)}{P_{accepted}/4\pi} \qquad (2.10)$$

Note that the traditional definition also implies EIRP(ϑ,φ) = 4πI(ϑ,φ). In this form the definition of EIRP has the advantage of being independent of accepted power and gain which are not measurable for tightly integrated AASs, such as in 3GPP AAS types 1-O and 2-O [4].

Moreover, the radiation intensity is related to the effective value of the electric field strength in the Far-field region as

$$I(\Theta,\phi) = \lim_{r\to\infty} \frac{\left|\vec{E}(r,\Theta,\varphi)\right|^2}{Z_0} r^2 \qquad (2.11)$$

Here, Z_0≈377 Ω is the impedance of vaccuum. Hence, EIRP can be obtained by measuring the electric field strength in a single point in the Far-Field region.

Relations to other parameters

- EIRP(ϑ,φ) = S(r,ϑ,φ) · 4πr^2 where r is the distance from the antenna and S(r,ϑ,φ) is the radial power flux per unit area.

- "EIRP" (ϑ,φ) = D(ϑ,φ) · TRP where TRP is the Total radiated Power and D is directivity.

In general, it is not always possible to measure $P_{accepted}$ in integrated AAS products as there is not a connector where the power can be measured. In such situations, the AAS Gain is introduced which can be derived as the EIRP divided by the “Configured Output Power” – which is the power that can be set on the O&M system.

Note: The meaning of "Configured Output Power" is to be defined and provided by the manufacturer.

Attributes applied to EIRP, radiation intensity and related parameters follow [1] and are summarized here for completeness:

- Total denotes the sum (in linear scale) of two partial EIRP values corresponding to two orthogonal polarizations of the electromagnetic field
- Partial denotes a value corresponding to a specific polarization
- Peak denotes the highest value with respect to angular directions.
- If no attribute is used and no direction is specified, then "Peak Total" is intended.

Example:
The statement "EIRP = 50 dBm", means that the Peak Total EIRP is 50 dBm.

An EIRP is a Total EIRP if not otherwise stated. If only one polarization component is measured e.g. +45 degs slanted polarization, then "Partial EIRP +45" shall be used.

2.6 BEAM

A beam is a radiation pattern of the antenna.

Note: For Passive Antennas the term main "Beam" indicates the main lobe of the radiation pattern of an antenna e.g., as stated in [2].

For an Active Antenna a beam can be characterised by:

- The half-power beamwidth (HPBW) along two orthogonal directions, see definition of HPBW section 2.8
- The beam peak direction: the direction of the maximum of the radiation pattern,
- The beam peak centre: the direction corresponding to the centre of the angular region where the HPBW is calculated.
- The radiation pattern ripple

In general, for symmetrical beams, the beam peak and the beam centre are the same but in case of asymmetrical beams, or beams with strong ripple the beam peak and the beam centre directions might be different, see example on Figure 2.16.

An AAS can generate, at the same time, one or more beams with various time-dependent shapes (different HPBW) and pointing to different directions using the same frequency band.

2.7 AAS BEAM-TYPES DEFINITION

A passive antenna has a radiation pattern whose shape and direction are fixed in time (not including the effect of the tilt change). The radiation pattern of an AAS can be dynamic.

By exploiting the processing capabilities of an AAS, the beams it radiates can be of two different types depending on their usage: broadcast beams and traffic beams. They are described in detail in the following sections.

2.7.1 Broadcast Beams

Broadcast beams (also named cell-specific beams) are beams used for providing the served cell with coverage. They are intrinsically non-user-based, so they are independent of UE presence.

It is useful to introduce the following definitions:

- **broadcast beam set** is the collection of all broadcast beams that can be radiated by the AAS;

- **broadcast beam configuration** is a sub-set of broadcast beams within a broadcast beam set; it identifies the overall radiating behaviour of the AAS suitable for serving a certain deployment/coverage scenario.

Broadcast beams in a given broadcast beam configuration could be selected sequentially in a loop over time.

For backward compatibility, in case of passive antennas, there is only one broadcast beam in the set (not including the effect of the tilt change), which also behaves as a traffic beam.

2.7.2 TRAFFIC BEAMS

Traffic beams are beams activated only if a traffic channel is assigned to a UE to deliver the required service, hence they are intrinsically user-based.

It is useful to define two different traffic beam implementations: Grid of Beams (GoB) and Eigen-Based Beamforming (EBB).

2.7.2.1 GRID OF BEAMS

In GoB implementation, traffic beams are selected among a finite number of pre-configured beams. This includes e.g. the so-called Codebook implementation [11]. An AAS may have more than one GoB configuration in order to adapt to the cell scenario. An example of a GoB configuration is shown in Figure 2.15.

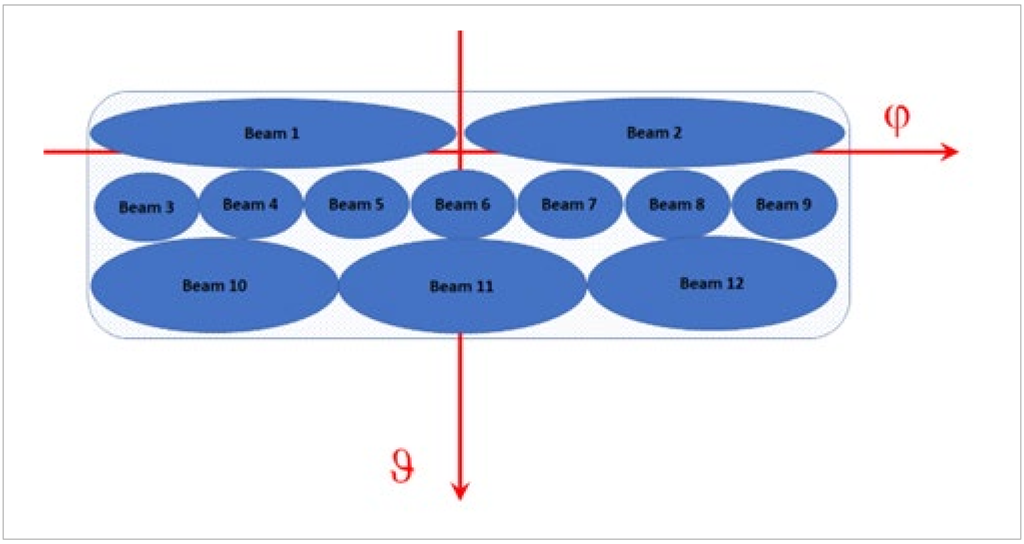


Figure 2.15: GoB Example

2.7.2.2 EIGEN-BASED BEAMFORMING

In Eigen-Based Beamforming (EBB) configuration, the calculation of the traffic beam (i.e. the array weights applied to each Array Element) is done adaptively in real-time to compensate for the variations of the propagation channel.

2.8 BEAMWIDTH

The X dB beamwidth is, in a radiation pattern cut containing the direction of the maximum of a lobe, the angle between the two directions in which the radiation intensity is X dB below the maximum value.

When the beamwidth is not calculated over the Total radiated power radiation pattern (see section 2.8 in [1]), the term co-polar beamwidth shall be used.

When X is equal to 3 dB, then the term half-power beamwidth (HPBW) is used.

In Figure 2.16 a peak normalized radiation pattern cut is depicted as a reference for azimuth and elevation half-power beamwidth calculation example. The distance between the HPBW points (red) are used for HPBW calculations, and the mid-point (green) defines the beam peak centre.

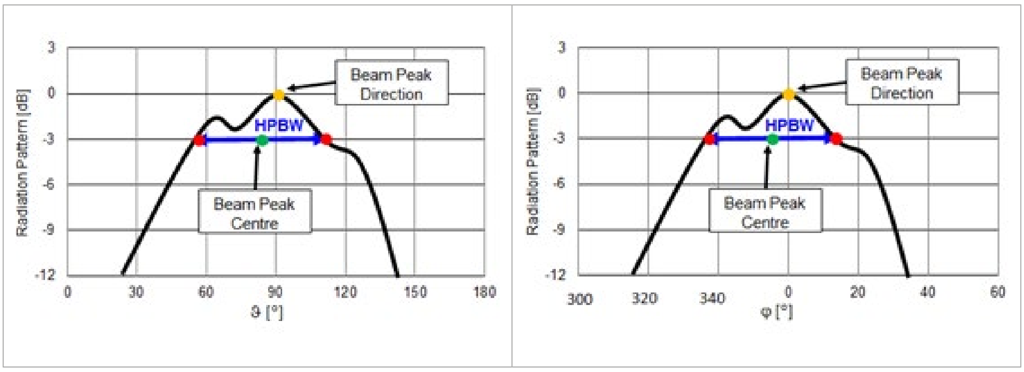


Figure 2.16: HPBW beam peak centre and beam peak direction derived from Beamwidth definition and assuming 3 dB reduction for the radiation intensity.

2.8.1 AZIMUTH BEAMWIDTH

The azimuth beamwidth is determined on the azimuth radiation pattern conical cut containing the main beam peak, see Figure 2.17

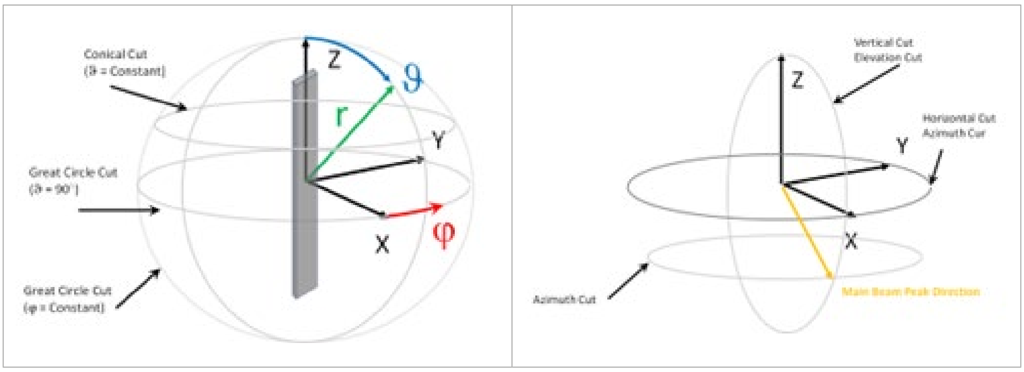


Figure 2.17: Cuts over the radiation sphere

2.8.2 ELEVATION BEAMWIDTH

The elevation beamwidth is determined on the elevation radiation pattern great circle cut containing the main beam peak, see Figure 2.17.

The elevation beamwidth is the beamwidth in the elevation radiation pattern cut which is the great circle cut containing the main beam peak. Such a cut is obtained over a path in which φ is constant and is a variable, see Figure 2.17.

2.9 ENVELOPE RADIATION PATTERN

The Envelope Radiation Pattern is a non-physical radiation pattern obtained by taking, for each direction in azimuth and elevation, the maximum of the absolute, not peak normalized to its own peak, radiation pattern among the radiation patterns that the AAS can generate for a given operating condition (deployment/coverage scenario). More details on envelope radiation patterns of an AAS can be found in Annex F.

Radiation pattern parameters defined in [1] also apply to envelope radiation patterns, with the exception of the changes described in the following sub-sections.

2.9.1 ENVELOPE AZIMUTHAL BEAMWIDTH AND PAN DIRECTION

The Envelope azimuthal beamwidth of the Envelope Radiation Pattern is defined as the angular region between two reference angles A and B, on the azimuthal cut containing the peak, where the pattern decays by X dB with respect to the maximum, as shown in Figure 2.18. For the calculation of Envelope azimuthal beamwidth, the procedure described in section 2.8.1 shall be used

The Pan direction of the Azimuthal Envelope Radiation Pattern is the midpoint between angles A and B.

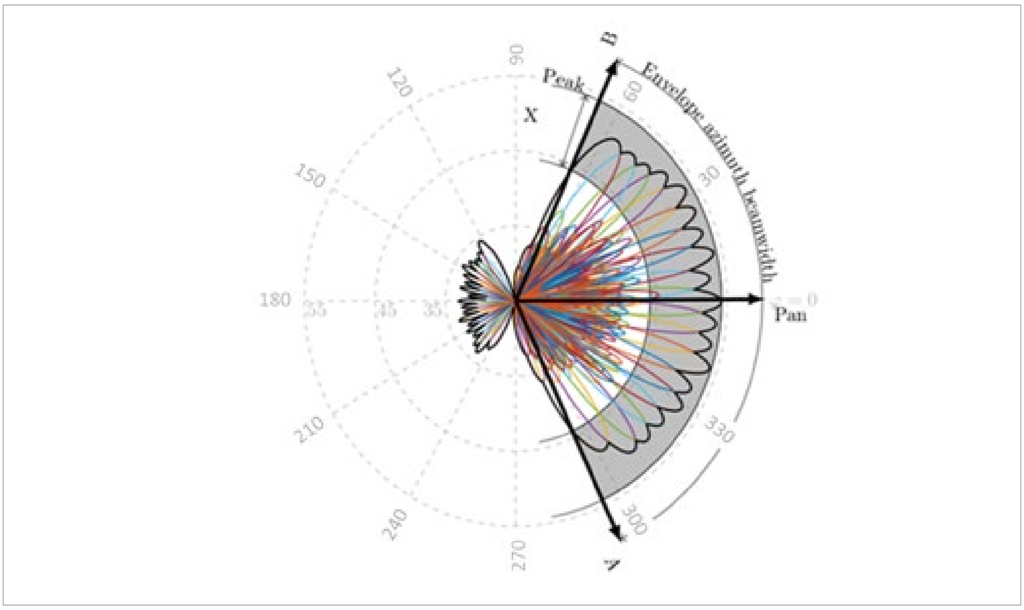


Figure 2.18: Envelope Azimuthal Radiation Pattern and related parameters example

The Envelope azimuthal beamwidth is by default calculated with X equal to 3 (i.e. envelope azimuthal half-power beamwidth) but other values may be chosen, e.g. X equal to 10 is typically used for coverage calculation purposes.

2.9.2 ENVELOPE ELEVATION BEAMWIDTH AND TILT DIRECTION

The elevation beamwidth of the Envelope Radiation Pattern is defined as the angular region between two reference angles C and D, on the great circle cut containing the peak, where the pattern decays by X dB with respect to the maximum, as shown in Figure 2.19. For the calculation of envelope elevation beamwidth, the procedure described in section 2.8.2 shall be used

The Tilt direction of the Elevation Envelope Radiation Pattern is the midpoint between angles C and D.

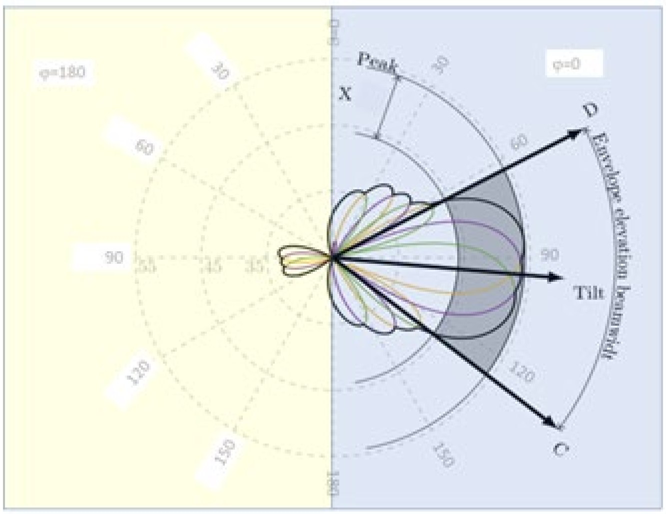


Figure 2.19: Envelope elevation beamwidth and Tilt direction and related parameters example

The envelope elevation beamwidth is by default calculated with X equal to 3 but other values may be chosen, e.g. X equal to 10 is typically used for coverage calculation purposes.

2.9.3 ENVELOPE RADIATION PATTERN RIPPLE

The Envelope Radiation Pattern Ripple is defined as the difference between the highest and the lowest radiation pattern levels per AR (see section 2.4) and it is expressed in dB. If no AR is defined, then it is intended as the Envelope azimuthal and elevation scanning ranges, see Sections 3.3.10 and 3.3.11.

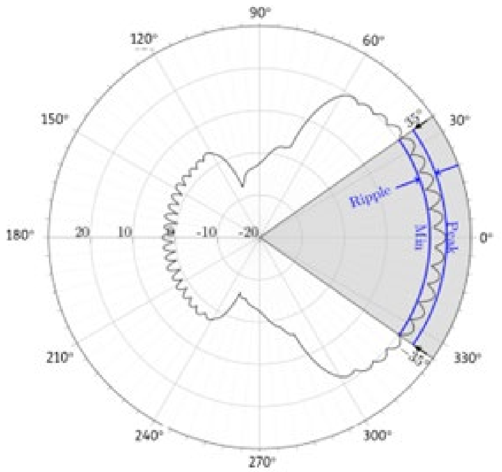


Figure 2.20: Ripple example of normalized envelope radiation pattern. The grey area illustrates the AR

2.10 ELECTRICAL DOWNTILT ANGLE

In addition to the beamforming capabilities of the AAS, that are achieved by modifying the feeding weights (amplitude and phases) applied to each radiator or group of radiators connected to a TRX, the AAS might have the additional capability to apply an offset in elevation to the whole set of patterns that the AAS can generate, which is not attributed to mechanical tilting of the antenna.

Unlike the feeding weights of each TRX that are adjusted dynamically during the normal operation of the AAS, the electrical downtilt angle is intended to be a parameter that is set when the AAS is deployed and it is modified only during network planning and optimization activities.

