RF exposure compliance assessment

Massive MIMO Adaptive Antenna Products – AEWF

FCC ID: VBNAEWF-01

Author	Christophe Grangeat
Owner	Christophe Grangeat
Organization	MN ATF
Approver	tbd
Document Type	Preliminary test report
Document ID	tbd
Document location	tbd

Change History

Version	Status	Date	Author	Owner	Reviewed by	Reviewed date	Approver	Approval date	Description of changes
0.1	Draft	30-11-2018	C. Grangeat	C. Grangeat					Initial draft
0.2	Draft	03-12-2018	C. Grangeat	C. Grangeat	W.S.Majkowski	03-12-2018			FCC ID Inclusion

This material, including documentation and any related computer programs, is protected by copyright controlled by Nokia. All rights are reserved. Copying, including reproducing, storing, adapting or translating, any or all of this material requires the prior written consent of Nokia. This material also contains confidential information, which may not be disclosed to others without the prior written consent of Nokia.

NOKIA

Contents

List of Tables

List of Figures

© Nokia 2018

© Nokia 2018

1 General content

This test report is addressing human exposure to radiofrequency electromagnetic fields (RF-EMF) transmitted by the following massive MIMO Adaptive Antenna (MAA) Product (see §2.2):

- Nokia AirScale MAA 2T2R 512 AE 8W n260 AEWF , FCC ID: VBNAEWF-01

It provides the RF exposure compliance boundaries for these products regarding both general population and occupational exposure. Outside of these compliance boundaries, human exposure to RF-EMF is below the limits defined by the US Federal Communications Commission (FCC), Canada Safety Code 6, Australia ARPANSA and European regulations (see §2.1 and 3).

2 References

2.1 Applicable RF exposure standards and regulations

[1] EU 1999/519/EC, “Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)”, July 1999

[2] EU 2013/35/EU, “Directive of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC”, June 2013

[3] EN 50385:2017, “Product standard to demonstrate the compliance of base station equipment with radiofrequency electromagnetic field exposure limits (110 MHz - 100 GHz), when placed on the market”, July 2017

[4] IEC/EN 62232:2017, “Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure”, September 2017.

[5] AS/NZS 2772.2, "Radiofrequency fields Part 2: Principles and methods of measurement and computation-3 kHz to 300 GHz", 2016

[6] ARPANSA “Maximum Exposure Levels to Radiofrequency Fields — 3 kHz to 300 GHz”, Radiation Protection Series Publication No. 3, 2016

[7] Canada Safety Code 6, “Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz”, June 2015

© Nokia 2018

[8] Canada RSS-102, “Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)”, Issue 5, March 2015,

[9] US FCC 47CFR 1.1310 “Radiofrequency radiation exposure limits”, August 1997.

[10] US FCC OET Bulletin 65, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields and its supplements”, edition 97-01, August 1997.

2.2 Product and assessment method

[11] Nokia, “Massive MIMO Adaptive Antenna Product Description”.

[12] Nokia, “AEWF-X21 474870A Antenna Performance Test Report”, 11-27-2018.

[13] Microwave Vision Group (MVG), “EMF Visual User Manual”, SEWB/EMF-VISUAL-UM.1/v2018.3.

[14] Z. Altman, B. Begasse, C. Dale, A. Karwowski, J. Wiart, M. Wong and L. Gattoufi, “Efficient models for base station antennas for human exposure assessment”, IEEE Trans. Electromagnetic Compatibility, Nov 2002, vol.44, pp. 588-592.

[15] P. Baracca, A. Weber, T. Wild and C. Grangeat, “A Statistical Approach for RF Exposure Compliance Boundary Assessment in Massive MIMO Systems”, WSA 2018, https://arxiv.org/abs/1801.08351.

[16] IEC TR62669, “Case studies supporting the implementation of IEC 62232”, (106/463/CD, July 2018).

3 RF exposure limits

The applicable RF exposure limits are defined by [1] and [2] to in Europe and ICNIRP countries, by [5] in Australia and New Zealand, by [7] in Canada and by [9] in the US and related countries such as Bolivia, Estonia, Mexico and Panama The applicable power density limits are recalled in Table 1 for the frequency range applicable to the equipment under test.

