RF exposure compliance assessment

5G AirScale mmWave Radio Solution – AWKUA/B

AWKUA/B:

US - FCC ID: 2AD8UAWKUAB01

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Document Type	Final
Document ID	TBD
Document location	https://nokia.sharepoint.com/:f:/r/sites/EMFProductManagement/Shared%20Documents/General/Products-RF-exposure-assessment/AWKUA_B?csf=1&web=1&e=pwYnbu

Change History

Version	Status	Date	Author	Owner	Reviewed by	Reviewed date	Approver	Approval date	Description of changes
1.0	Final	22-03-2024	K. Bechta, W. Silko	C. Grangeat	C. Grangeat	17-09-2024	E. Hartmann	18-09-2024	

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1 General content

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

- Nokia AWKUA/B AirScale mmWave 4T4R n257 63 dBm EIRP

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 established by the US Federal Communications Commission (FCC) regulations (see §2.1 and 3).

2 References

2.1 Applicable RF exposure standards and regulations

[1] US FCC 47CFR 0.71310 “Radiofrequency radiation exposure limits”, August 1997

2.2 Product and assessment method

[2] Microwave Vision Group (MVG), “EMF Visual User Manual”, SEWB/EMF-VISUAL-UM.1/v2023.03

[3] 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

[4] 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

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

[6] IEC 62232:2022 ED3, “Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure”, 2022

[7] 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

[8] NGMN white paper, “Recommendation on Base Station Active Antenna System Standards v1.0”, July 2020, https://www.ngmn.org/wp-content/uploads/Publications/2020/NGMN_BASTA-AA_WP_1_0.pdf

3 RF exposure limits

The applicable RF exposure limits are established by [1] 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.

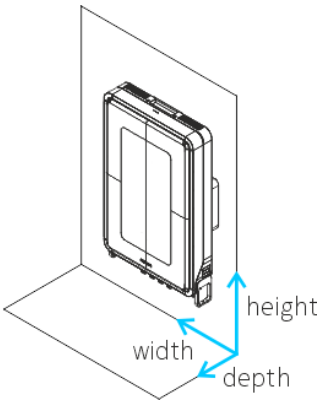
Table 1 – Applicable RF exposure levels in band n257 expressed in power density

Region of application	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
US/related	10 W/m²	50 W/m²

4 Description of the equipment under test (EUT)

The main technical characteristics of AWKUA/B products are reproduced in Table 2.

Table 2 – AWKUA/B products general technical characteristics

Product name	Nokia AWKUA/B AirScale mmWave 4T4R n257 63 dBm EIRP	
FCC ID	2AD8UAWKUAB01	
Model number	AWKUA – 476237A (AC) AWKUB – 476238A (DC)	
Number of TXRX paths	2TX2RX/4TX4RX	
Beamforming	Yes	
SW supported techno.	3GPP NR	
Frequency range	26500 – 29500 MHz (n257)	
Total max EIRP	72 dBm (2TX2RX), 69 dBm (4TX4RX)	
Typical Antenna gain per TXRX path	30 dBi (2TX2RX), 27 dBi (4TX4RX)	
Horizontal coverage angle	±60° (6 dB)	
Vertical steering angle	±45° (3 dB)	
Dimensions 	AWKUA/B: Height: 325 mm Width: 270 mm Depth: 130 mm	
Technology duty cycle factor	75 %	
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 - Table 5 include the EMF Visual models for beam configurations used for the assessment of the compliance boundary. Selected have been patterns related to 2TX2RX configuration, which 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 [8])