2.11 RADIATION PATTERN FILE FORMAT

Main elevation and azimuth cuts of the radiation pattern shall be given in MSI format. If required, beam radiation patterns generated by the AAS are made available in 3D format, preferably via a web link.

The recommended file format for 3D patterns is described in Annex G.

2.12 UL PATTERN

The definition of UL pattern is obtained for each direction in azimuth and elevation from the combined RX power received by the antenna for a specific constant configuration in response to a constant reference stimulus signal.

2.13 FREQUENCY RANGE AND BANDWIDTH

The following definitions are mainly taken from 3GPP terminology. See [3], [12] for more details and additional parameters.

2.13.1 OPERATING BAND AND SUPPORTED FREQUENCY RANGE

The operating band defined here follows [3] for New Radio (NR) and [13] for Multi Standard Radio (MSR) definition.
The supported frequency range is a specific band within the operating band and defined by a continuous range between two frequencies.

2.13.2 OCCUPIED BANDWIDTH

The definition of Occupied Bandwidth (OBW) used e.g. in [3] and [13] applies. This refers to 99% symmetric power utilization, i.e., 0.5% relative power leakage outside each band edge.

2.13.3 AGGREGATED OCCUPIED BANDWIDTH

The Aggregated Occupied Bandwidth (Aggregated OBW) indicates the bandwidth occupied by multiple carriers and is the sum of the OBWs of signals that can be output at the same time.

2.13.4 INSTANTANEOUS BANDWIDTH

The Instantaneous Bandwidth (IBW) is the span between the highest frequency and the lowest frequency of the signals that can be output at the same time. The IBW is always greater or equal to the Aggregated OBW. IBW is identical to “Maximum radiated Base Station RF Bandwidth for non-contiguous operation.” (D9.19) Sec. 4 in [14].

Figure 2.21 shows an example of calculation of IBW and Aggregated OBW.

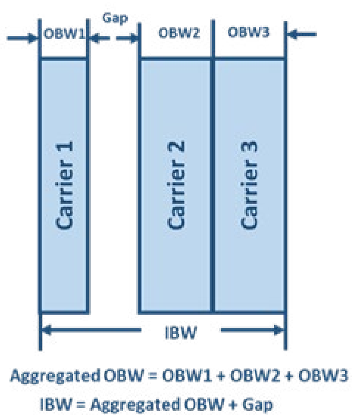


Figure 2.21: IBW and Aggregated OBW calculation example

03 TEST STATE, RF PARAMETERS AND SPECIFICATIONS

An AAS can be indicated as “BASTA-AA compliant” only if:

- Parameters used in its BASTA-AA XML (see Section 17) file or its BASTA-AA datasheet coincide with the ones listed in this section.
- Values associated to each parameter used in its BASTA-AA XML (see Section 17) file or its BASTA-AA datasheet are calculated according to the methods defined here.
- Its far-field radiation pattern files are made available.

3.1 ACTIVE ANTENNA SYSTEM TEST STATE (TS)

The Test State (TS) is a state of an AAS in which some specific operations for testing purposes are performed, accessed and managed by means of a tool (hardware and/or software) made available by the manufacturer. The TS is used for in lab, in situ and for pre-operation testing.

Note: In the TS the AAS, preferably, can be operated without any need to connect it to a commercial core network.

3.2 FORMAT, PARAMETER DEFINITIONS, VALIDATI-ON AND XML TAGS

Parameter description and format used in this WP follow what is provided in [1] section 3.1

For validation and specification of RF parameters, [1] will be used as a reference as well, and more specifically the section 4 of it.

XML tags and examples are provided in a separate document that is published as an annex to this WP XML (see Section 17).

3.3 REQUIRED RF PARAMETERS

3.3.1 FREQUENCY RANGE AND BANDWIDTH

Parameter Definition

Supported frequency band configuration(s), expressed in the terms defined in Section 2.13

Specification Definition

- The frequency range(s) are specified in MHz.
- If the AAS supports more than one Operating Band, the supported frequency range(s) shall be specified for each Operating Band

Specification Example

- Operating Band: n78
- Supported Frequency Range: 3400-3600 MHz
- Aggregated OBW: 160 MHz
- IBW: 200 MHz

3.3.2 NUMBER OF CARRIERS

Parameter Definition

- Number of carriers supported by the AAS.

Specification Definition

- For defining the number of carriers it is recommended to follow 3GPP documents [3] for New Radio (NR) and [14] for Multi Standard Radio (MSR)
- If the AAS supports more than one Operating Band, the supported number of carriers shall be specified for each Operating Band

Specification Example

- Number of Carriers: 2

3.3.3 POLARIZATION

Parameter Definition

- The nominal polarization associated to the radiating elements of the AAS.

Specification Definition

- Linear polarizations are declared as: H and V, +45 and -45, etc
- Circular polarizations are typically declared as RHCP and LHCP.
- If the polarization is expressed in terms of angle (number), the unit is degrees

Specification Example

- Type: Polarization:
- +45 and -45

3.3.4 MAXIMUM TOTAL OUTPUT RF POWER

Parameter Definition

- The Maximum Total Output RF power is the maximum power achievable by the AAS during the transmitter ON period, typically when all power amplifiers have the (same) maximum power at their outputs. Maximum Total Output RF power is identical to "OTA BS Output Power" Sec 9.3 in [3] [14], this is a TRP value declared by the vendor.
- Power values are intended to be RMS with respect to time.

Specification Definition

- Maximum Total Output RF power is specified in W or dBm.
- Unit shall be indicated

Specification Example

- Type: Absolute
- Maximum RF power: 200 W

3.3.5 OUTPUT RF POWER DYNAMIC RANGE

Parameter Definition

- The Output RF Power Dynamic Range defines the maximum reduction of the nominal Maximum Total Output RF radiated power while maintaining the performances within the range declared by the vendor.

Specification Definition

- Output RF Power Dynamic Range is specified in dB.

Specification Example

- Type: Relative
- Output RF Power Dynamic Range: 10 dB

3.3.6 MINIMUM CONFIGURABLE TOTAL OUTPUT RF POWER

Parameter Definition

- The Minimum Configurable Total Output RF power is the minimum power achievable by the AAS, typically when all power amplifiers have the (same) minimum power at their outputs. Minimum Configurable Total Output RF power is a TRP value declared by the vendor. At the Minimum Configurable Total Output power the performances declared by the vendor may not be achieved.
- Power values are intended to be RMS with respect to time.

Specification Definition

- Minimum Configurable Total Output RF power is specified in W or dBm.
- Unit shall be indicated

Specification Example

- Type: Absolute
- Minimum Configurable Total Output RF power: 1 W

3.3.7 BROADCAST BEAM SET

Parameter Definition

A broadcast beam set is defined as the collection of all the preconfigured broadcast beams (see section 2.7.1). Each beam is declared according to the table below. The configured output power associated to the given EIRP shall be reported.

Specification Definition

Beam ID	Frequency Band	EIRP	Nominal Polarization	Azimuth		Elevation	
				HPBW	Pan	HPBW	Tilt
		[dBm]	[deg]	[deg]	[deg]	[deg]	[deg]

Specification Example

SPCS_Polar

Beam ID	Frequency Band	EIRP	Nominal Polarization	Azimuth		Elevation	
				HPBW	Pan	HPBW	Tilt
		[dBm]	[deg]	[deg]	[deg]	[deg]	[deg]
1	n78	75.5	+45	15.0	307.5	6.0	96.0
2		76	-45		322.5		
3		76.5	0		337.5		
4		77	90		352.5		
5		77	+45		+7.5		
6		76.5	-45		+22.5		
7		76	0		+37.5		
8		75.5	90		+52.5		

The configured power was 50 dBm

3.3.8 BROADCAST BEAM CONFIGURATION

Parameter Definition

A broadcast beam configuration is defined as the overall radiating behaviour for a given deployment/coverage scenario (see section 2.7.1) obtained by radiating one or more beams selected from the ones belonging to the broadcast beam set.

The broadcast beam configuration can be:

- Composed by just one of the beams of the broadcast beam set;
- Composed by a number of broadcast beams of the broadcast beam set selected in a way for solving specific coverage needs. There can be a different number of available broadcast beam configuration implemented by the AAS, each one composed by beams belonging to the broadcast beam set.
- Sweeping across beams type, see section 2.7.1.

The broadcast beam configuration can:

- Have an associated envelope radiation pattern as described in section 2.9
- Refer to a single beam ID. In the case this section is not relevant

Example of configuration:

A possible configuration may comprise 8 beams, with the same elevation pointing direction (θ=0 degs for example) and equally distributed in azimuth from – 50 to + 50 degs. The following figure illustrates this example. Each single beam is depicted in green; the red curves (H65) correspond to a traditional coverage beam of a passive antenna.

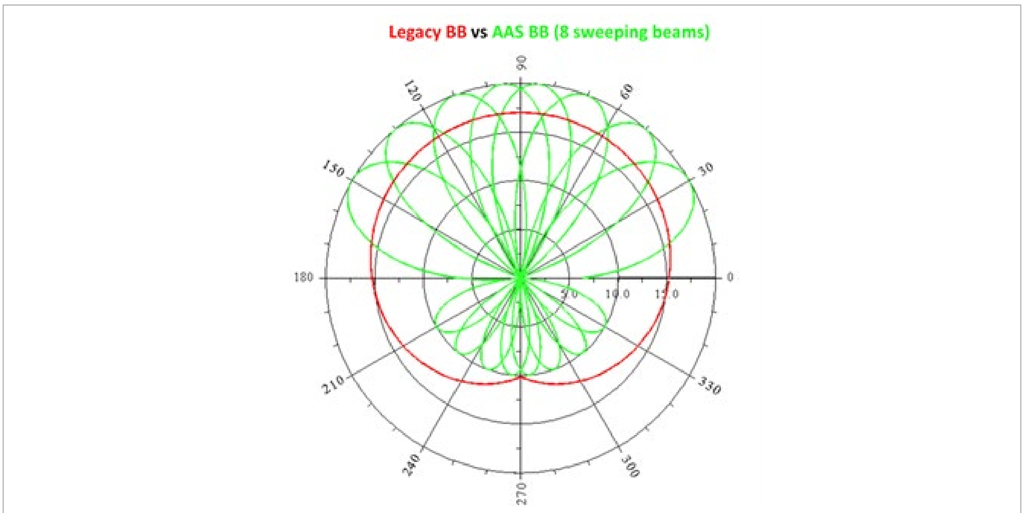


Figure 3.1: Broadcast beams configuration example (8 beams)

Other possible examples are depicted in the following figures.

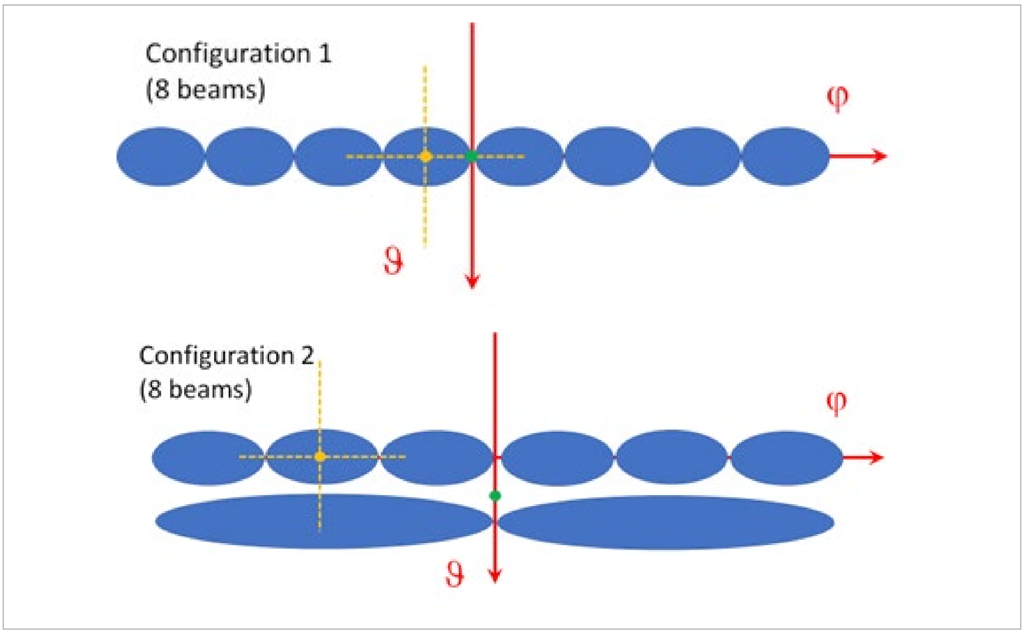


Figure 3.2: Broadcast beams configuration examples, using 8 beams where the green and orange dots indicate the envelope centre and peak direction, respectively (see also Figure 2.8 1)

Specification Definition

For each configuration ID, the main characteristics of the corresponding envelope radiation pattern are to be provided according to the following table format. For the values of Pan, Tilt and Beamwidth, either a single value or a set of values can be stated. If there is more than one beam, by default it is assumed that sweeping across beams is applied, see section 2.7.1. The Configured Output Power associated to the given EIRP shall be reported (exactly as for broadcast beam set)

Config. ID	Frequency Band	EIRP	Nominal Polarization	Envelope Azimuth			Envelope Elevation		
				HPBW	Pan	Conical Cut Direction	HPBW	Tilt	Great Circle Cut Direction
		[dBm]	[deg]	[deg]	[deg]	[deg]	[deg]	[deg]	[deg]

Specification Example

SPCS_Polar

Config. ID	Frequency Band	EIRP	Nominal Polarization	Envelope Azimuth			Envelope Elevation		
				HPBW	Pan	Conical Cut Direction	HPBW	Tilt	Great Circle Cut Direction
		[dBm]	[deg]	[deg]	[deg]	[deg]	[deg]	[deg]	[deg]
1	n78	77.0	+45	60	0	90,95,100	6	90,95,100	7.5
2		74.0	-45	60	0	90,93,96	12	90,93,96	7.5

The configured power was 50 dBm

3.3.9 TRAFFIC BEAMS

The following two mutually exclusive parameter definitions apply according to the traffic beam types defined in section 2.7.2.1 and section 2.7.2.2

3.3.9.1 GOB CONFIGURATION

Parameter Definition

- The characteristics of each beam in a traffic GoB set (see section 2.7.2.1) shall be specified according to the table given below. Beams having different Pan and Tilt are considered different, so a specific Beam_Id is associated to each beam.

When the number of beams in a traffic GoB is so large that it can be difficult, time consuming or inefficient to describe the characteristics of each beam in the set, the manufacturer can describe the traffic performances of the GoB AAS with one or more envelope patterns, as defined in section 2.9.

The configured output power associated to the given EIRP shall be reported.

Specification Definition

<table>
<tr><th rowspan="3">Beam ID</th><th rowspan="3">Frequency Band</th><th rowspan="2">EIRP</th><th>Nominal Polarization</th><th colspan="2">Azimuth</th><th colspan="2">Elevation</th></tr>
<tr><th></th><th>HPBW</th><th>Pan</th><th>HPBW</th><th>Tilt</th></tr>
<tr><th>[dBm]</th><th>[deg]</th><th>[deg]</th><th>[deg]</th><th>[deg]</th><th>[deg]</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Specification Example

SPCS_Polar

<table>
<tr><th rowspan="3">Beam ID</th><th rowspan="3">Frequency Band</th><th rowspan="2">EIRP</th><th>Nominal Polarization</th><th colspan="2">Azimuth</th><th colspan="2">Elevation</th></tr>
<tr><th></th><th>HPBW</th><th>Pan</th><th>HPBW</th><th>Tilt</th></tr>
<tr><th>[dBm]</th><th>[deg]</th><th>[deg]</th><th>[deg]</th><th>[deg]</th><th>[deg]</th></tr>
<tr><td>1</td><td rowspan="8">n78</td><td>73</td><td>+45</td><td rowspan="8">30</td><td>315</td><td rowspan="8">6</td><td rowspan="4">93</td></tr>
<tr><td>2</td><td>74</td><td>-45</td><td>345</td></tr>
<tr><td>3</td><td>74</td><td>0</td><td>15</td></tr>
<tr><td>4</td><td>73</td><td>90</td><td>45</td></tr>
<tr><td>5</td><td>73</td><td>+45</td><td>315</td><td rowspan="4">99</td></tr>
<tr><td>6</td><td>74</td><td>-45</td><td>345</td></tr>
<tr><td>7</td><td>74</td><td>0</td><td>15</td></tr>
<tr><td>8</td><td>73</td><td>90</td><td>45</td></tr>
</table>

The configured power was 50 dBm

3.3.9.2 EBB APPROACH

Parameter Definition

An AAS implementing traffic beams by using the EBB approach generates, in real time, radiation patterns whose shape depends on traffic conditions. For such systems, the radiating performance is summarized by the envelope radiation pattern as defined in section 2.9.

The configured output power associated to the given EIRP shall be reported.

Specification Definition

The EBB envelope radiation pattern characteristics are described according to the following table:

Envelope ID	Frequency Band	EIRP	Nominal Polarization	Ripple	Azimuth		Elevation	
					HPBW	Pan	HPBW	Tilt
		[dBm]	[deg]	[dB]	[deg]	[deg]	[deg]	[deg]

The maximum EIRP and the associated envelope radiation pattern correspond to an unlikely situation in which all the power is assigned to a single beam, to one user only, and in LoS (Line of Sight) conditions. However, this situation is important in the context of EMF, since it gives the absolute maximum EIRP in a given direction.

Note: For EBB, as the number of patterns that can be generated is unlimited, the envelope radiation pattern can be created by means of software taking as input the tested radiation pattern of each TRX, the array factor and weights calculated for each direction.