Table 1 – Applicable RF exposure levels in n260 band expressed in power density

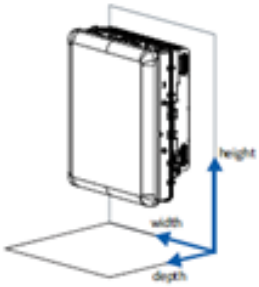
Region of application	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
EU/ICNIRP, Australia/NZ, Canada, US/related	10 W/m²	50 W/m²

© Nokia 2018

4 Description of the equipment under test (EUT)

The main technical characteristics of AEWF product are reproduced in Table 2 and Table 4.

Table 2 – AEWF product general technical characteristics

Product name	Nokia AirScale MAA 2T2R 512 AE 8W n260 AEWF
Model number	474870A
FCC Identification	VBNAEWF-01
Rated max Tx power	0.63 W (28 dBm)
Number of TXRX	2TX2RX
Beamforming	Yes
SW supported techno.	TDD NR
Frequency range	37 – 40 GHz (3GPP Band n260)
Nb of antenna elements	16 (horizontal) x 2x8 (vertical)
Distance between AE	3.81 mm (horizontal) x 5.2 mm (vertical)
Gain	29 dBi
Horizontal half-power beamwidth	6.5° (boresight)
Vertical half-power beamwidth	8.6° (boresight)
EIRP	57 dBm *
Beam steering range	± 45° (horizontal @3dB) and ± 11.25° (vertical@1.5dB)
Dimensions 	Height: 522 mm (w. fans) ; 475 mm (w.o. fans) Depth: 304 mm Width: 161 mm Note: includes front covers. 
Technology duty cycle factor	75 %
Transmitted power tolerance	1.5 dB
*Note: the version without fan has an EIRP of 51 dBm. For RF-EMF compliance assessment, only the 57 dBm version (with fan) is considered as it provides conservative compliance distances.	

The antenna pattern characteristics are derived from [12].

Table 3 – Measured antenna gain characteristics for various beam steering directions (from [12])

Azimuth	Elevation	Gain (dBi)	
		Vertical pol. array	Horizontal pol. array
-56.25°	0°	24.3	25.4
-3.75°	0°	28.96	**28.97**
+3.75°	0°	28.94	28.92
+56.25°	0°	24.8	**25.5**
0°	-10°	**28.8**	28.7

In order to provide a conservative assessment on the frequency range, we performed the calculation at 38.5 GHz using the maximum gain over all similar steering directions (indicated in bold letters in Table 3). The compliance boundary is defined by the box shape perimeter shown in Figure 4 of IEC 62232:2017 [4] and displayed in Figure 1. The distances Df, Ds, Da,u and Da,d are taken from the nearest point of the antenna. For convenience, the distances Dsc, Duc and Ddc (respectively) taken from antenna center are also provided.

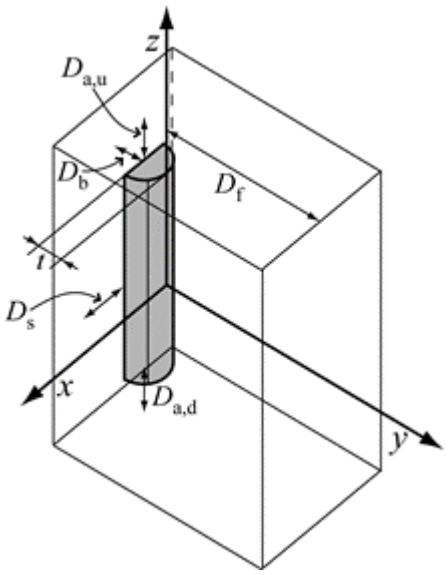


Figure 1 – Shape of the compliance boundary used for the RF exposure compliance assessment (from [4]).

5 RF exposure assessment method

RF exposure assessment is performed using the synthetic model computation method defined in B.4.4.1 of IEC 62232:2017 [4] Calculations are performed with the “EMF Visual” software release 4.0 (see [13] and [14]).

The validation of the model is performed in the configuration with the beam in front (azimuth = 3.75° and elevation = 0°). The validation results are provided in Table 4.

