RF exposure compliance assessment

5G Airscale mmWave Radio Solution – AWEUC/D + FA3UB

US - FCC ID: 2AD8UASMR24FA3UB
Canada - 109D-ASMR24FA3UB

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1 General content

This test report is addressing human exposure to radiofrequency electromagnetic fields (RF-EMF) transmitted by the following mmWave Radio Solution Product (see §2.2):

- Nokia AWEUC/D Airscale mmWave Radio 5G n258 24GHz
- Nokia FA3UB Extension Module, 5G n258 24GHz

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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

[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] Microwave Vision Group (MVG), “EMF Visual User Manual”, SEWB/EMF-VISUAL-UM.1/v2020.2.

[12] 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.

[13] 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.

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

[15] NGMN white paper, “Recommendation on Base Station Active Antenna System Standards”, to be published.

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.

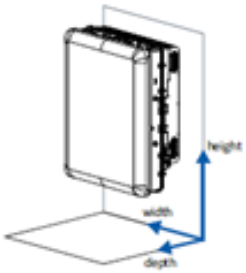
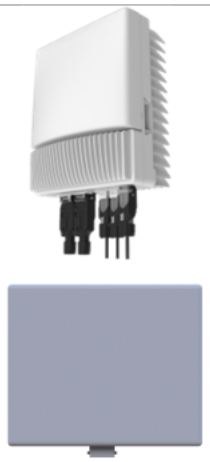
Table 1 – Applicable RF exposure levels in n258 band expressed in power density

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

4 Description of the equipment under test (EUT)

The main technical characteristics of AWEUC/D and FA3UB product are reproduced in Table 2.

Table 2 – AWEUC/D and FA3UB product general technical characteristics

Product name	Nokia AWEUC/D Airscale mmWave Radio 5G n258 24GHz Nokia FA3UB Extension Module, 5G n258 24GHz
Model number	AWEUC – 475168A (AC) AWEUD – 475169A (DC) FA3UB – 475046A
Certification ID	US - FCC ID: 2AD8UASMR24FA3UB Canada - 109D-ASMR24FA3UB
Rated max Tx power per antenna module	1 W
Number of TXRX per antenna module	2TX2RX
Beamforming	Yes
SW supported techno.	5G NR TDD
Frequency range	24250–27500MHz (3GPP n258)
Nb of antenna elements per antenna module	12 (row) x 8 (column) x 2 (polarization)
Gain per antenna module	24 dBi
EIRP per antenna module	55 dBm
Azimuth scanning range per antenna module	±45°
Elevation scanning range per antenna module	±15°
Max mechanical down-tilt	+30°
Dimensions 	AWEUC/D: Height: 325 mm Width: 270 mm Depth: 115 mm FA3UB: Height: 201 mm Width: 270 mm Depth: 90 mm 
Technology duty cycle factor	80 %
Transmitted power tolerance	1.5 dB

The antenna model used for the RF exposure assessment is derived from the model of the antenna array (pattern and gain) using the real beamforming weights (BFW) configured in the product. The antenna model is validated with the product antenna model using the same BFW, pattern and gain. Table 4 and Table 5 include the comparison of the EMF Visual model and the product antenna model for beam configurations used for the assessment of the compliance boundary. Selected patterns ensure that maximum compliance distance, applicable to evaluated product, is obtained.

Azimuth and elevation angles indicated in this report are provided according to the reference system used in product data sheets (see Table 3), unless otherwise stated.

Table 3 - Reference system used in this report (from NGMN white paper [15])