Specification Example

SPCS_Polar

Envelope ID	Frequency Band	EIRP	Nominal Polarization	Ripple	Azimuth		Elevation	
					HPBW	Pan	HPBW	Tilt
		[dBm]	[deg]	[dB]	[deg]	[deg]	[deg]	[deg]
1	n78	77	+45	3	60	0	12	96

The configured power was 50 dBm

3.3.10 MINIMUM AZIMUTH HPBW

Parameter Definition

The minimum azimuth HPBW that can be achieved when all the radiators in the AAS are active and fed with uniform phase and amplitude

Specification Definition

Range of values over frequency in degrees.
The HPBW is calculated from the Total radiated power radiation pattern.

Specification Example

Minimum Azimuth HPBW = 12° to 16°

3.3.11 MINIMUM ELEVATION HPBW

The minimum elevation HPBW that can be achieved when all the radiators in the AAS are active and fed with uniform phase and amplitude

Specification Definition

Range of values over frequency in degrees.
The HPBW is calculated from the Total radiated power radiation pattern.

Specification Example

Minimum Elevation HPBW = 5.5° to 7.5°

3.3.12 AZIMUTH SCANNING RANGE

Parameter Definition

Range of angles in azimuth in which the AAS is optimized and intended to be operated. It is a subset of the OTA peak direction set defined in 3GPP, see [3][14].

Specification Definition

The nominal range of values in degrees.

Specification Example

CRS_Polar: Azimuth Scanning Range = 300° to 60°

3.3.13 ELEVATION SCANNING RANGE

Parameter Definition

Angular range in elevation in which the AAS is optimized and intended to be operated. It is a subset of the OTA peak direction set defined in 3GPP, see [14].

Specification Definition

The nominal range of values in degrees.

Specification Example

CRS_Polar: Elevation Scanning Range = 75° to 105°

3.3.14 NUMBER OF TRX

Parameter Definition

Number of independent TRX in the AAS. For each TRX branch there can be one or more radiating elements connected to it.

Specification Definition

mTnR:, Where m is the number of TX and n is the number of RX

Specification Example

Number of TRX = 64T64R

3.3.15 MAXIMUM NUMBER OF LAYERS

Parameter Definition

Maximum number of data streams sharing time and frequency resources that the AAS can handle simultaneously. As an example, the layers can be associated to multiple users (MU-MIMO), one single user (SU-MIMO) or a combination of both, i.e., multiple users having each of them one or multiple layers associated.

Specification Definition

Integer value describing the maximum number of layers

Specification Example

Maximum number of layers = 8

3.3.16 FRONT TO BACK

The Front to Back is defined as in BASTA Passive White Paper V12.0, Section 3.2.15.

Note: An alignment between F/B definition is required to be developed applicable for both Passive and for Active Antennas Radiation Pattern and to 3D radiation patterns. The alignment will be commonly solved in the next edition of BASTA AA and PA White papers including description of use cases and examples.

04 MONITORING COUNTERS

In the context of RF-EMF exposure assessment [15] and [16], it is required that antenna manufacturers make available to operators a certain number of counters (see Section B.6.5.3 in [9][14] and Section 13.3.3.3 in [17]). In line with those requirements, the following power monitoring counters are defined:

- Total radiated power counter
- Directional radiated power counters
- The following characteristics mandatorily apply to such counters:
- counters names and formats are declared by AAS manufacturer;
- counters are made available to the operator's Network Management System;
- the averaging process is performed over a 6-minute time interval or its sub-multiple (e.g. 10 s, 30 s, 60 s, etc.), in line with what is specified in the applicable RF-EMF exposure regulations;
- the time-averaging methodology is described (e.g. moving window).

The availability of monitoring counters is required.

Specification Example

- Total Radiated Power Counter: Available
- AR Radiated Power Counter: Available
- Beam Radiated Power Counter: Not Available

If radiation control mechanisms are implemented, see Section 5, the corresponding counters are required.

Note: Counter reporting time interval may not correspond to average time interval

4.1 TOTAL RADIATED POWER COUNTER

The counter that monitors the total radiated power over the full sphere shall report:

- the time-averaged power level;
- as an option, its Probability Distribution Function (PDF).

4.2 DIRECTIONAL RADIATED POWER COUNTERS

Directional radiated power counters are introduced to monitor the time-averaged radiated power delivered to specific directions where exposure issues can happen.

Directional power counters can be associated to either an AR (per-AR radiated power counter) or a specific beam (per-beam radiated power counter).

AR radiated power counter can be used for both GoB and EBB traffic beam implementation choices while per-beam radiated power counter might be more straightforwardly applicable to GoB solutions. Anyway, it is not necessary to have both types of counters implemented and it is up to the AAS's manufacturer to decide which type of counter is more suitable for its own AAS product.

4.2.1 ANGULAR REGION RADIATED POWER COUNTER

The power radiated through an AR (AR TRP) is defined as:

$$AR\ TRP = \frac{1}{4\pi}\int_{\vartheta_{min}}^{\vartheta_{max}}\int_{\varphi_{min}}^{\varphi_{max}} \mathrm{EIRP}(\vartheta,\varphi) r^2 sin\vartheta \mathrm{d}\vartheta \mathrm{d}\varphi \quad (4.1)$$

being ϑ_{min}, ϑ_{max}, φ_{min}, φ_{max} the limits of the AR.

The AR radiated power counter monitors the time-averaged power radiated through each AR the served sector is divided into (AR definition and example is given in section 2.4).

Each AR needs to be described and identified with an ID, as specified in 2.4.

For each AR, the AR radiated power counter shall report:

- the AR ID it is associated to;
- the time-averaged power level;
- and optionally, the Probability Distribution Function (PDF) of the monitored power levels.

Similar counter reporting EIRP can also be provided.

Note: The power reported in each AR is the whole power radiated by the AAS in that region.

4.2.2 BEAM RADIATED POWER COUNTER

The beam radiated power counter monitors the time-averaged power radiated by each beam in the beam set the antenna is configured to use.

For each beam, the beam radiated power counter shall report:

- the beam ID it is associated to;
- the time-averaged power value;
- and optionally, the Probability Distribution Function (PDF) of the monitored power levels.

Similar counter reporting EIRP can also be provided.

05 RADIATED POWER LIMITING MECHANISMS

In this chapter the capability of controlling the AAS radiated power [9], either statically or dynamically depending on the scenario where it is operated, is addressed.

The purpose of such mechanisms is to limit the power radiated by an AAS, either in general or towards specific directions (e.g. to comply with RF-EMF exposure limits).

Power limiting mechanisms are always associated to the corresponding power monitoring counters described in [9], which allow the operator to monitor the evolution of the power radiated by the AAS over time.

The availability of radiated power control mechanisms is required.

Specification Example

- Total Radiated Power Control: Available
- AR Radiated Power Control: Available
- Beam Radiated Power Control: Not Available

5.1 TOTAL RADIATED POWER LIMITING MECHANISM

The total radiated power limiting mechanism indicates the capability to limit the Total radiated power radiated by an AAS. Implementation-dependent options are to limit:

- the peak power level;
- the time-averaged power level.

If such mechanism is supported, whatever option is implemented, the vendor shall provide:

- a description of the mechanism, by explicitly indicating whether the implemented mechanism is either static or dynamic;
- the range and the steps used to limit the power.

5.2 DIRECTIONAL RADIATED POWER LIMITING MECHANISM

The directional radiated power limiting mechanism indicates the capability to limit the power radiated by an AAS towards specific directions. Implementation-dependent options are to limit:

- the peak power level;
- the time-averaged power level.

If such mechanism is supported, whatever option is implemented, the vendor shall provide:

- a description of the mechanism, by explicitly indicating whether the implemented mechanism is either static or dynamic;
- the range and the steps used to limit the power per direction.

A direction can be defined either by the AR it refers to or by the beam associated to it in case of GoB approach. Whatever choice is made, two different directional power limiting mechanisms can be defined (associated to the corresponding directional power monitoring counters of sections 4.2.1 and 4.2.2), which are described in the two following two sections.

5.2.1 AR RADIATED POWER LIMITING MECHANISM

The AR radiated power limiting mechanism indicates the capability to limit the power radiated by an AAS towards a specific AR. Implementation-dependent options are to limit:

- the peak power level;
- the time-averaged power level.

If such mechanism is supported, whatever option is implemented, the vendor shall provide:

- the identification of the AR where the power limiting mechanism is operated;
- a description of the mechanism, by explicitly indicating whether the implemented mechanism is either static or dynamic;
- the range and the steps used to limit the power per-AR.

5.2.2 BEAM RADIATED POWER LIMITING MECHANISM

The beam radiated power limiting mechanism indicates the capability to limit the power of a specific beam radiated by an AAS. Implementation-dependent options are to limit:

- the peak power level;
- the time-averaged power level.

If such mechanism is supported, whatever option is implemented, the vendor shall provide:

- Beam ID (Section 3.3.5) where the power limiting mechanism is operated;
- a description of the mechanism, by explicitly indicating whether the implemented mechanism is either static or dynamic;
- the range and the steps used to limit the power per beam.

06 TEST STATE

The purpose of this section is to describe Test States (TS). TS implementation and availability are optional.
The manufacturer/supplier is expected to support the operator to conduct the corresponding test, if needed.

The manufacturer/supplier should provide information related to each TS listed below according to the following structure:

TS Available: [Yes/No], if Yes then provide the following:

1. Description:
   a. Test objective and procedure, test limitations and any other relevant information

2. Test State: TS01, TS02, TS03, TS04, TS05

3. Additional items: if Yes then provide further details
   a. Core Network need: [Yes/No]
   b. AAS related HW: [Yes/No]
   c. Test equipment: [Yes/No]
   d. Dedicated SW: [Yes/No]

4. Test environment: [Lab and/or on site]

Specification Example

- Test State Available: Yes
- Description: This is the description
- Test State: TS01
- Additional Items: Dedicated SW
- Test Environment: Laboratory and Onsite

6.1 TS01: BROADCAST BEAM RADIATION PATTERN MEASUREMENT

This TS enables the radiation pattern testing of beams (for each applicable nominal polarization as per section 3.2.3) in the broadcast beam set.
In case a broadcast configuration is composed of sweeping beams (see section 2.7.1), TS01 allows individual beams to be locked in time, see APPENDIX F.

6.2 TS02: TRAFFIC ENVELOPE RADIATION PATTERN (TERP) MEASUREMENT ASSOCIATED TO A SPECIFIC BROADCAST CONFIGURATION

This TS enables the measurement of TERP for a specific BERP configuration (for each applicable nominal polarization as per section 3.3.3) at a Configured Output Power given by the AAS datasheet, see APPENDIX F.

6.3 TS03: RADIATION PATTERN MEASUREMENT OF TRAFFIC BEAMS IN GOB CONFIGURATION

This TS enables the radiation pattern testing of traffic beams in a GoB configuration (for each applicable nominal polarization as per section 3.3.3) at Configured Output Power given by the AAS datasheet by locking each beam in time. The beam is selected among the available Beam Set as defined in section 3.3.7.1, see APPENDIX F.

6.4 TS04: RADIATION PATTERN MEASUREMENT OF TRAFFIC BEAMS IN EBB CONFIGURATION

This TS enables the radiation pattern testing of traffic beams in an EBB configuration (for each applicable nominal polarization as per section 3.3.3) at Configured Output Power given by the AAS datasheet by locking each beam in time. The selected beam may be defined by means of a specific pan and tilt direction and HPBWs, see APPENDIX F.

6.5 TS05: UL PATTERN MEASUREMENTS

This TS enables the UL pattern testing by selecting a specific configuration (as an example: beam ID, set of weights, manufacturer specific code) locked in time during the measurement with a constant reference stimulus signal.

Note: for the reference signal the 3GPP test signal could be used [13]. Alternatively, a UE with UL test signal could be used.

07 HYBRID PASSIVE & ACTIVE ANTENNA SYSTEMS

The term Hybrid Passive and Active Antenna (HPAA) refers to a radiating system made of two or more passive and active antenna systems placed in a defined mechanical layout, maybe but not necessarily placed inside the same enclosure.
AAS and PAS can be separated units or can form a single functional entity. Different layouts are possible depending on the specific HPAA implementation, see details in Annex B.

In case of separated antenna systems placed inside the same enclosure, performance of each antenna in the HPAA configuration with respect to its performance when operated in standalone configuration may be impacted.

The description of performance of each standalone antenna follows the recommendations of NGMN BASTA white papers, depending on its characteristics:

- the performance of the AAS are described as recommended by the current version of the NGMN BASTA Active Antenna White Paper;

- the performance of the PAS are described as recommended by the current version of the NGMN BASTA Passive Antenna White Paper;

- the mechanical performance of the HPAA systems are described by making use of the relevant recommendations as described in the current version of the NGMN BASTA Passive White Paper (ex: Wind Load requirements).

Further parameters/performance are described as detailed in the following sub-sections.

7.1 HPAA

Parameter definition

The parameter specifies if the antenna is an HPAA or it can be part of an HPAA system

Specification Definition

- Hybrid Passive and Active Antenna system
- Part of Hybrid Passive and Active Antenna system: the antenna can be used as a part of an HPAA system
- NA for not HPAA system

Specification Example

- Hybrid Passive Active Antenna system
- Part of Hybrid Passive and Active Antenna system
- NA

7.1.1 HPAA TYPE

Parameter definition

HPAA layout is made of two components:

- HPAA layout
- HPAA enclosure type

The definition of this parameter is relevant only to the layout of the HPAA systems and it is independent if the AAS and PAS are single or separated functional entities, modality of connection, typology and arrangement of connectors.

Table 7.1: List of acronyms for HPAA

Acronym	Layout
VS	Vertical Stacked
HIL	Horizontal Inline Layout
OL	Overlay Layout
IL	Interleaved
NS	Not Specified
NA	None of the Above

Configuration Description

1. Depending on the HPAA implementation, possible layouts are (see Annex B for details):
    1. VS, Top PAS, Bottom AAS
    2. VS, Top AAS, Bottom PAS
    3. VS, Top PAS, Bottom empty
    4. VS, Top Empty, Bottom PAS
    5. VS, Top AAS, Bottom Empty
    6. VS, Top Empty, Bottom AAS
    7. HIL, Left PAS, Right AAS
    8. HIL, Left AAS, Right PAS
    9. HIL, Left PAS, Right Empty
    10. HIL, Left Empty, Right PAS
    11. HIL, Left AAS, Right Empty
    12. HIL, Left Empty, AAS Right
    13. OL, Front AAS Back PAS
    14. OL, Front PAS Back AAS
    15. OL Front AAS, Back Empty
    16. OL front PAS, Back empty
    17. IL, Front PAS, Back AAS
    18. IL, Front AAS, Back PAS
    19. NS, Not Specified
    20. NA: none of the above - Description needed. NA apply also to describe HPAA including more than 2 antenna systems.

2. According to the HPAA layout, possible enclosure types are (see Annex B for details):
    a. Standalone: two separated standalone antenna systems are placed inside the same enclosure;
    b. Naked: two separated naked antenna systems (naked antenna is intended an antenna system without the enclosure or with its original enclosure removed) are placed inside the same enclosure;
    c. Separated: two separated antenna systems are arranged in an HPAA layout as described by the previous item list 1, but they are not placed inside the same enclosure (each antenna systems uses its own enclosure)
    d. NS: Not specified
    e. NA: no one of the above – Description needed

Specification Examples

HPAA Type

- Layout: VS, Top Empty, Bottom AAS
- Enclosure type: Standalone”

HPAA Type

- Layout: VS, Top Empty, Bottom AAS
- Enclosure type: NA. “Describe here the implementation. ....”

HPAA Type

- Layout: Not Specified
- Enclosure type: Not Specified

HPAA Type

- Layout: NA. “Describe here the implementation. ....”
- Enclosure type: NA. “Describe here the implementation. ....”

08 MECHANICAL PARAMETERS AND SPECIFICATIONS

Unless otherwise stated, mechanical definitions and specifications in [1] are applicable. The required parameters in [1] are:

- Weight
- Dimensions
- Wind load
- Max. operational wind speed (km/h)
- Survival wind speed (km/h)

Required parameters that are not considered in [1] are listed below.

8.1 HEAT DISSIPATION

Parameter Definition

Maximum Heat Dissipation

Specification Definition

Nominal values in kilowatt

Specification Example

Maximum Heat Dissipation = 0.47kW

Note: The manufacturers may specify the cooling type e.g. natural cooling

8.2 OPERATIONAL TEMPERATURE

Parameter Definition

The operational temperature is the temperature range in which the AAS is designed to operate.

Specification Definition

- Nominal values in Celsius degrees.
- Minimum and Maximum operating temperatures.

Specification Example

Minimum temperature = -20°C; Maximum temperature = +60°C.

8.3 RELATIVE HUMIDITY

Parameter Definition

The relative humidity is the relative humidity range in which the AAS is designed to operate.

Specification Definition

- Nominal value in % RH.
- Minimum and Maximum relative humidity values.

Specification Example

Minimum relative humidity = 5% RH; Maximum relative humidity = 100% RH

8.4 INGRESS PROTECTION INDEX

Parameter Definition

The ingress protection index is classification according to [17] in which the AAS is designed to operate.

Specification Definition

IP index

Specification Example

IP 65

8.5 POWER CONSUMPTION

Parameter Definition

The power consumption for operating the AAS according to traffic conditions according to [18].

Specification Definition

Nominal values in Watt.

Specification Example

Traffic load [%]	Power consumption [W]
10	450
30	550
50	700
100	900

Note: The manufacturers may specify environmental conditions in which the power consumptions are given (example 100% Traffic load @ 55°C).