Table 4 – Validation of the antenna model at 3600 MHz

	Product (from [12])	Model	Deviation
Gain	29 dBi	29 dBi	0
Horizontal half-power beamwidth	6.4°	6.5°	0.1°
Vertical half-power beamwidth	9.3°	9.5°	0.2°

For each configuration, the directivity pattern is derived from the simulation model and the antenna gain is adjusted to match exactly the measured values for accurate scaling.

The RF compliance distances are provided for the time-averaged maximum transmitted power of 85 W and, for information, the time-averaged actual maximum transmitted power of 21.2 W taking a 95th percentile approach as defined in [4], [15]and [16]. These values include a technology duty cycle factor of 75 % (see Table 2) for time averaging and a power tolerance of 1.5 dB due to electronic component dispersion and operational environmental conditions (temperature).

6 RF exposure computation results

The computed power density 3D distributions are displayed in Figure 2 to Figure 7 for RF exposure limits defined in [1], [2] for EU/ICNIRP countries, [5] Australia/NZ, [7] for Canada and [9] for US/related countries.

© Nokia 2018

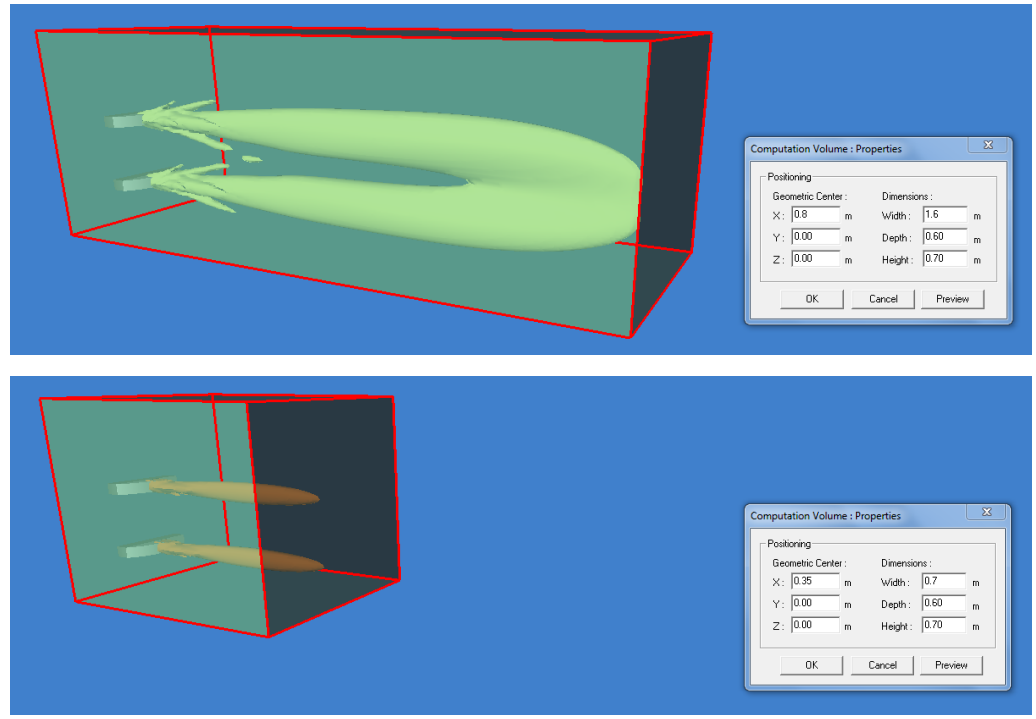


Figure 2 – AEWF, top view of the power density for the time-averaged maximum transmitted power of 0.67 W and the beam oriented in azimuth = 0° & elevation = 0°