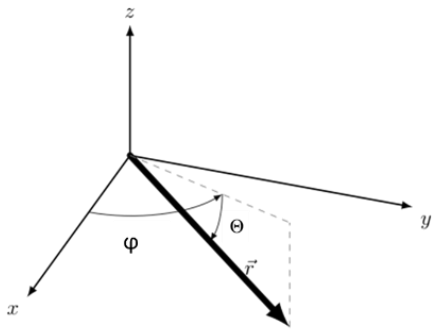
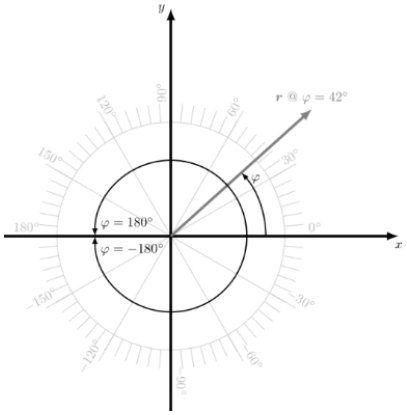
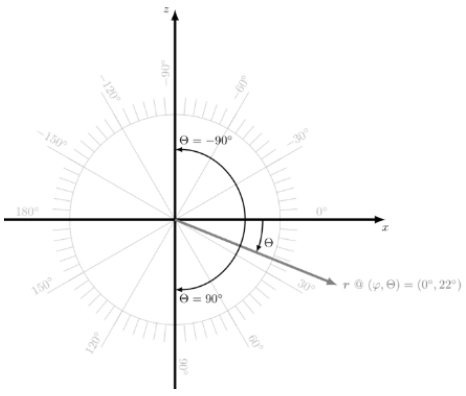
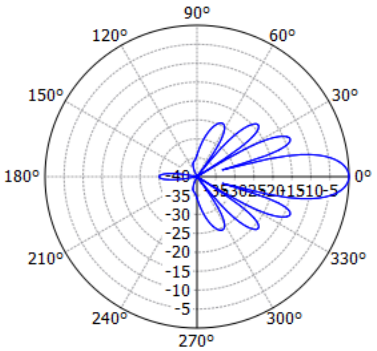
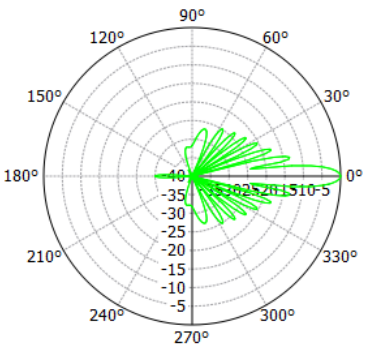
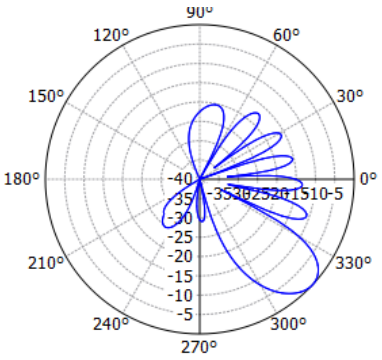
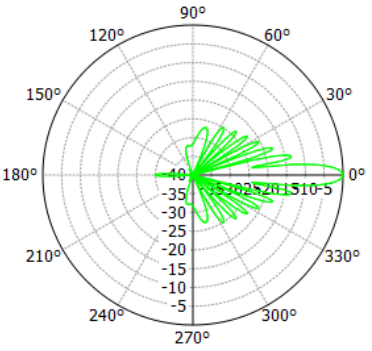
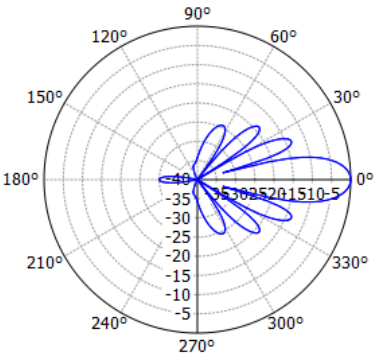
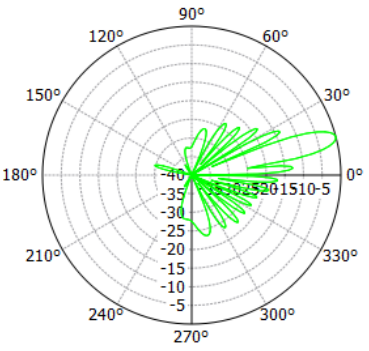
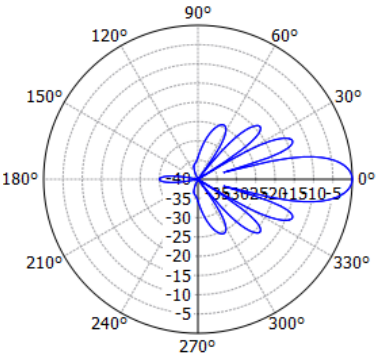
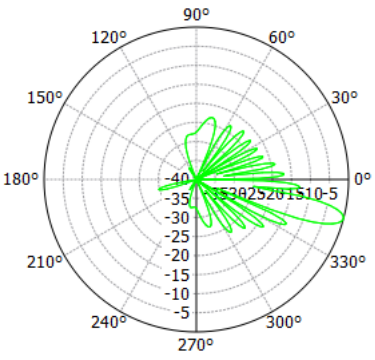
3D view Defintion of azimuth φ and elevation θ	
Top view (horizontal cut) Definition of azimuth φ	
Side view (vertical cut) Definition of elevation θ	