09 APPENDIX A – EXAMPLE OF ACTIVE ANTENNA DATASHEET

Note: Below is an example of an active antenna datasheet. All the data in the table below is only given for exemplary purposes and it is not intended to reflect the specifications of any existing product.

Table 10.1: AAS datasheet example

RF parameters	
Operating Band	n78
Supported Frequency Range (MHz)	3400 - 3600
Aggregated OBW (MHz)	160
IBW (MHz)	200
Number of carriers	Carriers:2, BW:100 MHz
Polarization	+45° and –45°
Maximum total output RF power (W)	200, Absolute
Broadcast beam set	See XML datasheet
Broadcast beam configuration	See XML datasheet
Traffic beams – GoB approach	See XML datasheet
Traffic beams – EBB approach	See XML datasheet
Coordinate System	SPCS_Polar
Minimum azimuth HPBW (°)	Min. 12, Max. 16
Minimum elevation HPBW (°)	Min. 5.5, Max. 7.5
Azimuth scanning range (°)	–60 to +60
Elevation scanning range (°)	–15 to +15
TR/RX Channels	TX: 64, RX: 64
Maximum number of layers	8
Monitoring counters	
Total Radiated Power Counter	Available
AR Radiated Power Counter	Available
Beam Radiated Power Counter	NotAvailable
Radiated power control mechanisms	
Total Radiated Power limiting mechanism	Available
AR Radiated Power limiting mechanism	Available
Beam Radiated Power limiting mechanism	NotAvailable

Mechanical specifications	
Dimensions (H x W x D) (mm)	1391 x 183 x 118
Weight Without Accessories (kg)	14.5
Weight of accessories only (kg)	3.4
Survival wind speed (km/h)	200
Windload – frontal at 150km/h (N)	500, at 150km/h
Windload – lateral at 150km/h (N)	360, at 150km/h
Heat Dissipation (kW)	0.47, Natural cooling
Operational Temperature (ºC)	–20 to +60
Relative humidity	5% RH~100% RH
Ingress protection index	IP65
Power consumption 100% Traffic load @ 55°C (W)	800

10 APPENDIX B – MIXED PASSIVE ACTIVE ANTENNA

10.1 GENERAL

AAS can be deployed in the same sites as the legacy (2G/3G/4G) PAS; in some installations the AAS can be arranged in a layout with a PAS in order to solve installations issues, i.e. available space on the pole hosting other antenna systems.

AAS arranged together with PAS systems are commonly referenced to as HPAA (Hybrid Passive Active Antenna), meaning that the same enclosure includes one or more AAS system and one more PAS system in a specific layout.

The following four arrangements are considered (see Figure 10.1):

- Option 1: AAS and PAS systems arranged in a Side-by-Side or Top Bottom configuration and physically separated;
- Option 2: AAS and PAS systems arranged in a stacked configuration and both are inside the same enclosure;
- Option 3: AAS and PAS systems interleaved in a common enclosure;
- Option 4: AAS deployed behind the PAS or vice versa.

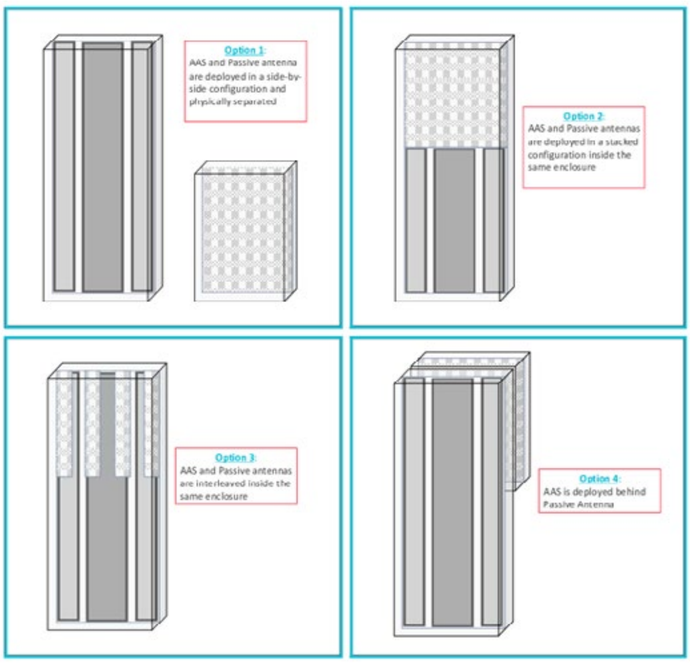


Figure 10.1: Hybrid Antennas Layout Options

10.2 OPTION 1: AAS AND PAS ARRANGED IN A SIDE-BY-SIDE OR TOP-BOTTOM CONFIGURATION AND PHYSICALLY SEPARATED

In Option 1 PAS and AAS are two distinct units, totally independent of each other (see Figure 10.2). Azimuth and mechanical tilt of the two systems may be set separately and independently of each other.

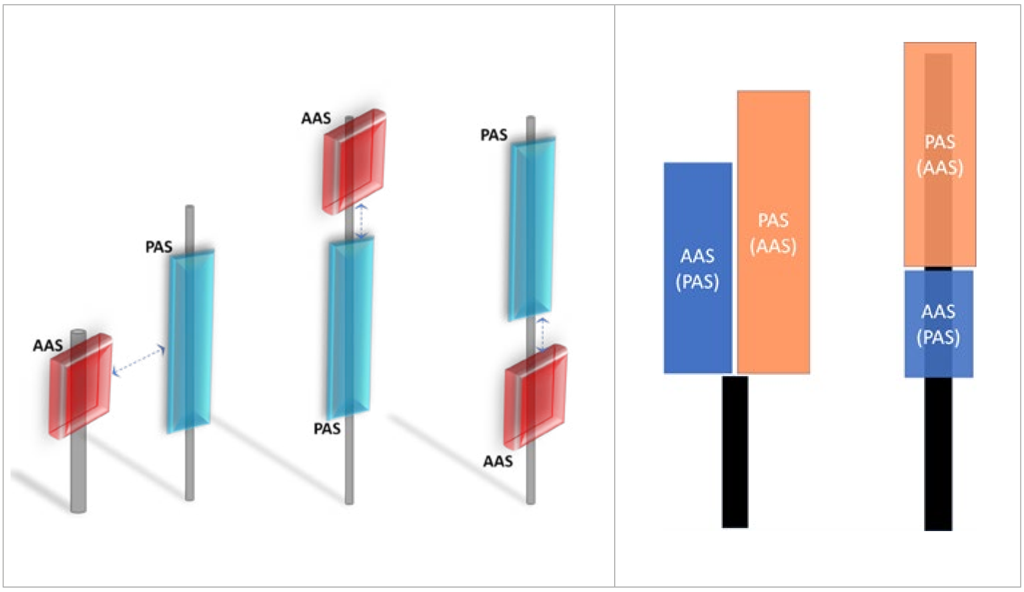


Figure 10.2: Schematic representations for Option 1: Side-by-Side or top-bottom

This is the simplest solution for site upgrade, as the AAS can be simply added either side-by-side or below/above the PAS.

Since the active and passive antennas are two separate entities, either antenna may be swapped without having to replace the other, offering a longer lifespan for each individual system.

From an operational point of view, some factors have to be taken into account:

- Mechanical constraints: arrangement and length of the cable tray
- Thermal constraints: spacing between elements to allow free cooling of the AAS.

10.3 OPTION 2: AAS AND PAS ARRANGED IN A STACKED CONFIGURATION AND BOTH ANTENNAS ARE INSIDE THE SAME ENCLOSURE

In Option 2 AAS and the PAS are arranged in the same enclosure, either one on the top of the other or side by side (see Figure 10.3).

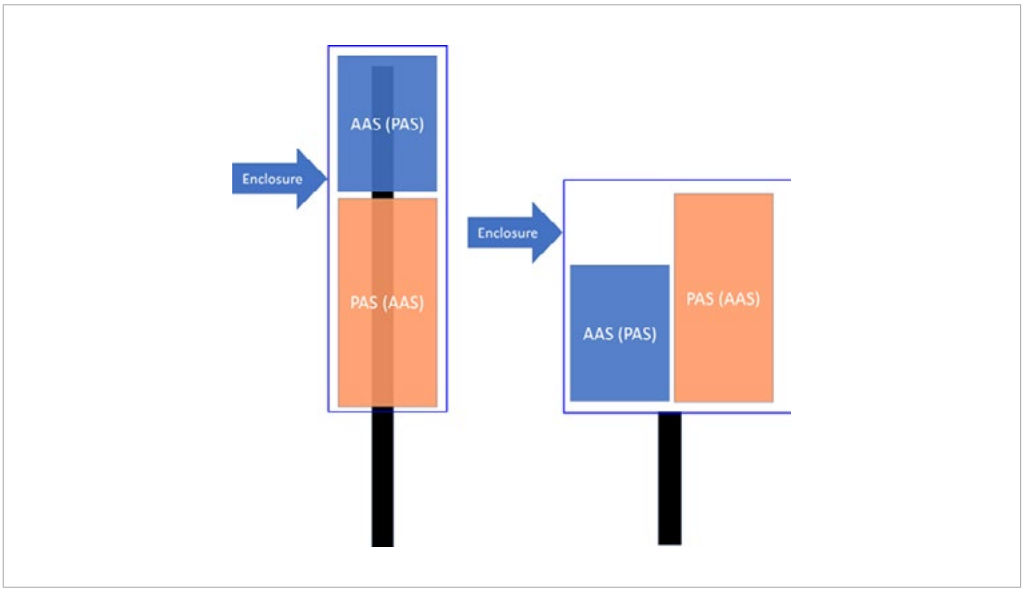


Figure 10.3: Schematic representations for Option 2

The antenna enclosure is a container capable to arrange the PAS and the AAS inside of it. The AAS and the PAS are installed inside such enclosure.

The active and passive antennas are still two separate entities. After opening or removal of the enclosure either antenna may be swapped without having to replace the other. From an operational point of view, the same factors have to be taken into account than for option 1:

- Mechanical constraints: arrangement and length of the cable tray
- Thermal constraints: spacing between elements to allow free cooling for the AAS.

10.4 OPTION 3: AAS AND PAS INTERLEAVED IN A COMMON ENCLOSURE

In option 3 (designated as interleaved configuration) passive and active modules are developed as a whole and placed within a common enclosure, by the same vendor (see Figure 10.4).

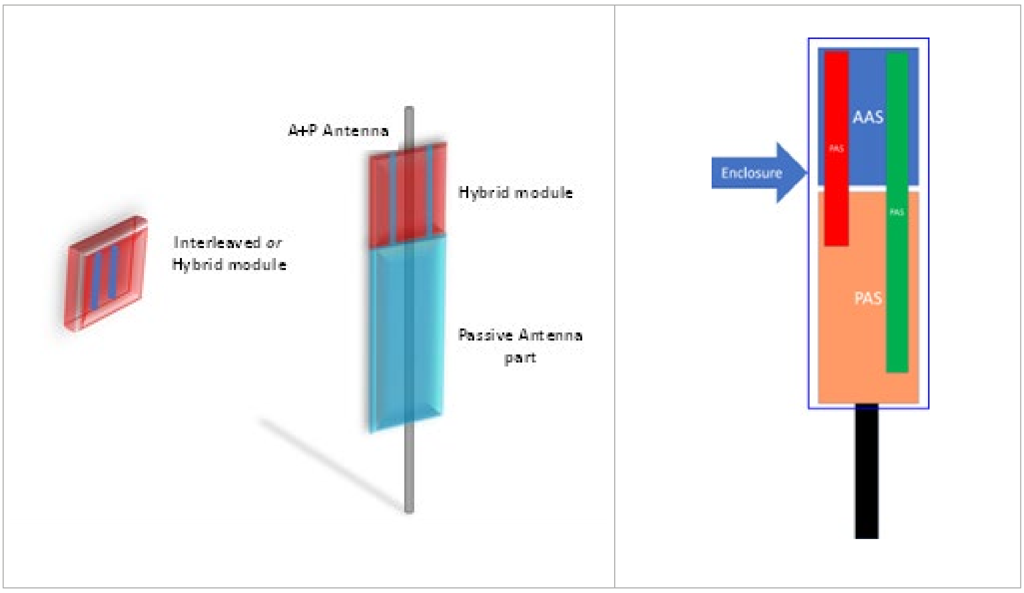


Figure 10.4: Schematic representation for Option 3: Interleaved concept

In general, the solution consists of:

- a hybrid module (Interleaved antenna in which m-MIMO elements are interleaved with passive antennas sub-arrays;
- a PAS with mid-band and low-band arrays.

The two antenna system elements are closely aligned to appear as an all-in-one radiating system and electrically interconnected, in order to guarantee “continuity” for the lowest frequencies.

Since the PAS requires the presence of the hybrid part to perform “as designed”, a common development in the design of the two parts is required.

The advantage of this implementation is that the hybrid module can be easily replaced in case of failure or for upgrading the m-MIMO unit (i.e. 32T32R to 64T64R swap).

10.5 OPTION 4: AAS DEPLOYED BEHIND THE PAS

In option 4 the PAS and the AAS are two distinct standalone units that can operate independently of each other. The passive antenna shows an RF-transparent window larger than the m-MIMO antenna radiating aperture that allows the AAS to be placed behind it (see Figure 10.5). As a result, RF signals from the AAS can pass through the PAS without any major impact on the overall antenna performance.

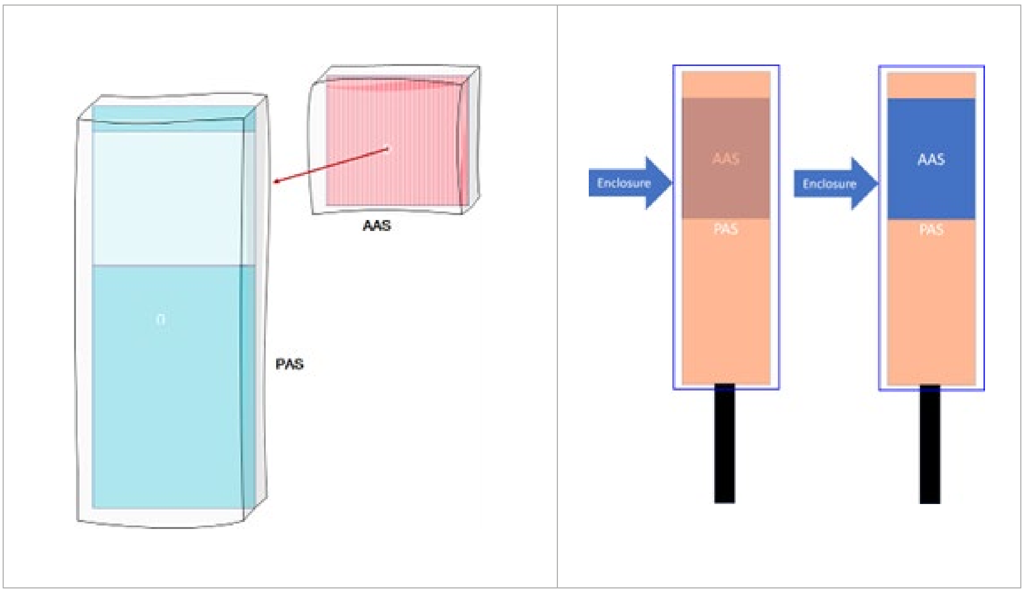


Figure 10.5: Schematic representation Option 4

With this approach, the evolution and lifespan of the AAS and the PAS are decoupled. AAS and PAS from either a single vendor or different vendors can coexist and be upgraded independently of each other.

11 APPENDIX C – EMF SCENARIOS, ASSUMPTIONS AND EXAMPLES

In order to better understand the behaviour of EMF in several relevant scenarios simulations have been performed. By monitoring EIRP in all directions of the antenna and defining a power grid, statistics have been collected. The model is based on a cluster of 21 cells using 3D-Uma 3GPP model. Three different scenarios have been evaluated; evenly distributed users, fully centralized users and single user.

Table 12.1: Simulation Scenarios

Scenarios (S#i)	Description
S#1: Normal MU	21 cells□50UE evenly distributed per cell
S#2: Extreme MU	21 cells□50UE fully centralized per cell
S#3: Single UE	21 cells□single UE distributed per cell

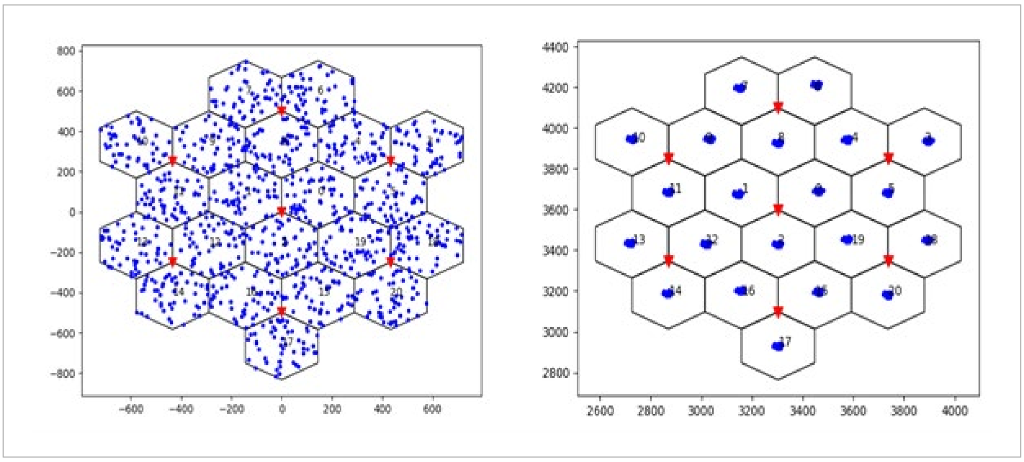


Figure 11.1: Example of UEs distribution for S#1 and S#2 – see left and right figure

Table 12.2: Simulation Assumptions

General Parameters	Description	Values
Scenarios		3D-Uma
Layout		Hexagonal grid, 7macro sites, 3 sectors per site, ISD 500 m
UE Rx configuration		4T4R
UE mobility		3 km/h
BS antenna height		29 m
Total BS Tx Power		43 dBm for 10 MHz(50 PRBs)
Carrier frequency		3.5 GHz
Min. UE-eNB 2D distance		35 m
UE height (h_{UT}) in meters	General equation	$h_{UT}=3(n_{fl} - 1) + 1.5$
	n_{fl} for outdoor UEs	1
	n_{fl} for indoor UEs	n_{fl} ~ uniform(1,N_{fl}) where N_{fl} ~ uniform(4,8)
Indoor UE fraction		80%
UE distribution (in x-y plane)	Outdoor UEs	Uniform in cell
	Indoor UEs	Uniform in cell
Traffic Model		Fullbuffer (2/4/8 layer)

Each grid point represents an AR. Then the EIRP value is recorded in each point.