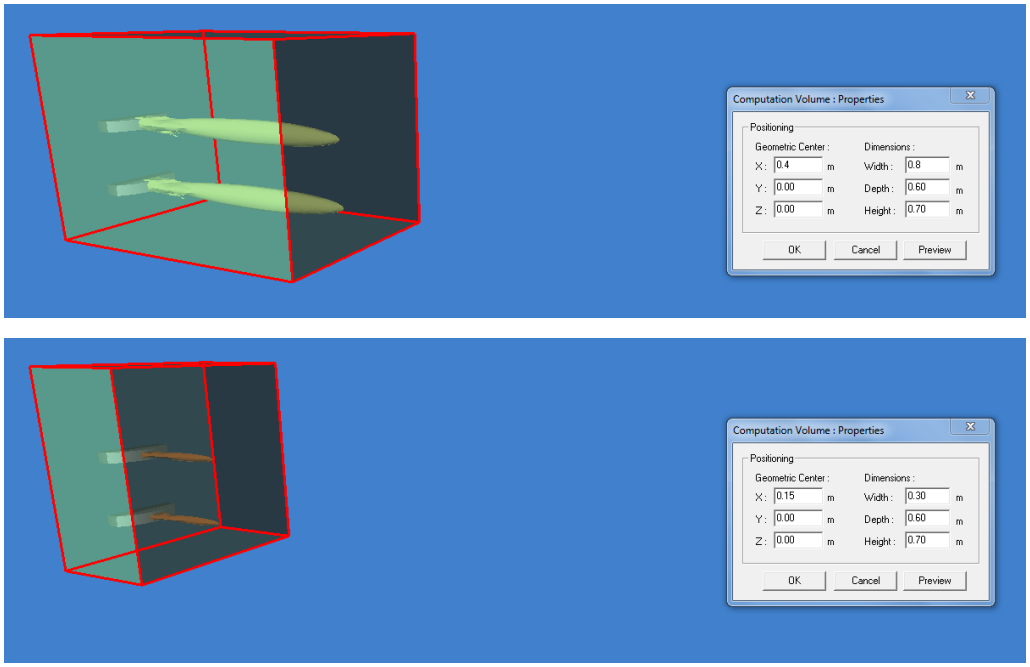


Figure 3 – Top view of the power density for the time-averaged actual maximum transmitted power of 0,168 W and the beam oriented in azimuth = 0° & elevation = 0°

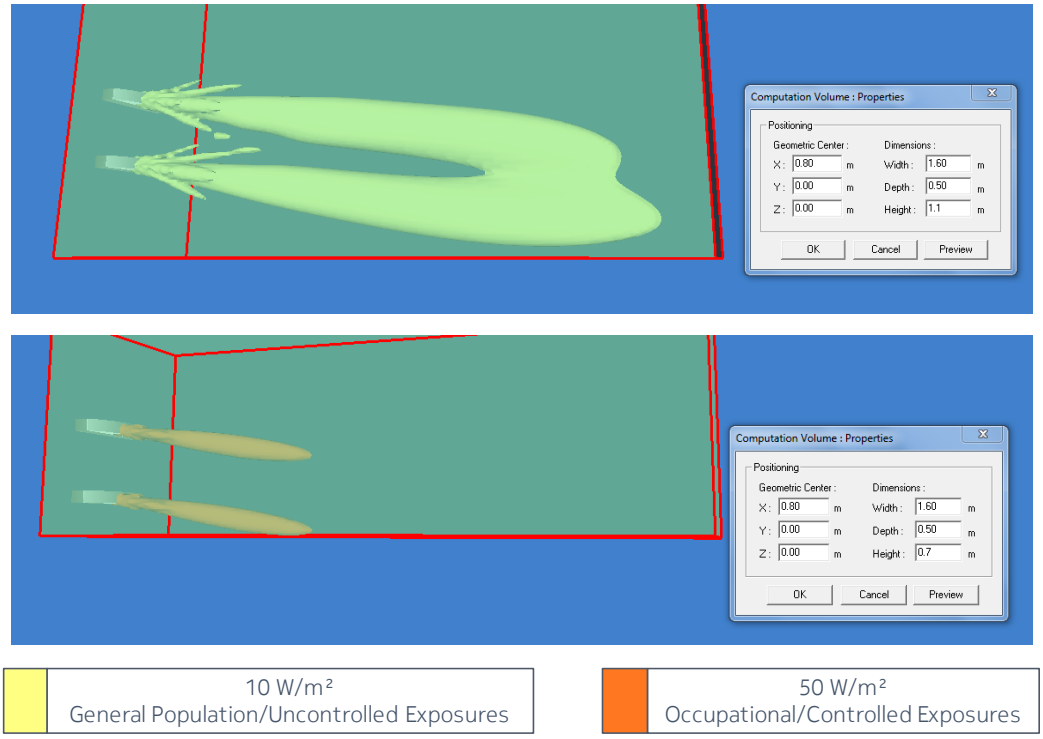


Figure 4 – Side view of the power density for the time-averaged maximum transmitted power of 0.67 W and the beam oriented in azimuth = 0° & elevation = -11°