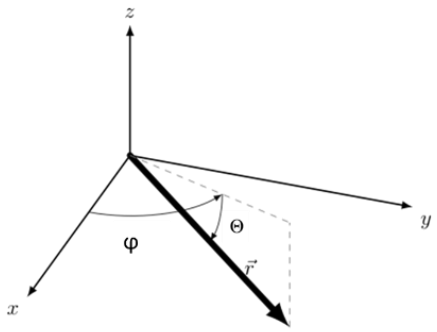
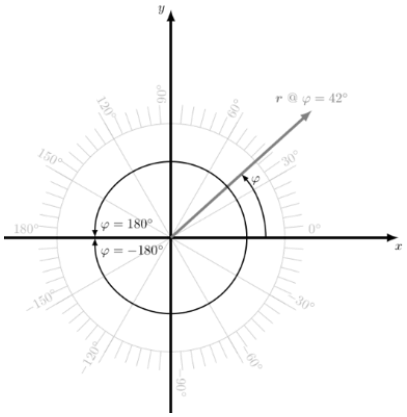
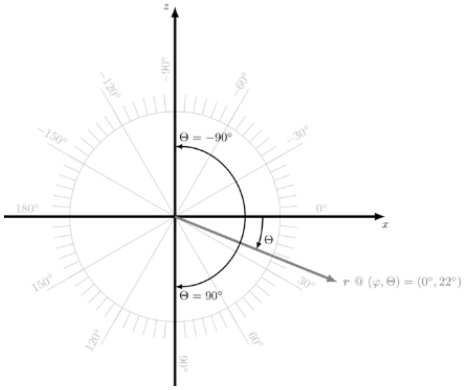
3D view Defintion of azimuth φ and elevation θ	
Top view (horizontal cut) Definition of azimuth φ	
Side view (vertical cut) Definition of elevation θ	

Table 4 – AWKUA/B 2TX2RX configuration antenna pattern models for RF exposure assessment

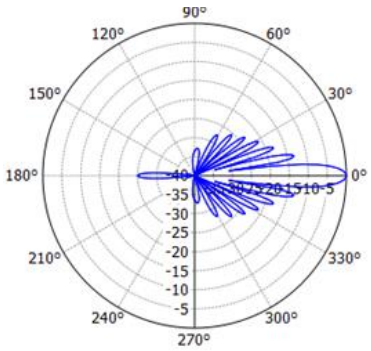
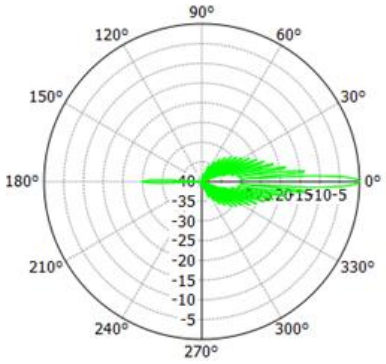
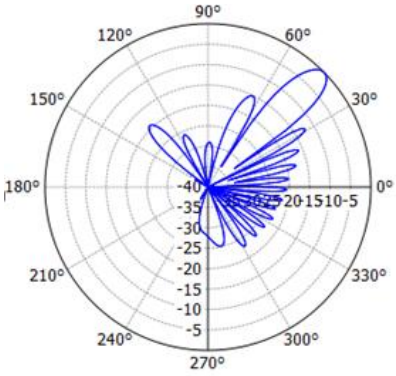
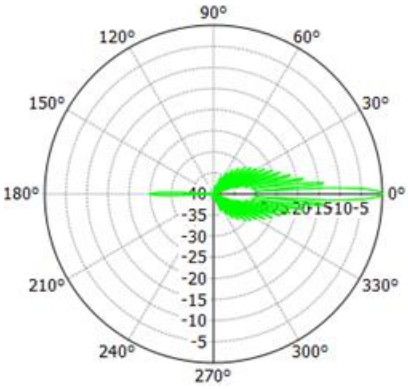
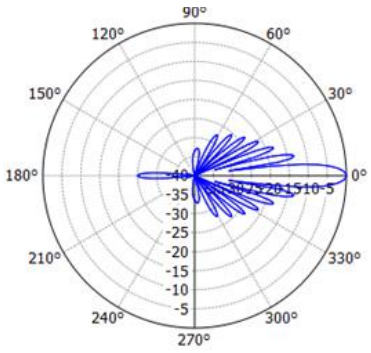
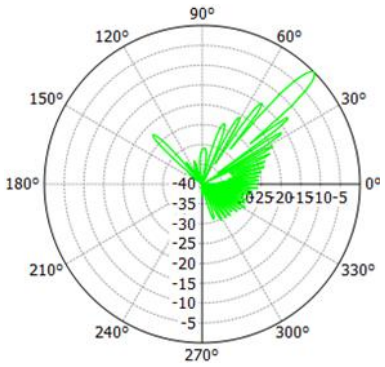
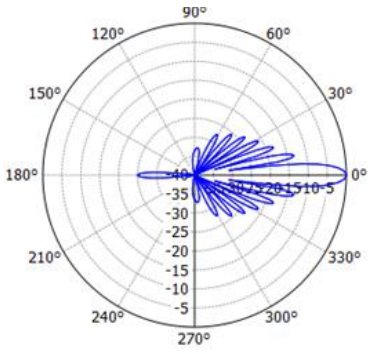
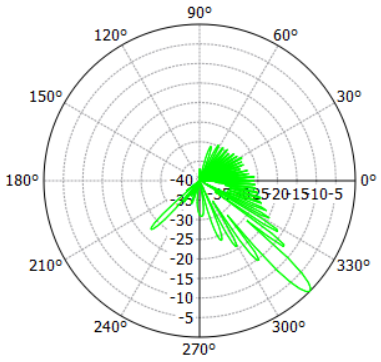
	Horizontal cut	Vertical cut
Boresight		
Max azimuth		
Max up-tilt		
Max down-tilt		
NOTE: Angle references used in these graphs are derived from EMF Visual, which may differ from product data sheet (see Table 3)		