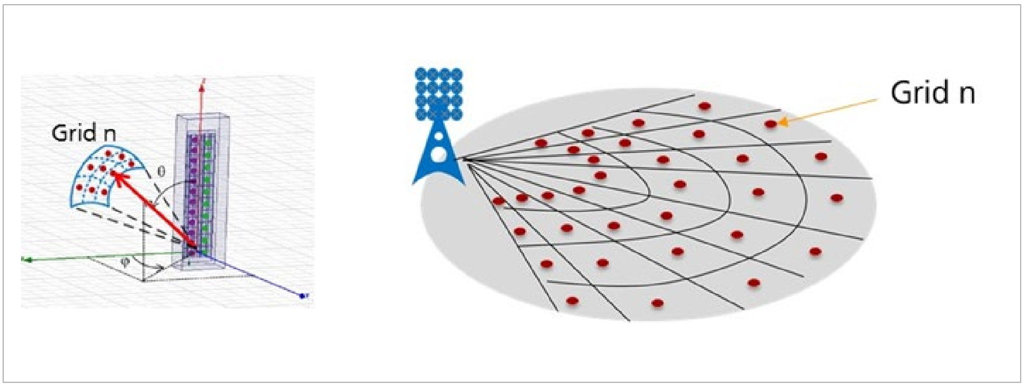


Figure 11.2: Grid points of the antenna

Scenario 1: Evenly Distributed Users

When looking at the instantaneous probability of exceeding a threshold of -6 dB backoff, one can notice that for 2 layers, the probability is close to 10% in some grid points. For 4 layers, the probability is almost zero. The CDF for all grid points, shows a 95% probability, that the output power of the antenna is 9-11dB less than peak power.

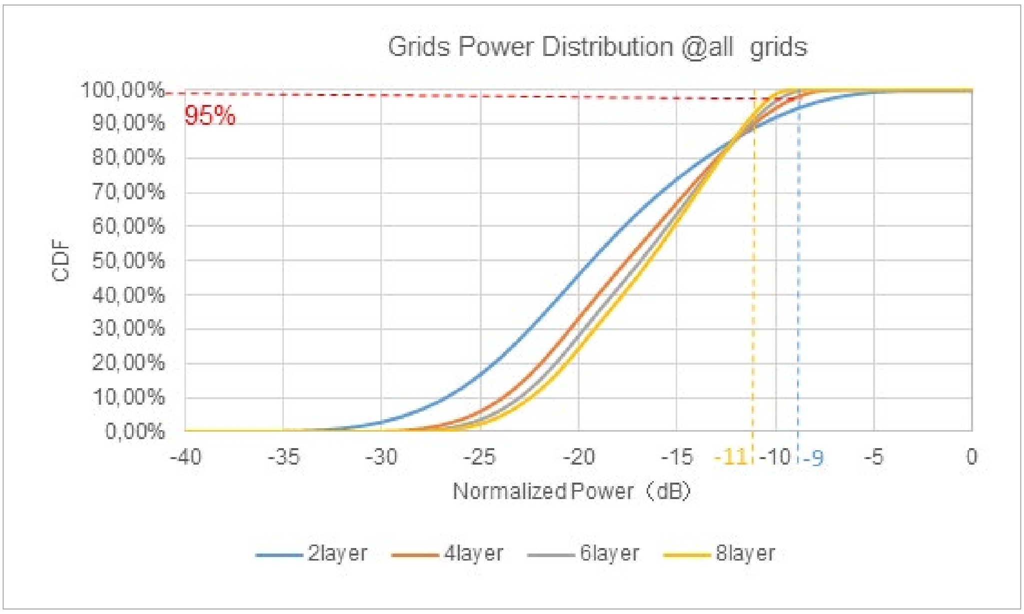


Figure 11.3: Grids Power distribution (Scenario 1)

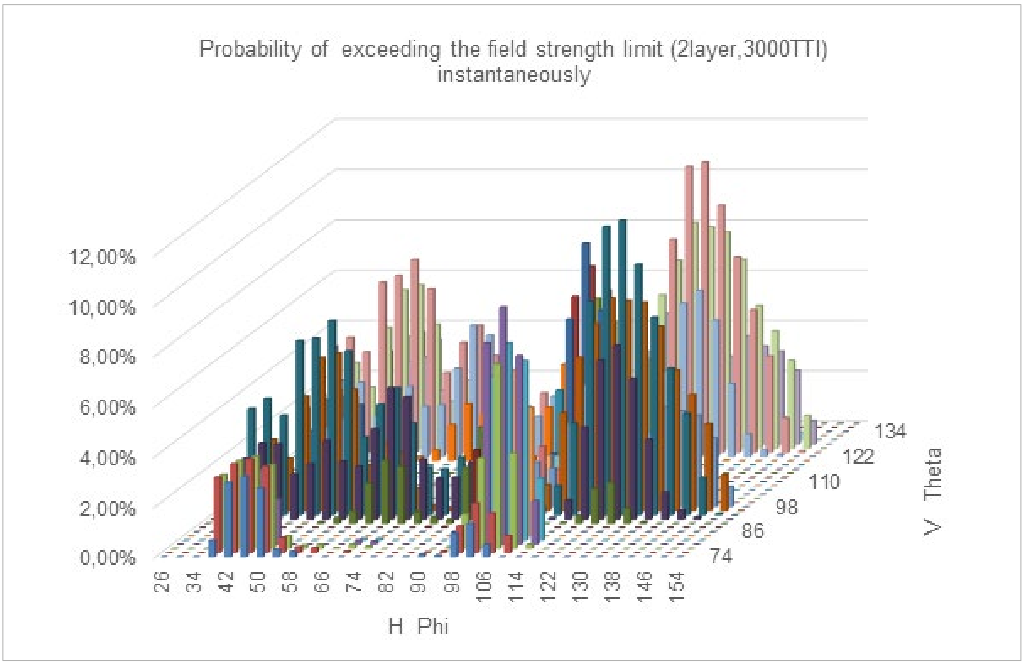


Figure 11.4: Probability of exceeding the field strength limit (2 layers, scenario 1)

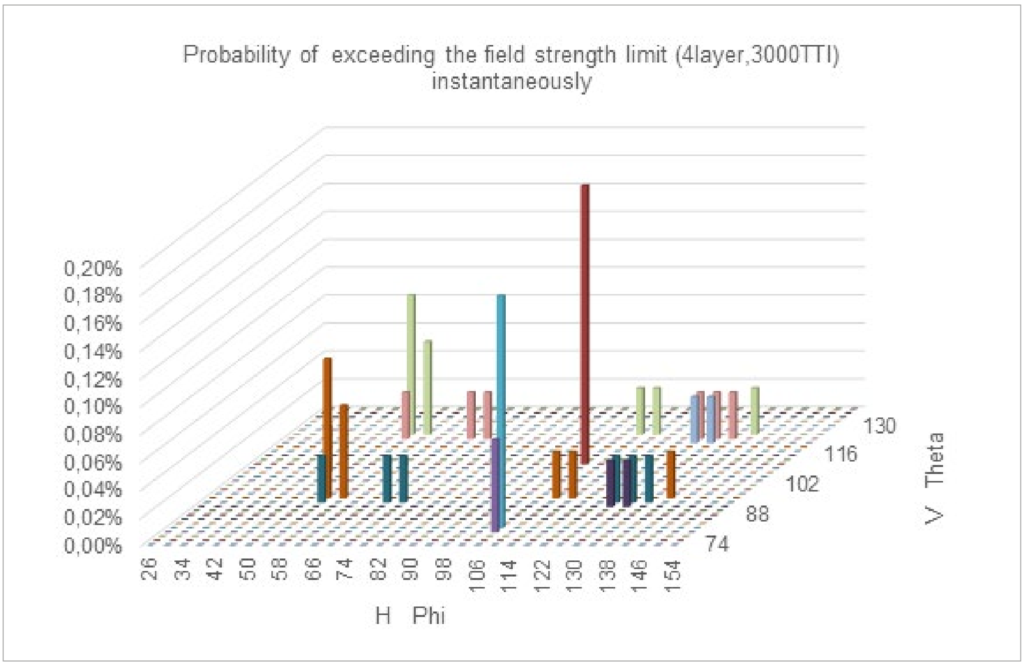


Figure 11.5: Probability of exceeding the field strength limit (4 layers, scenario 1)

If the averaged power is studied in each grid point, it is found that the level is always less than the -6 dB threshold (Pn=0.25). The averaging is here done over three seconds but similar result is expected using a longer filtering time such as 6 minutes as defined by ICNIRP

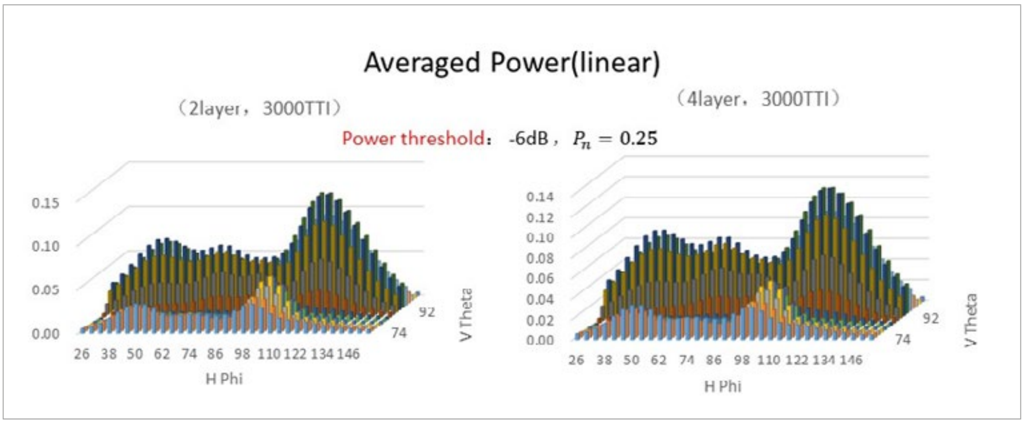


Figure 11.6: Grid points for averaged power (scenario 1)

The conclusion is that thanks to multi paths, multi user and user distribution, it is clear that the average power levels of a massive MIMO antenna system will be much lower than the peak levels.

Scenario 2: Centralized Users

In this scenario, all users are close to the antenna, it can be seen that the instantaneous probability that the power level exceed the -6 dB threshold will be significantly higher. The CDF for all grid points, shows a 95% probability, that the output power of the antenna is 8-10 dB less than peak power i.e. 1 dB more compared to scenario 1.

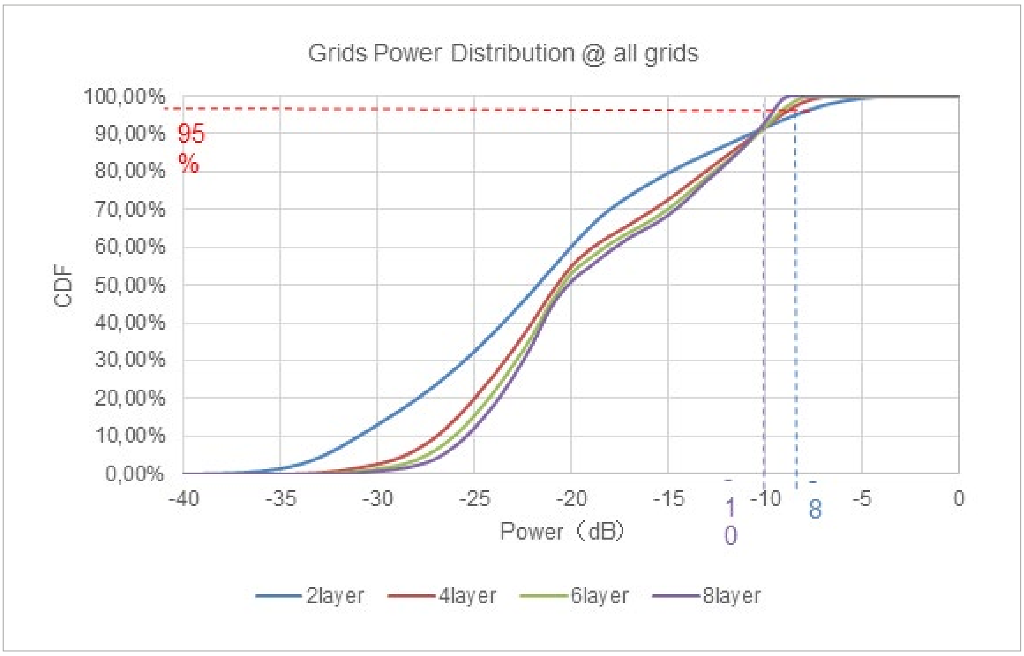


Figure 11.7: Grids Power distribution (Scenario 2)

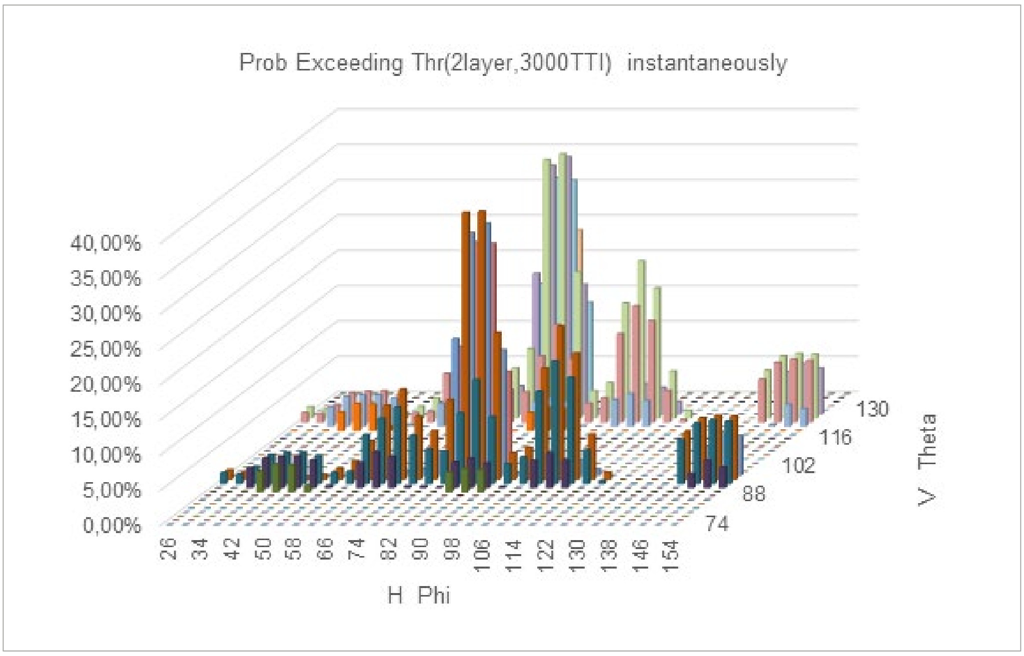


Figure 11.8: Probability of exceeding the field strength limit (2 layers, scenario 2)

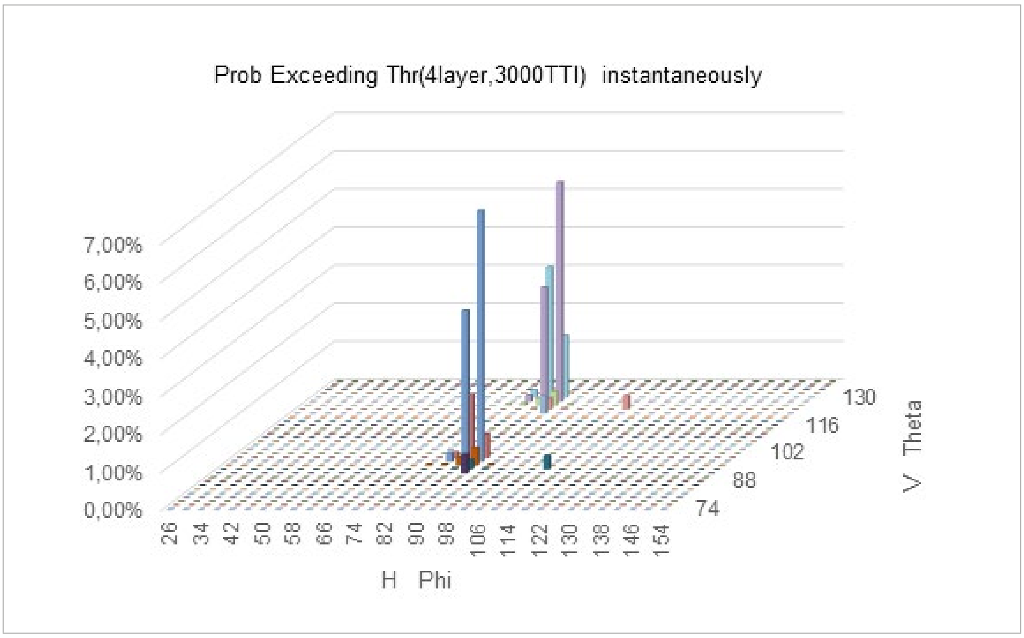


Figure 11.9: Probability of exceeding the field strength limit (4 layers, scenario 2)

If the averaged power is studied in each grid point, it can be found that the levels are very similar to those in scenario 1, i.e. always less than the -6 dB threshold (Pn=0.25). It is clear that beamforming can create spatial separation between different users even though the users are close to each other.