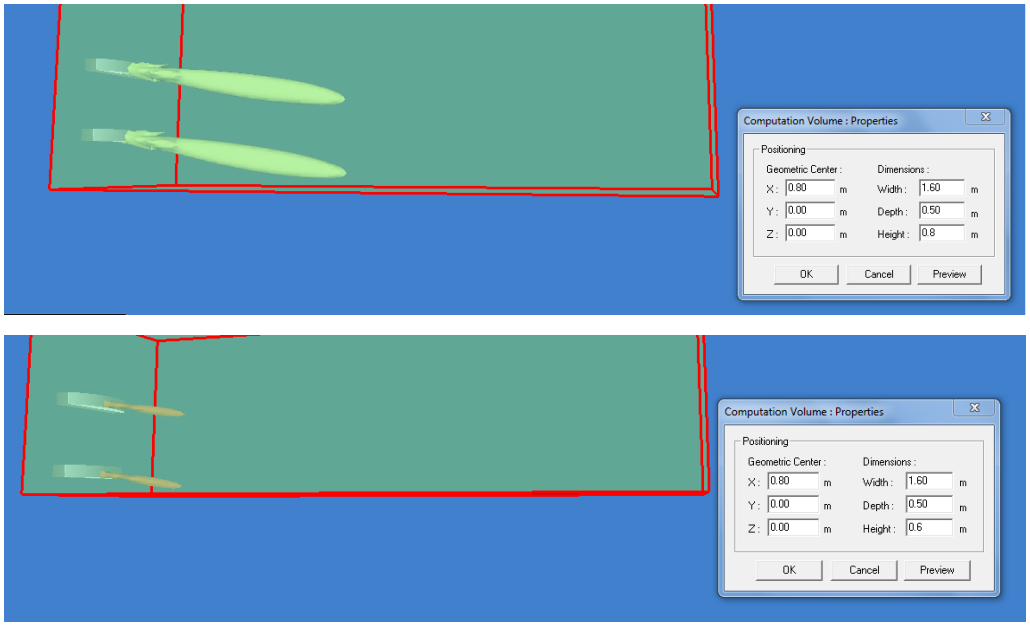


Figure 5 – Side view of the power density for the time-averaged actual maximum transmitted power of 0.168 W and the beam oriented in azimuth = 0° & elevation = -11°