Table 4 – Antenna pattern models for RF exposure assessment

	Horizontal cut	Vertical cut
Boresight		
Max azimuth		
Max up-tilt		
Max down-tilt		

NOTE: Angle references used in these graphs are derived from EMF Visual (left) and Planet Viewer (right), which may differ from product data sheet (see Table 3)

Table 5 – Antenna gain characteristics for various beam steering directions used during EMF evaluation

	Azimuth	Elevation	Gain (dBi)
			25750 MHz
Boresight	0°	0°	24.0
Max azimuth	-45°	0°	21.1
Max up-tilt	0°	-15°	23.7
Max down-tilt	0°	+15°	23.7

The compliance boundary is defined by the pipe shape (in case of 3 antennas) or half-pipe (in case of single antenna) perimeter shown in Figure 3 of IEC 62232:2017 [4] and displayed in Figure 1. The distances Df, Da,u and Da,d are taken from the nearest point of the antenna. For convenience the distances Duc and Ddc (respectively), taken from antenna center, are also provided. The distance Dr, taken from the center axis of the installation, can be calculated using the distance Di, taken from the center axis of the installation to the front of the antenna. In case of mechanical down-tilt, only Da,d is impacted and indicated as Da,dt in chapter 7.

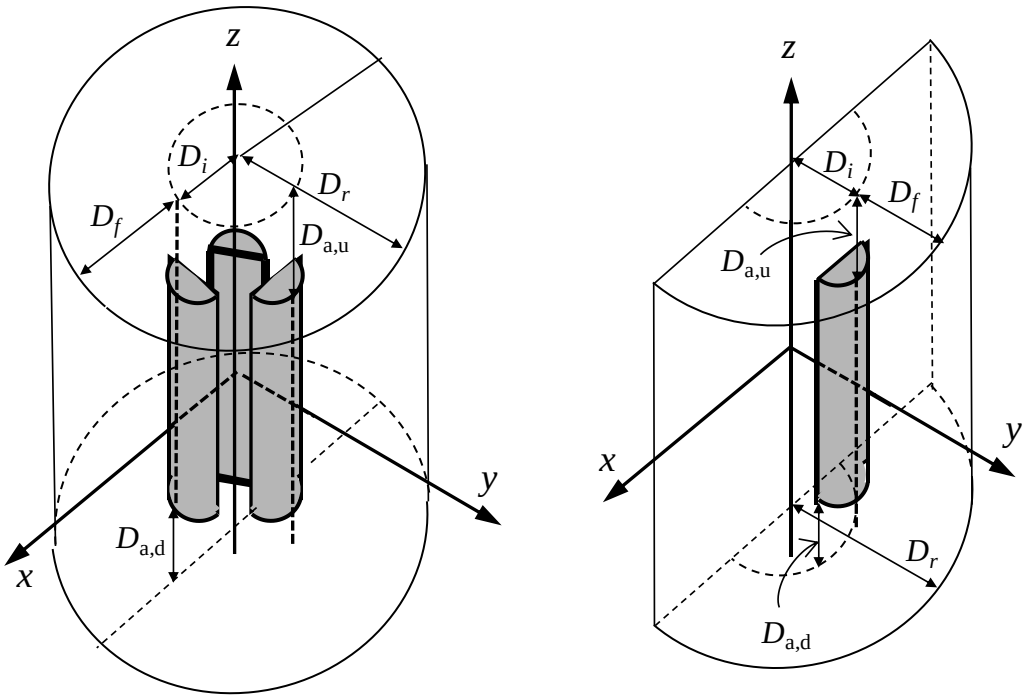


Figure 1 – Shape of the compliance boundary used for the RF exposure compliance assessment (from [4]).

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. Calculations are performed with the “EMF Visual” software release OKTAL 2020.1 (see [11] and [12]).

The validation of the model is performed in the configuration with the beam in front (azimuth = 0° and elevation = 0°). The validation results are provided in Table 6.

Table 6 - Validation of the antenna model at 25750 MHz

	Product model	EMF Visual model	Deviation
Gain	24.0 dBi	24.0 dBi	0.0 dB
Horizontal half-power beamwidth	13.4°	13.5°	0.1°
Vertical half-power beamwidth	6.5°	7.0°	0.5°

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

The RF compliance distances are provided for the time-averaged maximum transmitted power of 1.13 W and, for information, the time-averaged actual maximum transmitted power of 0.283 W taking a 95th percentile approach as defined in [4], [13] and [14]. These values include a technology duty cycle factor of 80 % (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

6.1 Regions of application: EU/ICNIRP, Australia/NZ, Canada and US/related

Illustration of example 3D exposure is presented in Figure 2.