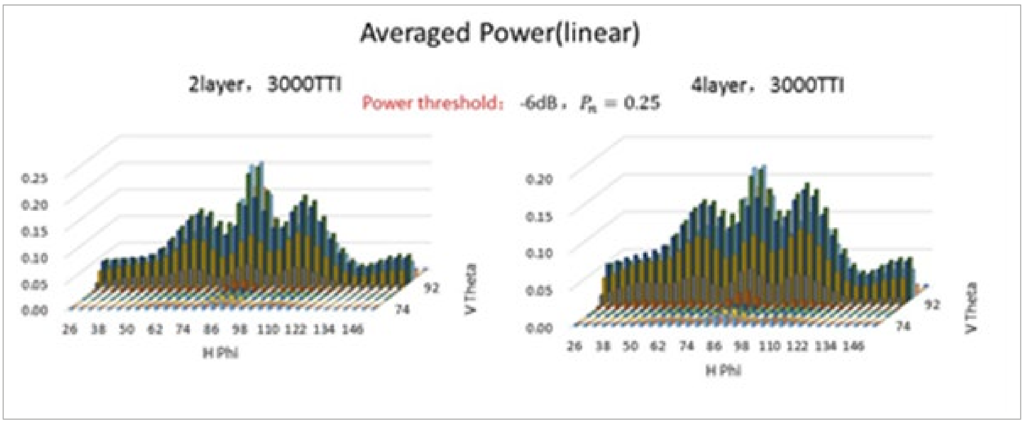


Figure 11.10: Averaged power per grid point (scenario 2)

Scenario 3: Single User

In case of a single user, the CDF for all grid points will be similar to scenario 1 and 2 and the probability to exceed the -6 dB level will be low. However, since all the power is transmitted to a single user there will be no back-off when averaging the power. This is a case that needs to be mitigated.

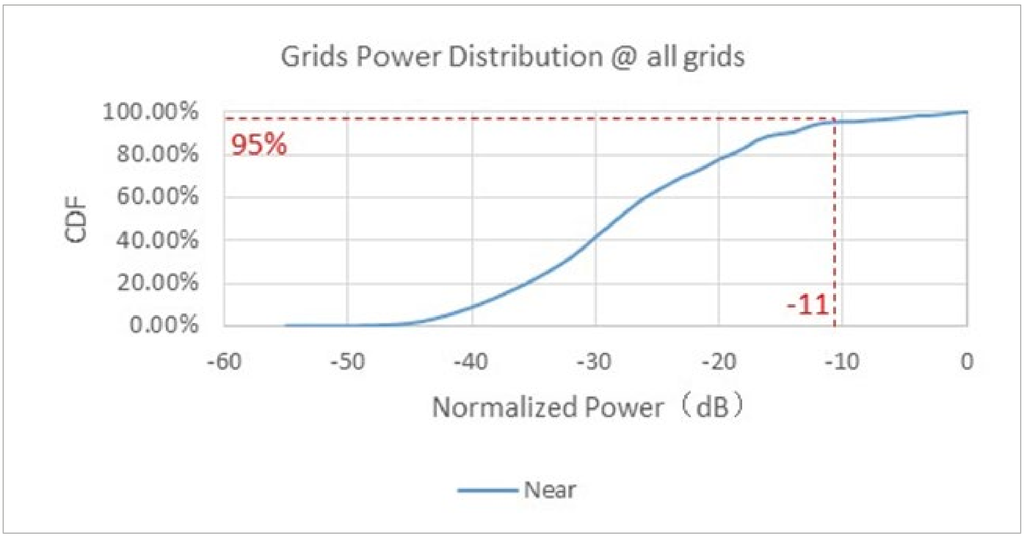


Figure 11.11: Grids Power distribution (Scenario 3)

Additional Examples

Additional examples of implementation of EMF compliance based on actual maximum transmitted power or EIRP can be found in [19] as well as in [15] and [16].

12 APPENDIX D – BASICS FOR COUNTERS

This appendix outlines some relations between power flux density, radiation intensity and EIRP relevant for EMF counters. The basic quantity is the radiated power per area, i.e., the power flux density

$$S(r,\vartheta,\varphi) = \frac{|\vec{E}|^2}{Z_0} \tag{D.1}$$

Here, |E| is the RMS value over time and Z_0≈377 Ω is the free space impedance. In the farfield region, the power density can be expressed in terms of radiation intensity (radiated power per solid angle) or EIRP. The relations to power flux density are [2]

$$S(\vartheta,\varphi) = \frac{I(\vartheta,\varphi)}{r^2} = \frac{EIRP(\vartheta,\varphi)}{4\pi\, r^2} \tag{D.2}$$

$$\mathrm{d}P_{rad}(\vartheta,\varphi) = I(\vartheta,\varphi)\sin\vartheta \mathrm{d}\vartheta \mathrm{d}\varphi = \frac{EIRP(\vartheta,\varphi)}{4\pi}\sin\vartheta \mathrm{d}\vartheta \mathrm{d}\varphi \tag{D.3}$$

The power radiated in an angular sector, given by the intervals $\vartheta \in [\vartheta_{START}, \vartheta_{STOP}]$ and $\varphi \in [\varphi_{START}, \varphi_{STOP}]$, is then

$$P_{sector} = \int_{\vartheta_{START}}^{\vartheta_{STOP}} \int_{\varphi_{START}}^{\varphi_{STOP}} I(\vartheta,\varphi) sin\vartheta d\vartheta d\varphi = \frac{1}{4\pi} \int_{\vartheta_{START}}^{\vartheta_{STOP}} \int_{\varphi_{START}}^{\varphi_{STOP}} EIRP(\vartheta,\varphi) sin\vartheta d\vartheta d\varphi \tag{D.4}$$

Note: If EIRP is integrated over an angular region, a scaling factor of 1/4π is required to get the power radiated in the angular region.

The reverse action is to estimate the field strength at a distance and in a given angular region from a given power level P_{sector}. Since P_{sector} is retrieved from an integrated value, only the average EIRP or Radiation Intensity is possible to estimate. The angular average of the radiation intensity is the solid angle of the angular sector. At a fixed distance r, the angular average of the power flux density is

$$I_{av} = \frac{1}{\Omega_{sector}} \int_{\vartheta_{START}}^{\vartheta_{STOP}} \int_{\varphi_{START}}^{\varphi_{STOP}} I(\vartheta,\varphi) sin\vartheta d\vartheta d\varphi = \frac{P_{sector}}{\Omega_{sector}} \tag{D.5}$$

Here,

$$\Omega_{sector} = \int_{\vartheta_{START}}^{\vartheta_{STOP}} \int_{\varphi_{START}}^{\varphi_{STOP}} sin\vartheta d\vartheta d\varphi = (\sin\Theta_{STOP} - \sin\Theta_{START})(\varphi_{STOP} - \varphi_{START}) \tag{D.6}$$

is the solid angle of the angular sector. At a fixed distance r, the angular average of the power flux density is

$$S_{av} = \frac{1}{r^2} \frac{P_{sector}}{\Omega_{sector}} \tag{D.7}$$

Finally, the angular average RMS E-field strength is calculated as

$$\left|\vec{E}\right| = \frac{1}{r} \sqrt{\frac{Z_0 P_{sector}}{\Omega_{sector}}} \tag{D.8}$$

13 APPENDIX E - POLARIZATION CORRELATION FACTOR

For a dual polarized system Polarization Correlation Factor (PCF) is defined as:

$$\mathrm{PCF}(\vartheta,\varphi) = \frac{\left|\vec{E_1}(\vartheta,\varphi)\cdot\vec{E_2^*}((\vartheta,\varphi))\right|^2}{\left|\vec{E_1}((\vartheta,\varphi))\right|^2\left|\vec{E_2}((\vartheta,\varphi))\right|^2} \tag{E.1}$$

This is a directional metric and the far fields $E_1(\vartheta,\varphi)$ and $E_2(\vartheta,\varphi)$ are

- Generated by two beams serving the same direction for GoB systems
- Not yet defined, in the EEB case

PCF generalizes the concept of Cross Polar Discrimination (CPD) wherein one of the fields has a constant polarization.

Note: In the case of orthogonal polarizations PCF = 0 and for equal polarizations PCF = 1 or equivalently 100%. This definition is related to the IEEE definition of Polarization Mismatch Factor [2].

Synonym to PCF is "Polarization Parallelity"

The following table illustrates PCF and may be used for reference calculations

Table 14.1: Examples of Polarization Correlation Factors (PCFs)

Polarization 1	$\vec{E}_1$	$\lvert\vec{E}_1\rvert^2$	**Polarization 2**	$\vec{E}_2$	$\lvert\vec{E}_2\rvert^2$	$\lvert\vec{E}_1\cdot\vec{E}_2^*\rvert$	**PCF** (%)
V	$\hat{\Theta}$	1	H	$\hat{\varphi}$	1	0	0%
V	$\hat{\Theta}$	1	V	$\hat{\Theta}$	1	1	100%
V	$\hat{\Theta}$	1	+45/-45	$\hat{\Theta}\pm\hat{\varphi}$	2	1	50%
V	$\hat{\Theta}$	1	LHCP/RHCP	$\hat{\Theta}\pm j\hat{\varphi}$	2	1	50%
Elliptical	$\hat{\Theta}+2\hat{\varphi}$	5	Elliptical	$\hat{\Theta}-\hat{\varphi}$	2	1	10%
Elliptical	$\hat{\Theta}+2j\hat{\varphi}$	5	Elliptical	$2j\hat{\Theta}-\hat{\varphi}$	5	0	0%
Elliptical	$\hat{\Theta}+2j\hat{\varphi}$	5	Elliptical	$\hat{\Theta}-2j\hat{\varphi}$	5	3	36%

14 APPENDIX F - ENVELOPE RADIATION PATTERNS

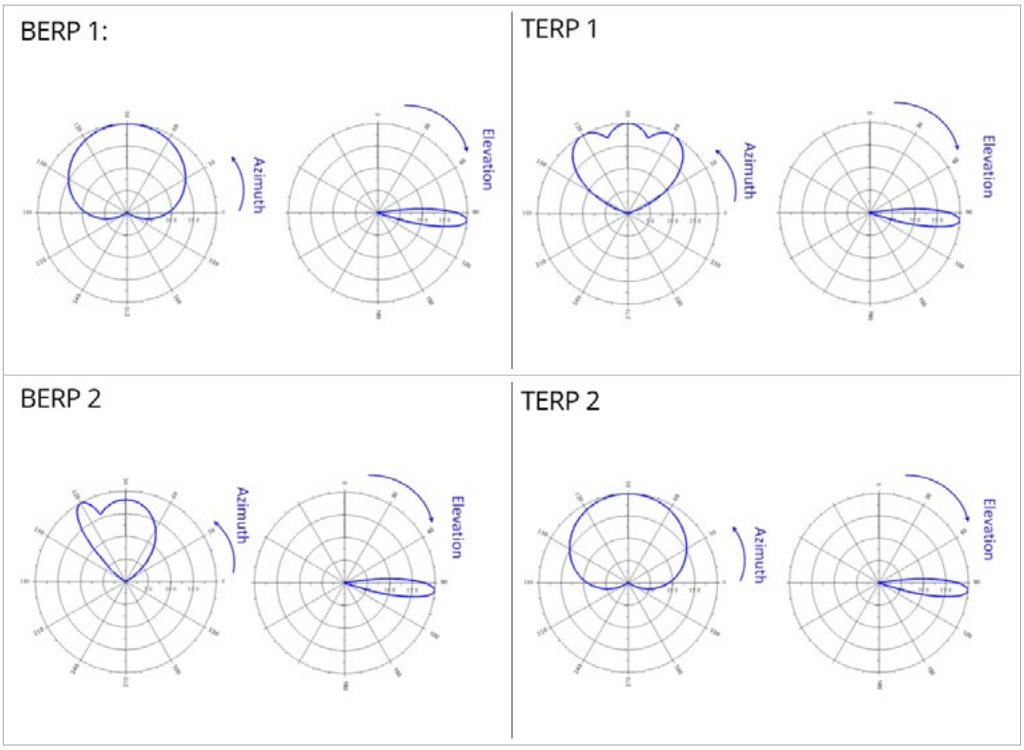
It might be convenient to distinguish between Broadcast and Traffic envelopes. An AAS has the following set of envelope radiation patterns:

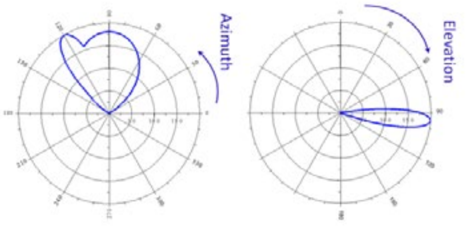
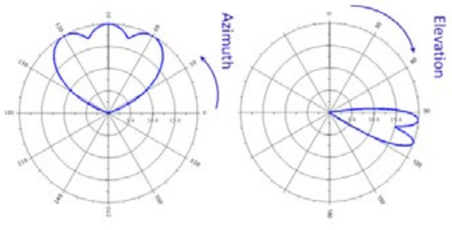
- Broadcast Envelope Radiation Pattern (BERP): is the envelope pattern of each Broadcast Beam Configuration. Since the AAS can have different broadcast configurations available for specific coverage requirements, there are as many BERP as the number of configurations implemented by the AAS. In case the configuration is made of just one beam, the BERP corresponds to the radiation pattern of that beam;

- Traffic Envelope Radiation Pattern (TERP): is the envelope pattern of the traffic beams associated with a Broadcast Configuration. TERP could be associated to more than one Broadcast Configuration.

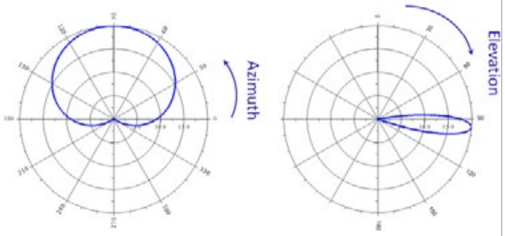
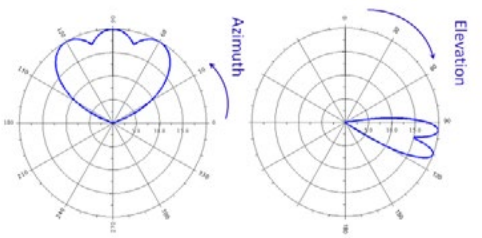
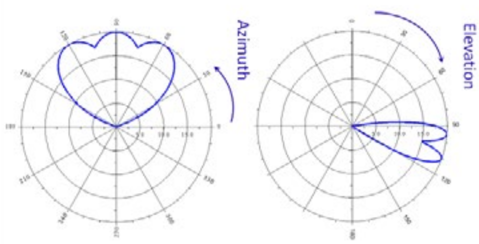
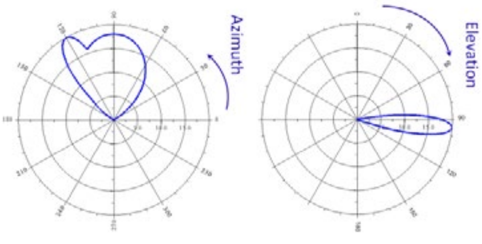
The following examples show different combinations of BERP and TERP:

A. AAS implementing some configurations for BERP, each one having a corresponding TERP:

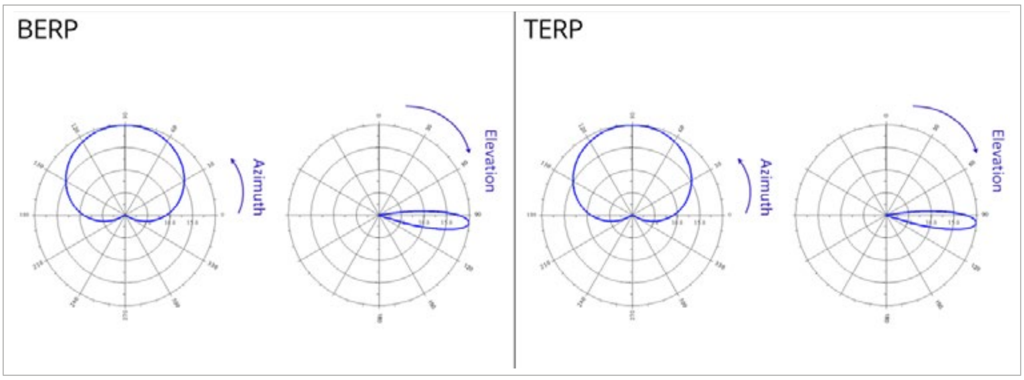


---	---
BERP N 	TERP N 

B. AAS implementing some configurations for BERP, each one has the same TERP:

BERP 1: 	
BERP 2 	TERP 
--- BERP N 	

c. AAS implementing one BERP and TERP, which are the same pattern:



15 APPENDIX G - RADIATION PATTERN FILE FORMAT

This section describes the file format for interchanging the antenna radiation pattern data. The file format is thought to represent the antenna radiation pattern independently by the antenna typology, passive or active. The file format described here is also suitable for describing the envelope radiation pattern.