Table 5 – AWKUA/B 2TX2RX configuration antenna gain characteristics for various beam steering directions used during EMF evaluation

	Azimuth	Elevation	Gain (dBi)
			28000 MHz
Boresight	0°	0°	30.0
Max azimuth	+45°	0°	27.0
Max up-tilt	0°	-45°	27.0
Max down-tilt	0°	+45°	27.0

The compliance boundary is described by the box shape perimeter shown in Figure 4 of IEC 62232:2022 [6] and displayed in Figure 1. The distances CD_f, $CD_{s,a}$, $CD_{u,a}$ and $CD_{d,a}$ are taken from the nearest point of the antenna. For convenience, the distances $CD_{s,c}$, $CD_{u,c}$ and $CD_{d,c}$ (respectively) taken from antenna center are also provided.

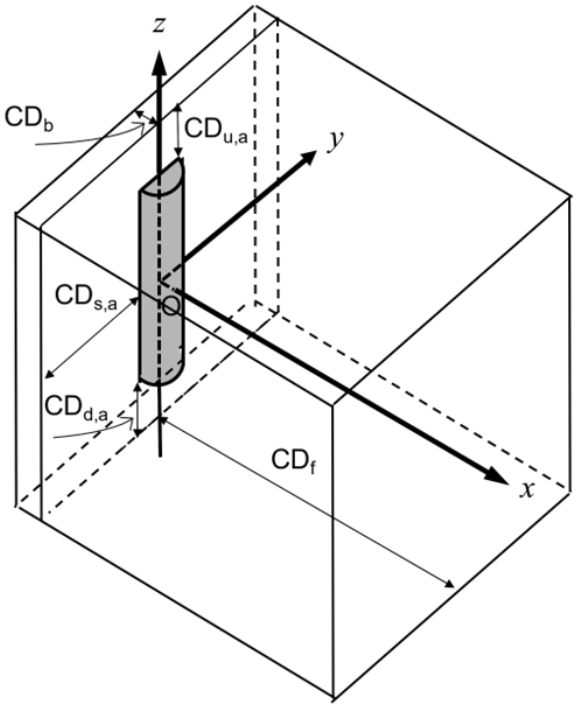


Figure 1 – Shape of the compliance boundary used for the RF exposure compliance assessment (from [6]).

5 RF exposure assessment method

RF exposure assessment is performed using the synthetic model computation method specified in B.7 of IEC 62232:2022 [6]. Calculations are performed with the “EMF Visual” software release OKTAL 2023.03 Version 4.0 (see [2] and [3]).