The computed power density 3D distributions are displayed in Figure 3 to Figure 12 for RF exposure limits defined in [1], [2] for EU/ICNIRP countries, [5] for Australia/NZ, [7] for Canada and [9] for US/related countries. 3D power distributions presented in Figure 11 and Figure 12 for beams oriented in azimuth = -45°/+45° & elevation = 0° were calculated to clarify whether the maximum compliance distance Df can be obtained by superposition of exposures from two neighboring antenna panels. Simulation results indicate that the maximum distance Df is obtained for the beam oriented in azimuth = 0° & elevation = 0° for single antenna panel.

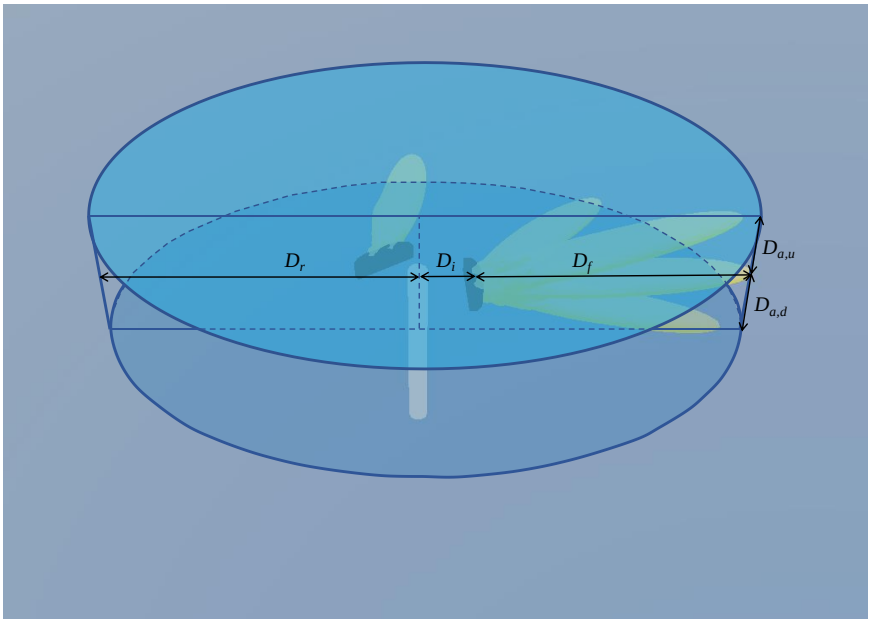


Figure 2 – Example 3D exposure with the shape of compliance boundaries

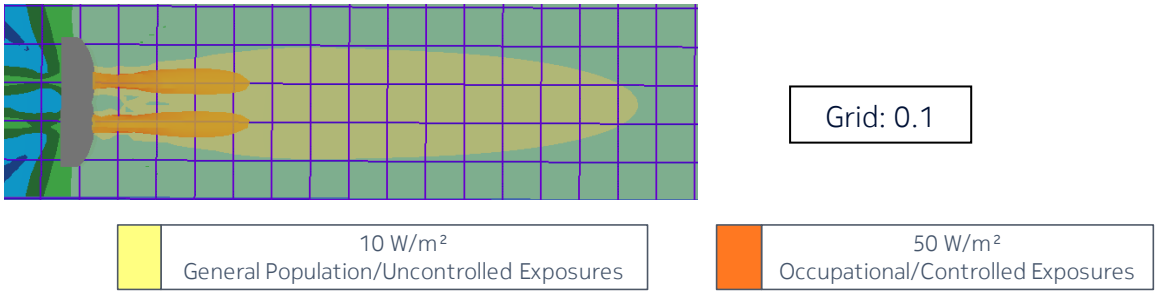


Figure 3 – Top view of the power density for the time-averaged maximum transmitted power of 1.13 W and the beam oriented in azimuth = 0° & elevation = 0°