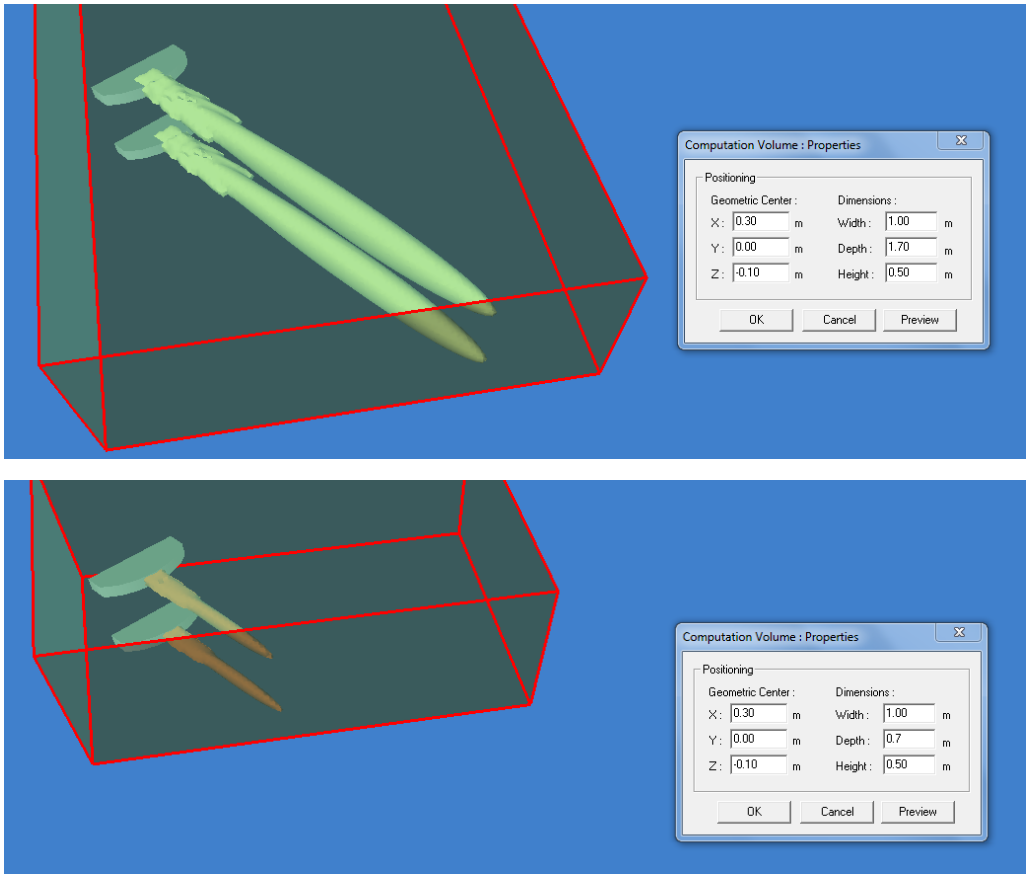


Figure 6 – Top view of the power density for the time-averaged maximum transmitted power of 0.67 W and the beam oriented in azimuth = 56° & elevation = 0°