The available coordinate systems for using this radiation pattern file format are described in section 2.2; the adopted Coordinate System shall be declared in the header section - see Section 13.2.

Any deviation shall be reported in the headers of radiation pattern file format in the optional set of information – see following Table G.2.

Radiation pattern data is coded into file by using the JSON data-interchange format (see Section 16, see https://www.json.org/json-en.html).

15.1 FILE NAMING

The file name is constructed by fields separated by the symbol underscore "_". Each field shall contain only the characters: alphanumeric (0-9, a-z, A-Z), hash (ASCII 35), dash (ASCII 45), dot (ASCII 46). The following set of fields shall be included in the file name for easy file selection, according to the order given in the bulleted list below:

1. Manufacturer: the name of the Manufacturer of the Antenna (example: TheCompanyName)

2. Antenna Model: the name the Manufacturer has given to the antenna (example: Antenna1)

3. Frequency: frequency is reported in units of MHz (example: 3700 for 3.7 GHz, 2569.8 for 2.5698 GHz, 0.1 for 100 kHz). No limits on the decimals.

4. Beam identification for the radiation pattern, a selection of:
    a. Letter "E" for Envelope Radiation Pattern followed by the beam ID (example: E123 is an envelope pattern whose ID is 123)
    b. Letter "B" for Beam Radiation Pattern followed by the beam ID (example: B456 is a beam whose ID is 456)

c. Code “A-” (reference to the AISG Color Code – see [20]) for a Passive Antenna Radiation Pattern then followed by

   i. the ARRAY ID built as a concatenated string which consists of the first letter of the appropriate colour (R, Y, G, B, P) and a unique number within each colour.

   ii. the RF port number as defined in [20] RFp followed by 2 digits for port number

   Example:

   - A-Y1_RFp07
   - A-R3_RFp02

5. Tilt coded as T followed by 2 digits tilt followed by a p (p stands for plus – downtilt) or m (m stands for minus - uptilt) followed by 1 digit for decimals (example: T02p1 stands for 2.1 degrees downtilt, T02m1 stands for 2.1 degrees uptilt).

   Note: downtilt means the direction down from the horizon.

6. Nominal Polarization: allowed codification for polarization is listed below (corresponding to Table G1 at row “Nominal_Polarization”)
   - Total: in the case the pattern is not related to a specific polarization
   - P45: for Positive 45 degrees
   - M45: for Negative 45 degrees
   - P45M45: for Positive 45 degrees and Negative 45 degrees
   - M45P45: for Negative 45 degrees and Positive 45 degrees
   - H: for Linear Horizontal
   - V: for Linear Vertical
   - HV: for Linear Horizontal and Linear Vertical
   - VH: for Linear Vertical and Linear Horizontal
   - RHC: for Right Hand Circular
   - LHC: for Left Hand Circular
   - P###: for Positive ### degrees
   - M###: for Negative ### degrees
   - P###-M###: for Positive ### degrees and Negative ### degrees
   - M###-P### for Negative ### degrees and Positive ### degrees

   Note: ### stands for any integer value of angles in degrees (max. 3 digits)

7. **Extra Information (optional):** optional field the manufacturer may add to provide extra information (example: ThisIsAnExtraInformation)

8. **File extension:** “_3drp.json”.

Note: Double polarization codes (e.g. M45P45, P45M45, HV, VH, P###M### and M###P###) could be used for Active Antenna systems in the case there is not confusion in the description of the polarization in the Radiation Pattern data file. For Passive Antenna Systems each polarization is described in a specific radiation pattern data file.

Examples:

- An active antenna working at 700.5 MHz, Envelope Radiation Pattern ID 123, both +45 and -45 degrees polarizations

```
TheCompanyName_Antenna1_700.5_E123_P45M45_3drp.json
```

- The same as in example 1) with an extra optional information,

```
TheCompanyName_Antenna1_700.5_E123_P45M45_
ThisIsAnExtraInformation_3drp.json
```

- An active antenna working at 2.5 GHz, Beam Radiation Pattern ID 123, total pattern not related to a specific polarization, including an optional extra information

```
TheCompanyName_Antenna1_2500_B123_Total_
ThisIsAnExtraInformation_3drp.json
```

- A passive antenna working at 934.7 MHz, Array ID no. R5, RF port no. 7, 3.5 degrees uptilt, RHC polarization, including an optional extra information

```
TheCompanyName_Antenna1_934.7_A-R5_RFp07_T03m5_RHC_
ThisIsAnExtraInformation_3drp.json
```

- A passive antenna working at 934.7 MHz, Array ID no. R5, RF port no. 7, 3.5 degrees uptilt, +45 and -45 degrees polarizations, including an optional extra information

```
TheCompanyName_Antenna1_934.70_A-R5_RFp07_T03m5_P45M45_
ThisIsAnExtraInformation_3drp.json
```

15.2 FILE CONTENT

File content consists of an unordered set of information lines:

- each information line consists of a name/value pair;
- an information line can be either mandatory or optional:
  - the name of a mandatory information line (see Table G.1, first column) cannot be changed
  - a mandatory information line shall be present even if its value, in the name/value pair, is empty
  - empty values shall be coded with the keyword null according to the JSON format.

- optional name/value pair can be added by the manufacturer

`Optional_Comment`	Any comment the manufacturer wants to include	String or numerical data	`"Optional_Comment": “any comment”`

- the name of an optional information line shall be different than the names of any mandatory information lines
- any optional information line shall be placed before the “Data_Set_Row_Structure” mandatory information line, see Table G.1

• names in the name/value pairs are case-sensitive.

Each information line is mapped into an object consisting of a name/value pair according to the JSON (JavaScript Object Notation) data-interchange format (https://www.json.org/).

The radiation pattern data are given in the angular coordinates depending on the selected SPCS as defined in Section 2.2. For brevity, these are here forth referred to by their symbol names Theta and Phi.

Table 16.1: Mandatory Information Lines

Name	Description	Type	JSON example
BASTA_AA_WP_ version	BASTA AA WP version in which the .3drp format is referred to. This is useful for maintaining the coherence of the file content to the relevant WP version	String	"BASTA_AA_WP_version": "3.0"
Supplier	The name of the manufacturer or supplier	String	"Supplier": "ACME Inc."
Antenna_Model	The model of the antenna as defined by the manufacturer	String	"Antenna_Model": "BeepBeep"
Antenna_Type	Allowed values are: Active, Passive, Hybrid	String	"Antenna_Type": "Active"
Revision_Version	The version of the file as defined by the antenna manufacturer	String	"Revision_Version": "1.2.3a"
Released_Date	The release date of the file. The date is reported in [21] format: 4 digits for the year followed by a dash, 2 digits for the month (01 to 12) followed by a dash and 2 digits for the day (01 to 31)	String	"Released_Date": "2021-12-31"
Coordinate_ System	The adopted Coordinate System for the representation of angles in the file format as defined in Section 2.2 Allowed keywords are: • SPCS_Polar • SPCS_Polar • SPCS_CW • SPCS_CCW • SPCS_Geo	String	"Coordinate_System": "SPCS_CCW"
Pattern_Name	The name the manufacturer gives to the pattern. 'null' in case of passive antennas	String	"Pattern_Name": "BB_01" "Pattern_Name": null
Beam_ID	Beam Identification code the manufacturer gives to the beams as indicated in section 3.3.9. If there is no ID use the keyword null	String	"Beam_ID": "ID12345" "Beam_ID": null
Pattern_Type	Allowed values are: • Broadcast Beam • Broadcast Configuration Envelope • Traffic Beam • Traffic Envelope • Uplink • Generic (it is used for non-specific radiation patterns, as an example for passive antennas)	String	"Pattern_Type": "Traffic Envelope" "Pattern_Type": "Generic"

Name	Description	Type	JSON example

`Frequency`	The pattern frequency and the associated unit.
	Allowed units are:
	• Hz
	• kHz
	• MHz
	• GHz
	• THz
		Object:
		• Float (value)
		• String (unit)
			`"Frequency": {`
			`"value": 3.126,`
			`"unit": "GHz"`
			`}`

`Frequency_Range`	The frequency range (lower bound, the frequency upper bound and the associated unit) within which data in the file are valid.
	Allowed units are:
	• Hz
	• kHz
	• MHz
	• GHz
	• THz
	
	If Frequency_Range is not present null shall be used.
		Object:
		• Float (lower)
		• Float (upper)
		• String (unit)
			`"Frequency_Range": {`
			`"lower": 2145.8,`
			`"upper": 3280.0,`
			`"unit": "MHz"`
			`}`
			`"Frequency_Range": null`

`EIRP`	The maximum EIRP value and the associated unit.
	Allowed units are:
	• mW
	• W
	• dBW
	• dBm
	
	If populated, the Configured_Output_Power shall be populated with the power whose EIRP is referred to.
	If EIRP cannot be indicated (e.g. for Passive Antennas) null shall be used
		Object:
		• Float (value)
		• String (unit)
			`"EIRP": {`
			`"value": 5.0,`
			`"unit": "W"`
			`}`
			`"EIRP": null`

`Configured_ Output_Power`	The configured output power the EIRP is referred to. Allowed units are:
	• mW
	• W
	• dBW
	• dBm
	If EIRP is not populated, null shall be used
		Object:
		• Float (value)
		• String (unit)
			`"Configured_Output_Power": {`
			`"value": 5.0,`
			`"unit": "dBm"`
			`}`
			`"Configured_Output_Power": null`

Name	Description	Type	JSON example

`Gain`	The gain and the associated unit.
	Allowed units are:
	• dBi
	• dBd
	If not populated null shall be used, and both EIRP and Configured_Output_Power shall be populated
		Object:
		• Float (value)
		• String (unit)
			`"Gain": {`
			`"value": 5.0,`
			`"unit": "dBi"`
			`}`
			`"Gain": null`

`Configuration`	The configuration of the Active Antenna which the radiation pattern refers to. Use null for Passive Antennas	String	`"Configuration": "TNT_01"` `"Configuration": null`
`RF_Port`	The RF port name given by the manufacturer, according to the AISG Standard [20] Use null for Active Antennas	String	`"RF_Port": "5"` `"RF_Port": null`
`Array_ID`	Codification of the Array ID according to the AISG Standard. Use null for Active Antennas	String	`"Array_ID": "Y1"` `"Array_ID": null`
`Array_Position`	Codification of the Array Position according to the AISG Standard [20]. Use null for Active Antennas or single column passive	String	`"Array_Position": "CR"` `"Array_Position": null`
`Phi_HPBW`	Half-Power BeamWidth on the azimut plane at the maximum gain position. Unit: degrees	Float	`"Phi_HPBW": 65.0`
`Theta_HPBW`	Half-Power BeamWidth on the elevation plane at the maximum gain position. Unit: degrees	Float	`"Theta_HPBW": 5.0`
`Front_to_Back`	Minimum attenuation relative to “Gain” along the backside direction, in Theta angle range +/-30° and in Phi angle range +/-30°. Unit: dB	Float	`"Front_to_Back": 10.0`
`Phi_Electrical_Pan`	The electrical pan on the azimuth plane, see Section 2.2; value depends on the adopted Coordinate System Unit: degrees If phi_Electrical_Pan is not present null shall be used.	Float	`"Phi_Electrical_Pan": 30.0` `"Phi_Electrical_Pan": null`

Name	Description	Type	JSON example
`Theta_ Electrical_Tilt`	The electrical tilt on the elevation plane with respect to the horizontal direction. Value depends on the adopted Coordinate System Unit: degrees If Theta_Electrical_Tilt is not present null shall be used.	Float	`"Theta_Electrical_Tilt": 10.0` `"Theta_Electrical_Tilt": null`
`Nominal_ Polarization`	The nominal polarization(s) the pattern is referred to. Depending on how many polarizations are contained in the data section, the following values are allowed: • Total: in the case the pattern is not related to a specific polarization • P45: for Positive 45 degrees • M45: for Negative 45 degrees • P45M45: for Positive 45 degrees and Negative 45 degrees • M45P45: for Negative 45 degrees and Positive 45 degrees • H: for Linear Horizontal • V: for Linear Vertical • HV: for Linear Horizontal and Linear Vertical • VH: for Linear Vertical and Linear Horizontal • RHC: for Right Hand Circular • LHC: for Left Hand Circular • P###: for Positive ### degrees • M###: for Negative ### degrees • P###M###: for Positive ### degrees and Negative ### degrees • M###P### for Negative ### degrees and Positive ### degrees *Note: ### stands for any integer value of angles in degrees (max. 3 digits)*	String	`"Nominal_Polarization": "P45"`

Name	Description	Type	JSON example
Theta_Sampling	Theta angles the pattern is sampled at. The format is as follows, according to sampling format: • uniform sampling: start angle, step angle, stop angle; values are in degrees. • non-uniform sampling: null; Theta angle must be provided in Data_Set; Phi_Sampling shall be null as well. Value depends on the adopted Coordinate System Unit: degrees	3-element float array	"Theta_Sampling": [-90.0, 1.0, 90.0] "Theta_Sampling": null
Phi_Sampling	Phi angles the pattern is sampled at. The format is as follows, according to sampling format:: • uniform sampling: start angle, step angle, stop angle; values are in degrees. • non-uniform sampling: null; Phi angle must be provided in Data_Set; Theta_Sampling shall be null as well. Value depends on the adopted Coordinate System Unit: degrees	3-element float array	"Phi_Sampling": [0.0, 1.0, 359.0] "Phi_Sampling": null

Name	Description	Type	JSON example

`Data_Set_Row_Structure`	The list of elements in each row of Data_Set:
	1. angular elements
	• if Theta_Sampling and Phi_Sampling are null: "Theta","Phi"
	• if Theta_Sampling and Phi_Sampling are not null angles can be omitted
	2. radiation pattern elements - a selection of position-independent strings:
	• "MagAttenuationTP" for Total Power magnitude
	• "MagAttenuationCo" for CoPolar component magnitude
	• "MagAttenuationCr" for CrossPolar component magnitude
	• "PhaseCo" for CoPolar component phase
	• "PhaseCr" for CrossPolar component phase
	
	Attenuation is given in dB (positive with respect to maximum EIRP or Gain) and phase is given in degrees (see Note 1).
		Array of strings	`If Theta_Sampling and phi_Sampling are null:`
			`[`
			`"Theta",`
			`"Phi",`
			`"MagAttenuationCo",`
			`"PhaseCo"`
			`]`
			
			`If Theta_Sampling and Phi_Sampling are not null:`
			`[`
			`"MagAttenuationCo",`
			`"PhaseCo"`
			`]`

Name	Description	Type	JSON example

`Data_Set`	Radiation Pattern matrix built as follows:
	`[`
	`[data set row 1],`
	`[data set row 2]`
	`…`
	`]`
	
	where the content of each row is described by Data_Set_Row_Structure.
	
	If angles Theta and phi are omitted in the data set row, radiation pattern elements shall be provided by scanning the sphere according to the following rule:
	`for (Theta=start;step;stop)`
	`{`
	`for (Phi=start;step;stop)`
	`{`
	`radiation pattern elements`
	`}`
	`}`
	where start, step and stop are given by Theta_Sampling and Phi_Sampling.
	
	Note: Any order for angle representation, uniform or not, is allowed. Ordered data as in the side example is recommended, if possible.
		Array of arrays	`If Theta_Sampling and Phi_Sampling are null and with reference to the Data_Set_Row_Structure example given above:`
			`[`
			`[-90.,0.,0.1,10.],`
			`[-90.,3.,0.6,15.],`
			`…`
			`[-86.,0.,0.1,10.],`
			`[-86.,9.,0.6,15.],`
			`[-86.,10.,0.6,15.],`
			`]`
			
			`If Theta_Sampling and Phi_Sampling are not null and with reference to the Data_Set_Row_Structure example given above:`
			`[`
			`[0.1,10.],`
			`[0.6,15.],`
			`…`
			`]`

Note 1: To convert from MagAttenuation and Phase to linear relative Far Field (FF) use $FF = 10^{-MagAttenuation/10} e^{jPhase\,\pi/180}$ *where is the* $|FF|^2$ *the relative gain.*

15.3 JSON FILE FORMAT EXAMPLES

Numerical data contained in the following examples and in the accompanying data files (include here the link to BASTA AA WP3.0 repository) are only for showing the _3drp.json file format, so not corresponding to real or realistic radiation patterns.