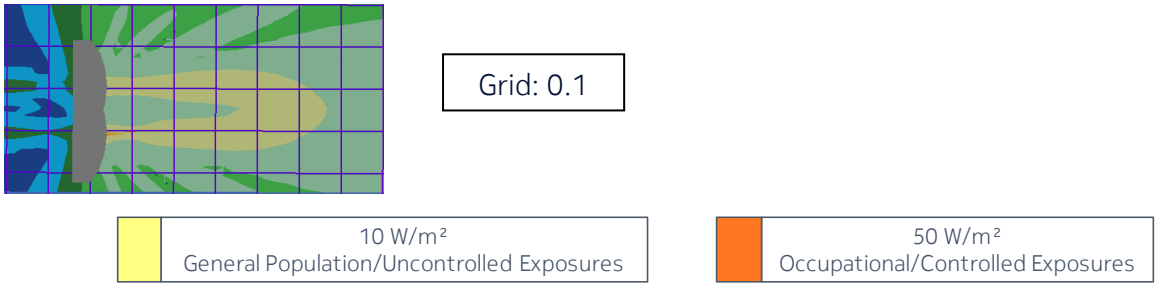


Figure 4 – Top view of the power density for the time-averaged actual maximum transmitted power of 0.283 W and the beam oriented in azimuth = 0° & elevation = 0°

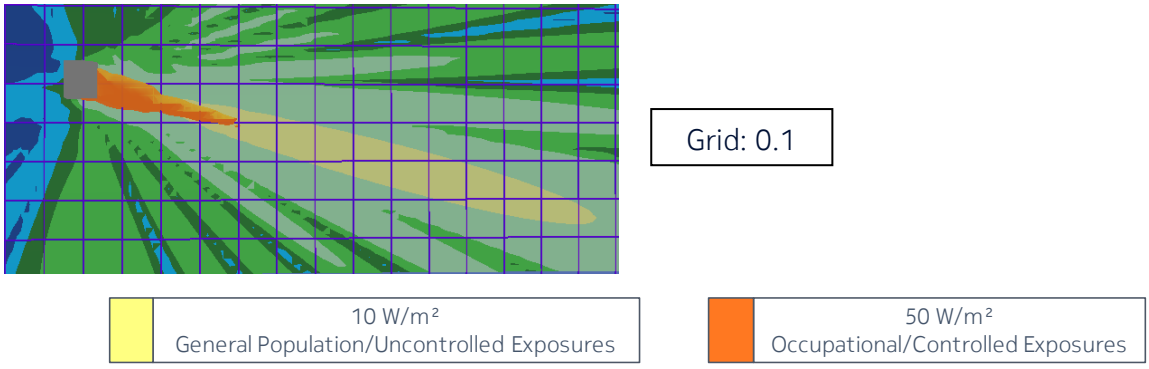


Figure 5 – Side view of the power density for the time-averaged maximum transmitted power of 1.13 W and the beam oriented in azimuth = 0° & elevation = +15°

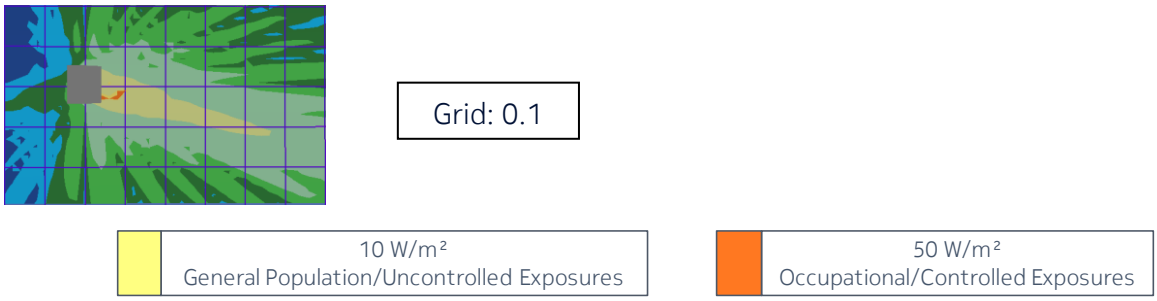


Figure 6 – Side view of the power density for the time-averaged actual maximum transmitted power of 0.283 W and the beam oriented in azimuth = 0° & elevation = +15°