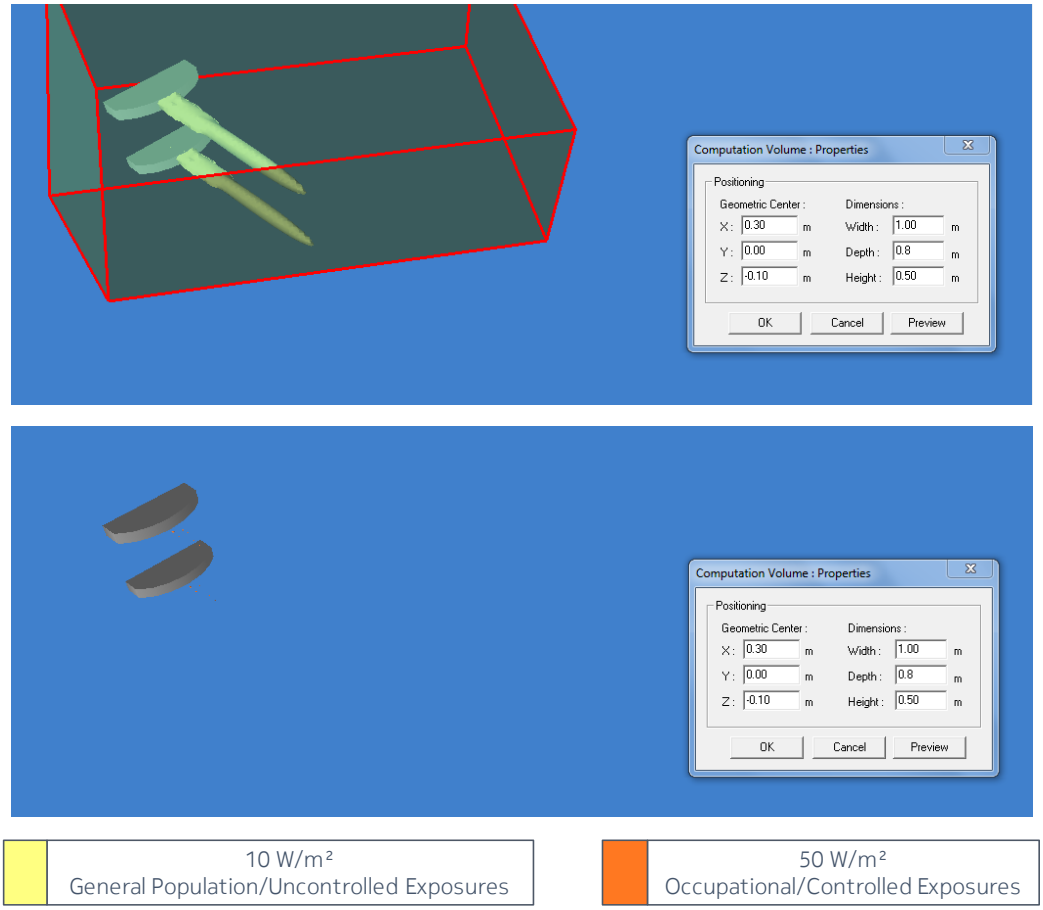


Figure 7 – Top view of the power density for the time-averaged actual maximum transmitted power of 0.167 W and the beam oriented in azimuth = 56° & elevation = 0°

7 Conclusion and installation recommendations

The RF exposure compliance distances for the Nokia AirScale MAA 2T2R 512 AE 8W n260 AEWF product are summarized in Table 5 for EU/ICNIRP [1][2], Australia/NZ [5] and US/related [9] requirements.

NOKIA

Table 5 – AEWF RF exposure compliance distances based on the time-averaged maximum transmitted power of 0,65 W (corresponding to 0,63 W rated max transmitted power)

Region of application: EU/ICNIRP, Australia/NZ, Canada and US/related	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
RF-EMF power density exposure limits	10 W/m²	50 W/m²
Distance in front (Df)	1.6 m	0.7 m
Distance to the side (Ds)	0.7 m	0.2 m
Distance below and above (Da,d and Da,u)	0.3 m	0.1 m
Distance to the side (Dsc)	0.9 m	0.4 m
Distance below and above (Ddc and Duc)	0.6 m	0.4 m

The RF exposure compliance distances based on the actual maximum transmitted power considering a 95th percentile approach are summarized in Table 6. These values are provided for information about the RF exposure levels that may be reached in operational conditions considering a time-averaging window of 6 minutes according to [4], [15] and [16].

Table 6 – AEWF RF exposure compliance distances based on the time-averaged actual maximum transmitted power of 0.167 W (corresponding to 0.63 W rated max transmitted power)

For information in EU/ICNIRP, Austalia/NZ, Canada and US/related countries based on IEC/EN 62232:2017 [4] and IEC TR62669 [16]	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
RF-EMF power density exposure limits	10 W/m²	50 W/m²
Distance in front (Df)	0.8 m	0.3 m
Distance to the side (Ds)	0.3 m	0 m
Distance below and above (Da,d and Da,u)	0.2 m	0.1 m
Distance to the side (Dsc)	0.4 m	0 m
Distance below and above (Ddc and Duc)	0.4 m	0.3 m

Installation of the Nokia AirScale MAA 2T2R 512 AE 8W n260 AEWF product shall be performed in accordance with all applicable manufacturer's recommendations and national laws and regulations related to human exposure to radiofrequency fields. In particular:

© Nokia 2018

- The operator or entity putting the equipment into service shall take the necessary measures to ensure that the general population cannot access the area within the general population/uncontrolled compliance boundary in the vicinity of the transmitting antennas (see Table 5 and Table 6).
- Depending on the site installation configuration, the operator or the entity putting the equipment into service determines the most suitable place to display the appropriate warning signs and any other necessary information or precautionary measures.
- Workers that are required to operate in the close proximity of the transmitting antennas connected to the equipment, for example installation and maintenance personnel, need to be informed about the potential risks of human exposure to RF fields and how to protect against them. They should strictly follow instructions provided by their employer. They should stand-off the occupational/controlled exposure compliance boundary defined in the vicinity of transmitting antennas (see Table 5 and Table 6). If it is necessary to operate within this compliance boundary, workers shall make sure that the transmitters contributing to exposure in this area are all switched off, or they must contact the relevant operator(s) to switch off emissions during operation period.

----- end of the test report ---------

© Nokia 2018