15.3.1 PASSIVE ANTENNA UNIFORM SAMPLING EXAMPLE

File Name :
`VENDOR_ANTMODEL2_2100_A-Y1_RFp01_T00p0_P45_UniformSampling_3drp.json`

```
{
   "BASTA_AA_WP_version": "3.0",
   "Supplier": "VENDOR",
   "Antenna_Model": "ANTMODEL2",
   "Antenna_Type": "Passive",
   "Revision_Version": "1.0",
   "Released_Date": "2023-05-05",
   "Coordinate_System": "SPCS_CW",
   "Pattern_Name": null,
   "Beam_ID": null,
   "Pattern_Type": "Generic",
   "Frequency": {
      "value": 2100,
      "unit": "MHz"
      },
   "Frequency_Range": null,
   "EIRP": null,
   "Configured_Output_Power": null,
   "Gain": {
      "value": 15.11,
      "unit": "dBi"
      },
   "Configuration": null,
   "RF_Port": "01",
   "Array_ID": "Y1",
   "Array_Position": "L",
   "Phi_HPBW": 91.64,
   "Theta_HPBW": 10.8,
   "Front_to_Back": 21.72,
   "Phi_Electrical_Pan": null,
   "Theta_Electrical_Tilt": 0,
   "Nominal_Polarization": "P45",
   "Theta_Sampling": [-90.0, 1.0, 90.0],
   "Phi_Sampling": [0.0, 1.0, 359.0],
   "Optional_Comments": "example of passive antenna; theta and phi
of radiation pattern are omitted in Data_Set (uniform sampling)",
```

```
    "Data_Set_Row_Structure": [
      "MagAttenuationCo",
      "MagAttenuationCr"
      ],
    "Data_Set": [
      [
        65.63973311055209,
        112.76348938213428
      ],
      [
        65.64120737221384,
        106.04556131402066
      ],
      [
        65.64563443576502,
        102.2783015522732
      ],
      [
        65.65301291621606,
        99.6665197293747
      ],
      [
        65.66334051866878,
        97.67415975082629
      ],
      [
        65.67661406007106,
        96.06978747488755
      ],
      ……
      ……
    }
```

15.3.2 PASSIVE ANTENNA NOT UNIFORM SAMPLING EXAMPLE

File Name:
VENDOR_ANTMODEL1_2100_A-Y1_RFp01_T00p0_P45_NonUniformSampling_3drp.json

```
{
    "BASTA_AA_WP_version": "3.0",
    "Supplier": "VENDOR",
    "Antenna_Model": "ANTMODEL1",
    "Antenna_Type": "Passive",
    "Revision_Version": "1.0",
    "Released_Date": "2023-05-05",
    "Coordinate_System": "SPCS_CW",
    "Pattern_Name": null,
    "Beam_ID": null,
    "Pattern_Type": "Generic",
```

```
    "Frequency": {
      "value": 2100,
      "unit": "MHz"
    },
    "Frequency_Range": null,
    "EIRP": null,
    "Configured_Output_Power": null,
    "Gain": {
      "value": 15.11,
      "unit": "dBi"
    },
    "Configuration": null,
    "RF_Port": "01",
    "Array_ID": "Y1",
    "Array_Position": "L",
    "Phi_HPBW": 91.64,
    "Theta_HPBW": 10.80,
    "Front_to_Back": 21.72,
    "Phi_Electrical_Pan": null,
    "Theta_Electrical_Tilt": 0.0,
    "Nominal_Polarization": "P45",
    "Theta_Sampling": null,
    "Phi_Sampling": null,
    "Optional_Comments": "example of passive antenna; theta and phi of
radiation pattern are provided in Data_Set (non-uniform sampling)",
    "Data_Set_Row_Structure": [
      "Theta",
      "Phi",
      "MagAttenuationCo",
      "MagAttenuationCr"
    ],
    "Data_Set": [
      [
        -90,
        0,
        65.63973311055209,
        112.76348938213428
      ],
      [
        -90,
        1,
        65.64120737221384,
        106.04556131402066
      ],
      [
        -90,
        2,
        65.64563443576502,
        102.2783015522732
      ],
      [
```

```
        -90,
        3,
        65.65301291621606,
        99.6665197293747
      ],
      ……
      ……
   }
```


15.3.3 ACTIVE ANTENNA UNIFORM SAMPLING EXAMPLE

File Name:
`VENDOR_ANTMODEL4_3700_BID67890_T00p0_P45_UniformSampling_3drp.json`


```
{
   "BASTA_AA_WP_version": "3.0",
   "Supplier": "VENDOR",
   "Antenna_Model": "ANTMODEL4",
   "Antenna_Type": "Active",
   "Revision_Version": "1.0",
   "Released_Date": "2023-05-05",
   "Coordinate_System": "SPCS_CW",
   "Pattern_Name": "ThePatternName",
   "Beam_ID": "ID67890",
   "Pattern_Type": "Broadcast Beam",
   "Frequency": {
      "value": 3700,
      "unit": "MHz"
   },
   "Frequency_Range": null,
   "EIRP": null,
   "Configured_Output_Power": null,
   "Gain": {
      "value": 15.11,
      "unit": "dBi"
   },
   "Configuration": null,
   "RF_Port": null,
   "Array_ID": null,
   "Array_Position": null,
   "Phi_HPBW": 91.64,
   "Theta_HPBW": 10.8,
   "Front_to_Back": 21.72,
   "Phi_Electrical_Pan": 0.0,
   "Theta_Electrical_Tilt": 0,
   "Nominal_Polarization": "P45",
   "Theta_Sampling": [-90.0, 1.0, 90.0],
   "Phi_Sampling": [0.0, 1.0, 359.0],
   "Optional_Comments": "example of active antenna; theta and phi of
radiation pattern are omitted in Data_Set (uniform sampling)",
```

```
   "Data_Set_Row_Structure": [
      "MagAttenuationCo",
      "MagAttenuationCr"
   ],
   "Data_Set": [
      [
         65.63973311055209,
         112.76348938213428
      ],
      [
         65.64120737221384,
         106.04556131402066
      ],
      [
         65.64563443576502,
         102.2783015522732
      ],
      [
         65.65301291621606,
         99.6665197293747
      ],
      [
         65.66334051866878,
         97.67415975082629
      ],
   …
}
```

15.3.4 ACTIVE ANTENNA NOT UNIFORM SAMPLING EXAMPLE

FileName:
VENDOR_ANTMODEL3_3700_EID12345_T00p0_P45_NonUniformSampling_3drp.json

```
{
   "BASTA_AA_WP_version": "3.0",
   "Supplier": "VENDOR",
   "Antenna_Model": "ANTMODEL3",
   "Antenna_Type": "Active",
   "Revision_Version": "1.0",
   "Released_Date": "2023-05-05",
   "Coordinate_System": "SPCS_CW",
   "Pattern_Name": "ThePatternName",
   "Beam_ID": "ID12345",
   "Pattern_Type": "Traffic Envelope",
   "Frequency": {
      "value": 3700,
      "unit": "MHz"
   },
   "Frequency_Range": null,
```

```
    "EIRP": null,
    "Configured_Output_Power": null,
    "Gain": {
       "value": 15.11,
       "unit": "dBi"
    },
    "Configuration": null,
    "RF_Port": null,
    "Array_ID": null,
    "Array_Position": null,
    "Phi_HPBW": 91.64,
    "Theta_HPBW": 10.80,
    "Front_to_Back": 21.72,
    "Phi_Electrical_Pan": 0.0,
    "Theta_Electrical_Tilt": 0.0,
    "Nominal_Polarization": "P45",
    "Theta_Sampling": null,
    "Phi_Sampling": null,
    "Optional_Comments": "example of active antenna; theta and phi of
radiation pattern are provided in Data_Set (non-uniform sampling)",
    "Data_Set_Row_Structure": [
       "Theta",
       "Phi",
       "MagAttenuationCo",
       "MagAttenuationCr"
    ],
    "Data_Set": [
       [
          -90,
          0,
          65.63973311055209,
          112.76348938213428
       ],
       [
          -90,
          1,
          65.64120737221384,
          106.04556131402066
       ],
       [
          -90,
          2,
          65.64563443576502,
          102.2783015522732
       ],
    …
}
```

15.4 JSON SCHEMA

The JSON file format used for exchanging the 3D radiation pattern data must comply with both ordinary JSON syntax rules[1] (see https://www.json.org/json-en.html) and the specific NGMN BASTA rules described in section 15.2.

In order to help validating the formal correctness of a JSON file it is useful to introduce a JSON Schema, which is a declarative language that allows to annotate and validate JSON documents so as to enable the confident and reliable use of the JSON data format (see https://json-schema.org/).

The NGMN BASTA JSON Schema to be used for validating JSON files which describe 3D radiation patterns compliant with the rules detailed in section 15 of current document is made available by NGMN at the following link:

https://www.ngmn.org/schema/basta/NGMN_BASTA_AA_3drp_JSON_Schema_WP3_0_latest.json

Among different implementations of JSON file validation against a given schema listed in JSON Schema reference web page (see https://json-schema.org/implementations.html#validators), for convenience an example is presented here for a JSON file whose name is taken from the second example of section 15.1. It is an example based on the Python Command-Line Interface command `check-jsonschema`[2] (full documentation can be found at https://check-jsonschema.readthedocs.io/) where the abovementioned NGMN BASTA JSON Schema may be specified as either a local file:

```
check-jsonschema --schemafile "NGMN_BASTA_3drp_schema_WP3_0_
latest.json" TheCompanyName_Antenna1_700.5_E123_P45M45_
ThisIsAnExtraInformation_3drp.json
```
[3]

or as a remote file (HTTP or HTTPS; remote files are automatically downloaded and cached if possible):

```
check-jsonschema --no-cache --schemafile
https://www.ngmn.org/schema/basta/NGMN_BASTA_3drp_schema_WP3_0_latest.
json

TheCompanyName_Antenna1_700.5_E123_P45M45_
ThisIsAnExtraInformation_3drp.json2
```

If errors are found, details are provided to help identifying them, if not the output is

```
ok -- validation done.
```

1 NGMN considered the JSON open standard file format as being the leading interchange format for web applications and more to describe 3D radiation patterns of antennas

2 check-jsonschema can be installed under basic Python environment with pip install check-jsonschema.

3 Command to be given on one line only.

15.4.1 JSON SCHEMA FILE EXAMPLE

The latest release of the JSON Schema can be found in:
https://www.ngmn.org/schema/basta/NGMN_BASTA_AA_3drp_JSON_Schema_WP3_0_latest.json

```
{
   "$schema": "http://json-schema.org/draft/2020-12/schema#",

   "type": "object",
   "properties": {
      "BASTA_AA_WP_version": {
      "type": "string"
    },
    "Supplier": {
      "type": "string"
    },
    "Antenna_Model": {
      "type": "string"
    },
    "Antenna_Type": {
      "type": "string"
    },
    "Revision_Version": {
      "type": "string"
    },
    "Released_Date": {
      "type": "string",
      "format": "date"
    },
    "Coordinate_System": {
      "type": "string",
      "enum": [
         "SPCS_Polar",
         "SPCS_CW",
         "SPCS_CCW",
         "SPCS_Geo"
      ]
    },
    "Pattern_Name": {
      "type": [
         "string",
         "null"
      ]
    },
    "Beam_ID": {
      "type": [
         "string",
         "null"
      ]
    },
```

```
"Pattern_Type": {
   "type": "string",
   "enum": [
      "Broadcast Beam",
      "Broadcast Configuration Envelope",
      "Traffic Beam",
      "Traffic Envelope",
      "Uplink",
      "Generic"
   ]
},
"Frequency": {
   "type": "object",
   "properties": {
      "value": {
         "type": "number",
         "minimum": 0
      },
   "unit": {
      "type": "string",
      "enum": [
         "Hz",
         "kHz",
         "MHz",
         "GHz",
         "THz"
       ]
      }
   },
   "required": [
      "value",
      "unit"
   ]
},
"Frequency_Range": {
   "type": [
      "object",
      "null"
   ],
   "properties": {
      "lower": {
         "type": "number",
         "minimum": 0
   },
   "upper": {
      "type": "number",
      "minimum": 0
   },
```

```
            "unit": {
               "type": "string",
               "enum": [
                  "Hz",
                  "kHz",
                  "MHz",
                  "GHz",
                  "THz"
               ]
            }
         },
            "required": [
               "lower",
               "upper",
               "unit"
            ]
         },
         "EIRP": {
            "type": [
               "object",
               "null"
            ],
            "properties": {
               "value": {
                  "type": "number"
                  },
                  "unit": {
                     "type": "string",
                     "enum": [
                         "mW",
                         "W",
                         "dBW",
                         "dBm"
                     ]
                  }
               },
               "required": [
                  "value",
                  "unit"
               ]
            },
            "Configured_Output_Power": {
               "type": [
                  "object",
                  "null"
               ],
               "properties": {
                  "value": {
                     "type": "number"
                  },
```

```
      "unit": {
        "type": "string",
        "enum": [
          "mW",
          "W",
          "dBW",
          "dBm"
        ]
      }
    },
    "required": [
      "value",
      "unit"
    ]
  },
  "Gain": {
    "type": [
      "object",
      "null"
    ],
    "properties": {
      "value": {
        "type": "number"
      },
      "unit": {
        "type": "string",
        "enum": [
          "dBi",
          "dBd"
        ]
      }
    },
    "required": [
      "value",
      "unit"
    ]
  },
  "Configuration": {
    "type": [
      "string",
      "null"
    ]
  },
  "RF_Port": {
    "type": [
      "string",
      "null"
    ]
  },
```

```
"Array_ID": {
   "type": [
      "string",
      "null"
   ]
},
"Array_Position": {
      "type": [
         "string",
         "null"
      ]
},
"Phi_HPBW": {
   "type": "number",
   "exclusiveMinimum": 0
},
"Theta_HPBW": {
   "type": "number",
   "exclusiveMinimum": 0
},
"Front_to_Back": {
   "type": "number",
   "exclusiveMinimum": 0
},
"Phi_Electrical_Pan": {
   "type": [
      "number",
      "null"
   ]
},
"Theta_Electrical_Tilt": {
   "type": [
      "number",
      "null"
   ]
},
```

```
    "Nominal_Polarization": {
      "anyOf": [
        {
          "type": "string",
          "enum": [
            "Total",
            "P45",
            "M45",
            "P45M45",
            "M45P45",
            "H",
            "V",
            "HV",
            "VH",
            "RHC",
            "LHC"
          ]
        },
        {
          "$comment": "M### or P###M### for Negative|Positive ###
  degrees (### is an integer, max. 3 digits)",
          "type": "string",
          "pattern": "^(P[0-9]{1,3})?M[0-9]{1,3}$"
        },
        {
          "$comment": "P### or M###P### for Positive|Negative ###
  degrees (### is an integer, max. 3 digits)",
          "type": "string",
          "pattern": "^(M[0-9]{1,3})?P[0-9]{1,3}$"
        }
      ]
    },
    "Theta_Sampling": {
      "type": [
        "array",
        "null"
      ],
      "minItems": 3,
      "maxItems": 3,
      "items": {
        "type": "number"
      }
    },
```

```
    "Phi_Sampling": {
      "type": [
        "array",
        "null"
      ],
      "minItems": 3,
      "maxItems": 3,
      "items": {
        "type": "number"
      }
    },
    "Data_Set_Row_Structure": {
      "type": "array",
      "minItems": 1,
      "maxItems": 7,
      "items": {
        "type": "string",
        "enum": [
          "Theta",
          "Phi",
          "MagAttenuationTP",
          "MagAttenuationCo",
          "MagAttenuationCr",
          "PhaseCo",
          "PhaseCr"
        ]
      }
    },
    "Data_Set": {
      "type": "array",
      "items": {
        "type": "array",
        "minItems": 1,
        "maxItems": 7,
        "items": {
          "type": "number"
        }
      }
    }
  },
```

```
"required": [
   "BASTA_AA_WP_version",
   "Supplier",
   "Antenna_Model",
   "Antenna_Type",
   "Revision_Version",
   "Released_Date",
   "Coordinate_System",
   "Pattern_Name",
   "Beam_ID",
   "Pattern_Type",
   "Frequency",
   "Frequency_Range",
   "EIRP",
   "Configured_Output_Power",
   "Gain",
   "Configuration",
   "RF_Port",
   "Array_ID",
   "Array_Position",
   "Phi_HPBW",
   "Theta_HPBW",
   "Front_to_Back",
   "Phi_Electrical_Pan",
   "Theta_Electrical_Tilt",
   "Nominal_Polarization",
   "Theta_Sampling",
   "Phi_Sampling",
   "Data_Set_Row_Structure",
   "Data_Set"
   ]
}
```

16 APPENDIX H - XML FILE

The XML file format used for exchanging the BASTA WP compliant antenna datasheet information must comply with both ordinary XML syntax rules (see https://www.w3.org/XML) and the specific NGMN BASTA rules for each parameter as described in the body of the White Paper.

In order to help validating the formal correctness of a XML file it is useful to introduce a XML Schema, which is a file that describes the structure of a XML document.

The NGMN BASTA XML Schema can be used to validate that a BASTA antenna XML datasheet file. The schema file is made available by NGMN at the following link:

https://www.ngmn.org/schema/basta/

Please right click and download the file *'NGMN_BASTA_datasheet_schema_AAS_WP3.0_latest.xsd'*. To open the file please use a text editor.

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NEXT GENERATION MOBILE NETWORKS ALLIANCE

NGMN, established in 2006, is a global, operator-led alliance of over 80 companies and organisation spanning operators, manufacturers, consultancies and academia.

VISION

The vision of the NGMN Alliance is to provide impactful guidance to achieve innovative and affordable mobile telecommunication services for the end user with a particular focus on supporting 5G's full implementation, Mastering the Route to Disaggregation, Sustainability and Green Networks, as well as 6G.

MISSION

The mission of the NGMN Alliance is

- To evaluate and drive technology evolution towards 5G's full implementation and the three major priorities for 2021 and beyond:

  Route to Disaggregation: Leading in the development of open, disaggregated, virtualised and cloud native solutions with a focus on the end to end operating model.

  Green Future Networks: Building sustainable and environmentally conscious solutions.

  6G: Emergence of 6G highlighting key trends across technology and societal requirements plus use cases to address.

- to establish clear functional and non-functional requirements for mobile networks of the next generation.
- to provide guidance to equipment developers, standardisation bodies and cooperation partners, leading to the implementation of a cost-effective network evolution
- to provide an information exchange forum for the industry on critical and immediate concerns and to share experiences and lessons learnt for addressing technology challenges
- to identify and remove barriers for enabling successful implementations of attractive mobile services