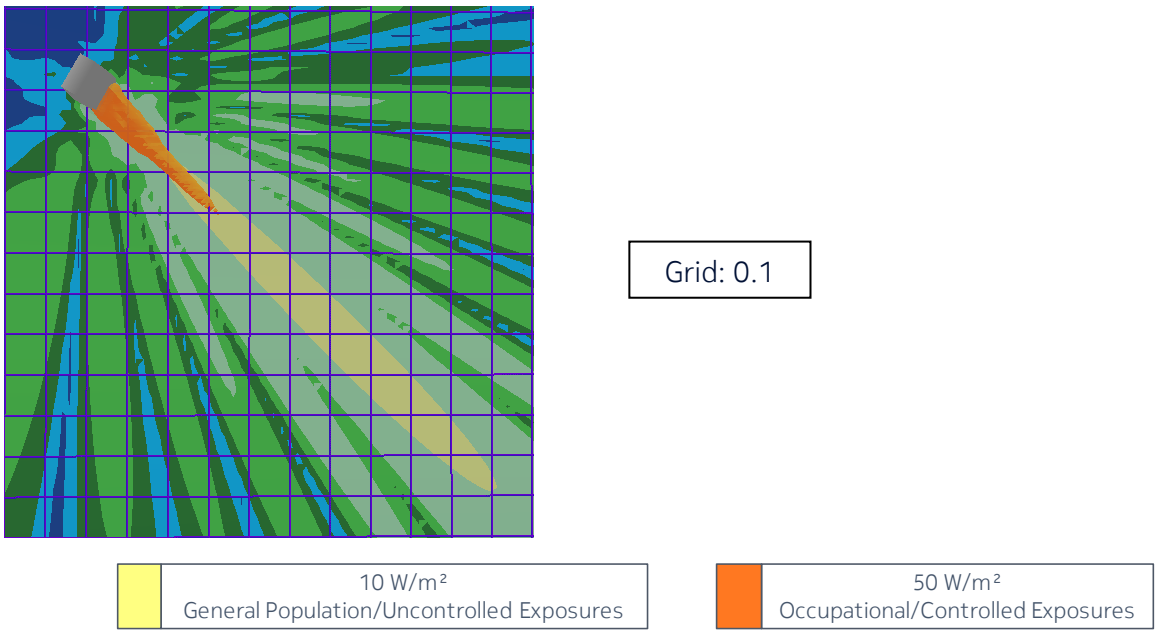


Figure 7 – Side view of the power density for the time-averaged maximum transmitted power of 1.13 W and the beam oriented in azimuth = 0° & elevation = +15° and mechanical down-tilt = +30°

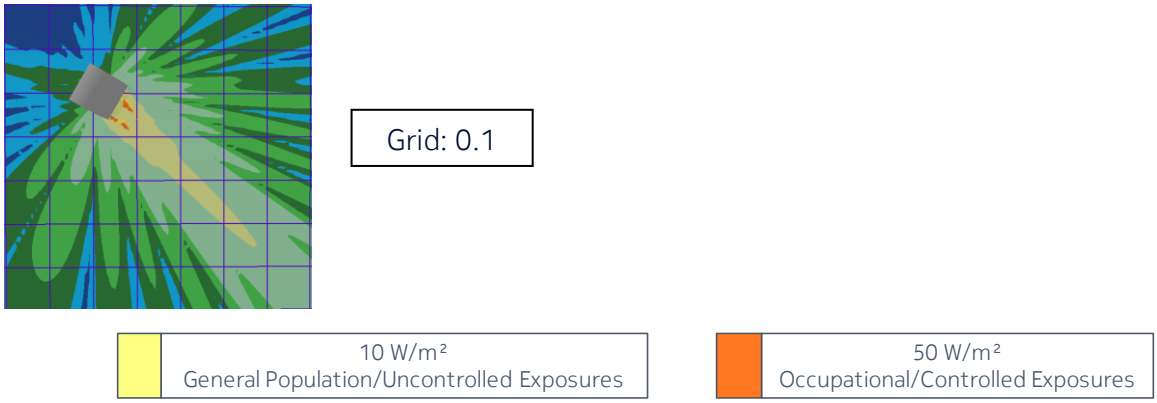


Figure 8 – Side view of the power density for the time-averaged actual maximum transmitted power of 0.283 W and the beam oriented in azimuth = 0° & elevation = +15° and mechanical donw-tilt = +30°

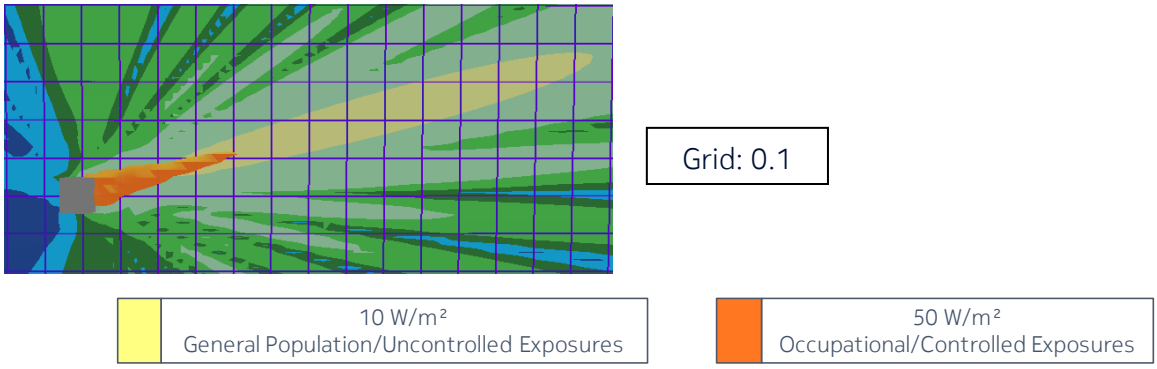


Figure 9 – Side view of the power density for the time-averaged maximum transmitted power of 1.13 W and the beam oriented in azimuth = 0° & elevation = -15°

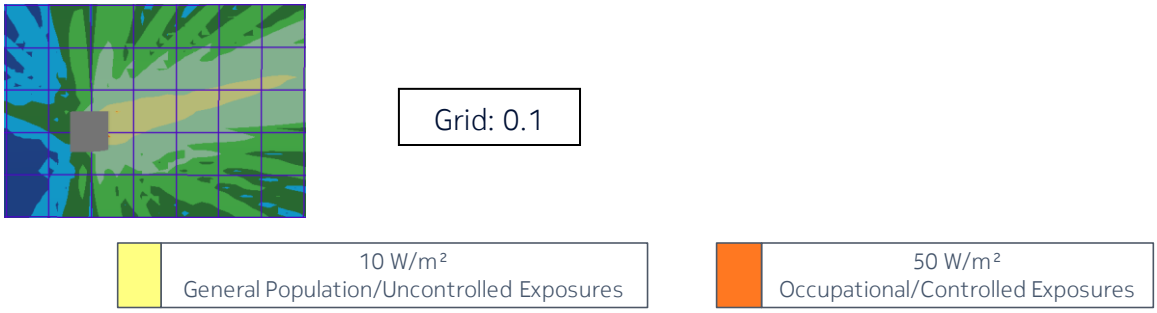


Figure 10 – Side view of the power density for the time-averaged actual maximum transmitted power of 0.283 W and the beam oriented in azimuth = 0° & elevation = -15°

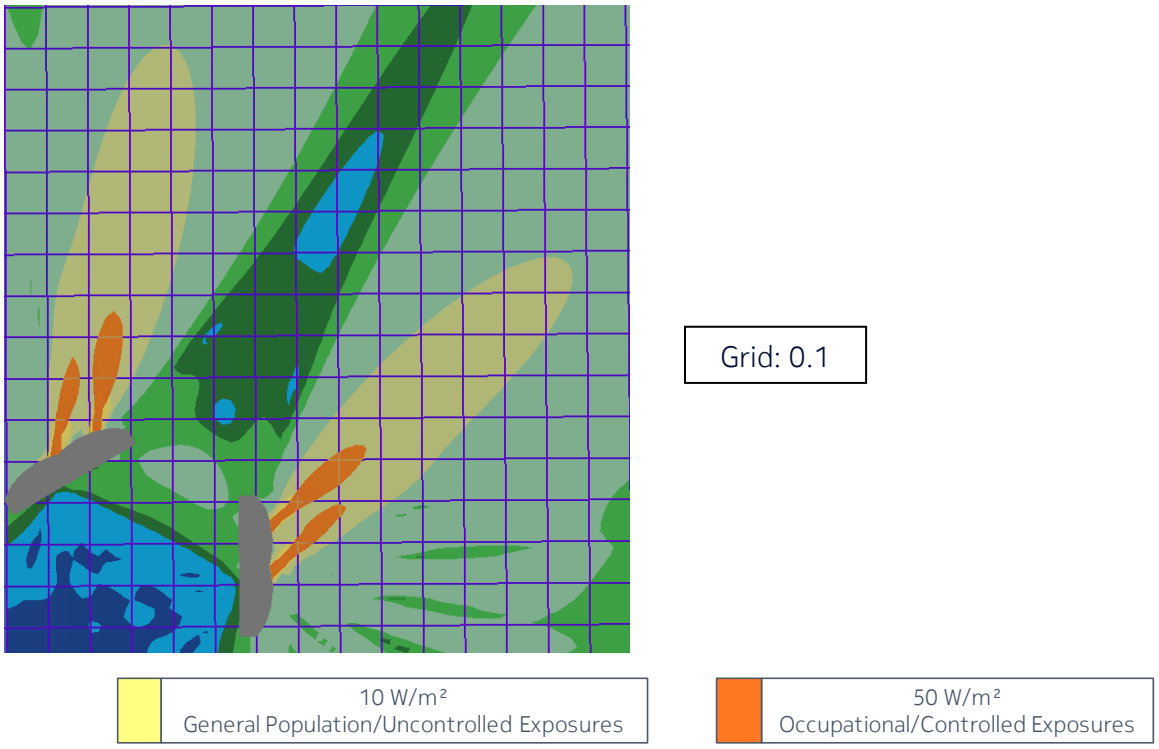


Figure 11 – Top view of the power density for the time-averaged maximum transmitted power of 1.13 W and the beam oriented in azimuth = -45°/+45° & elevation = 0°

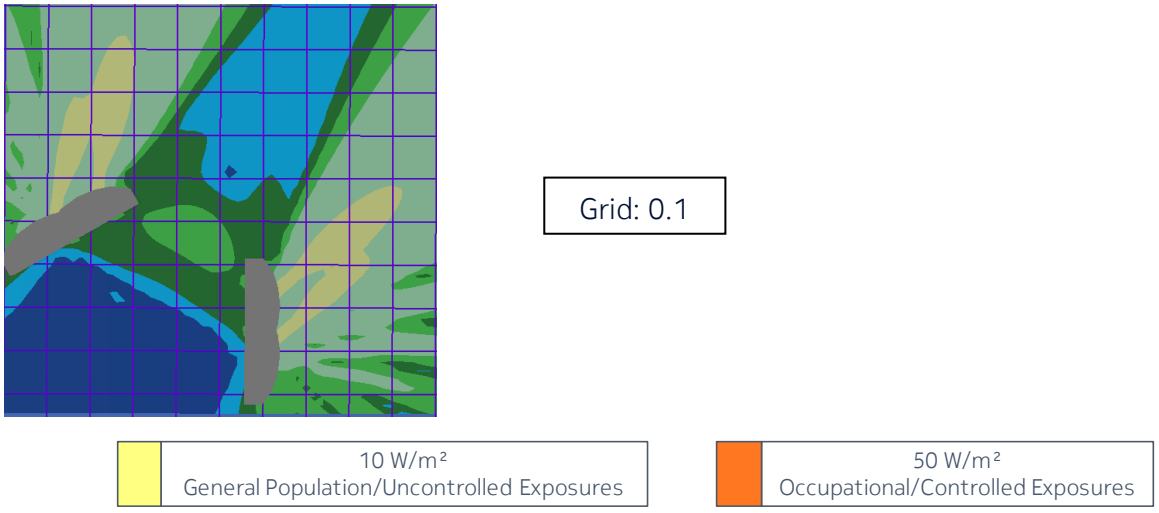


Figure 12 – Top view of the power density for the time-averaged actual maximum transmitted power of 0.283 W and the beam oriented in azimuth = -45°/+45° & elevation = 0°

7 Conclusion and installation recommendations

The RF exposure compliance distances for the Nokia AWEUC/D Airscale mmWave Radio 5G n258 24GHz and Nokia FA3UB Extension Module, 5G n258 24GHz products are summarized in Table 7 for EU/ICNIRP [1][2], Australia/NZ [5], for Canada [7] and US/related [9] requirements.

Table 7 – AWEUC/D and FA3UB RF exposure compliance distances based on the time-averaged maximum transmitted power of 1.13 W (corresponding to 1 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)	1.5 m	0.5 m
Distance below (Da,d)	0.3 m	0.1 m
Distance below (Da,dt)	0.9 m	0.2 m
Distance above (Da,u)	0.3 m	0.1 m
Distance below (Ddc)	0.4 m	0.2 m
Distance below (Ddtc)	1.0 m	0.3 m
Distance above (Duc)	0.4 m	0.2 m

The RF exposure compliance distances based on the actual maximum transmitted power considering a 95th percentile approach are summarized in Table 8. 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], [13] and [14].

Table 8 – AWEUC/D and FA3UB RF exposure compliance distances based on the time-averaged actual maximum transmitted power of 0.283 W (corresponding to 1 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 [14]	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
RF-EMF power density exposure limits	10 W/m²	50 W/m²
Distance in front (Df)	0.6 m	0.1 m
Distance below (Da,d)	0.1 m	0.0 m
Distance below (Da,dt)	0.3 m	0.0 m
Distance above (Da,u)	0.1 m	0.0 m
Distance below (Ddc)	0.2 m	0.1 m
Distance below (Ddtc)	0.4 m	0.1 m
Distance above (Duc)	0.2 m	0.1 m

Installation of the Nokia AWEUC/D Airscale mmWave Radio 5G n258 24GHz and Nokia FA3UB Extension Module, 5G n258 24GHz products 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:

- 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 7).
- 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 7). 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 ---------