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 AWKUA/B 2TX2RX configuration antenna model at 25875 MHz

	Product model	EMF Visual model	Deviation
Gain	30.0 dBi	30.0 dBi	0.0 dB
Horizontal half-power beamwidth	6.8°	7.0°	0.2°
Vertical half-power beamwidth	3.3°	3.5°	0.2°

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

The compliance distances are assessed for the time-averaged maximum transmitted power of 16.8 W, corresponding to the time-averaged maximum EIRP of 72.25 dBm for the beam with gain of 30.0 dBi in the boresight direction. The RF compliance distances are also provided for the actual EIRP threshold of 66.25 dBm, applying a power reduction factor of – 6 dB as specified in [4], [5] and [6].

Above values of transmitted power 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

6.1 Regions of application: US/related

The computed power density 3D distributions are displayed in Figure 2 to Figure 9 for RF exposure limits established in [1] for US/related countries.

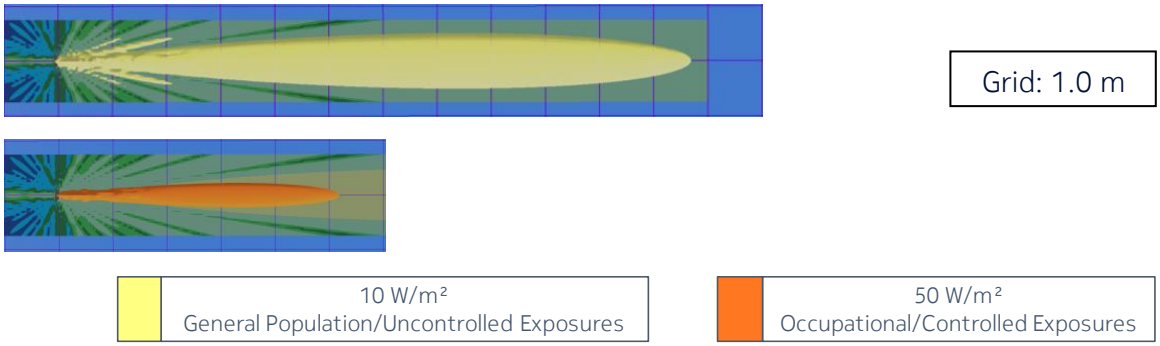


Figure 2 – Power density from AWKUA/B for the time-averaged maximum transmitted power of 16.8 W (corresponding to the time-averaged maximum EIRP of 72.25 dBm) and the beam oriented in azimuth = 0° & elevation = 0° (top view)

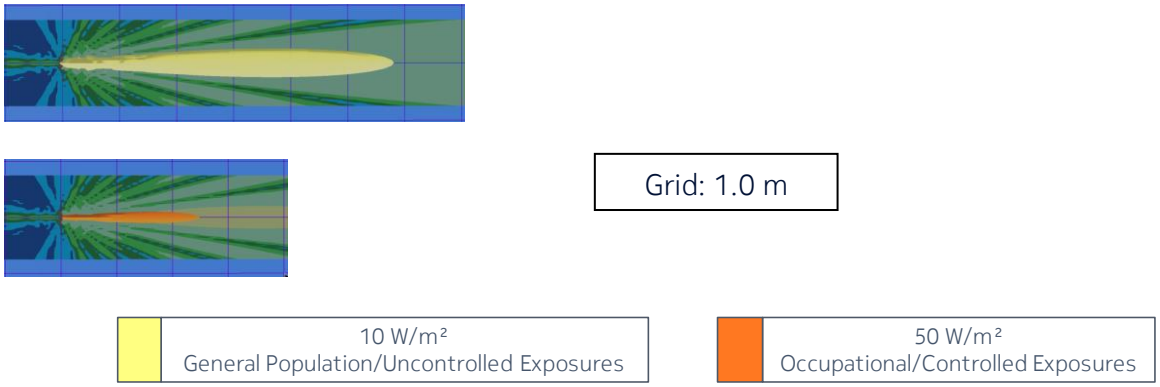


Figure 3 – Power density from AWKUA/B for the actual maximum transmitted power of 4.2 W (corresponding to the actual EIRP threshold of 66.25 dBm) and the beam oriented in azimuth = 0° & elevation = 0° (top view)

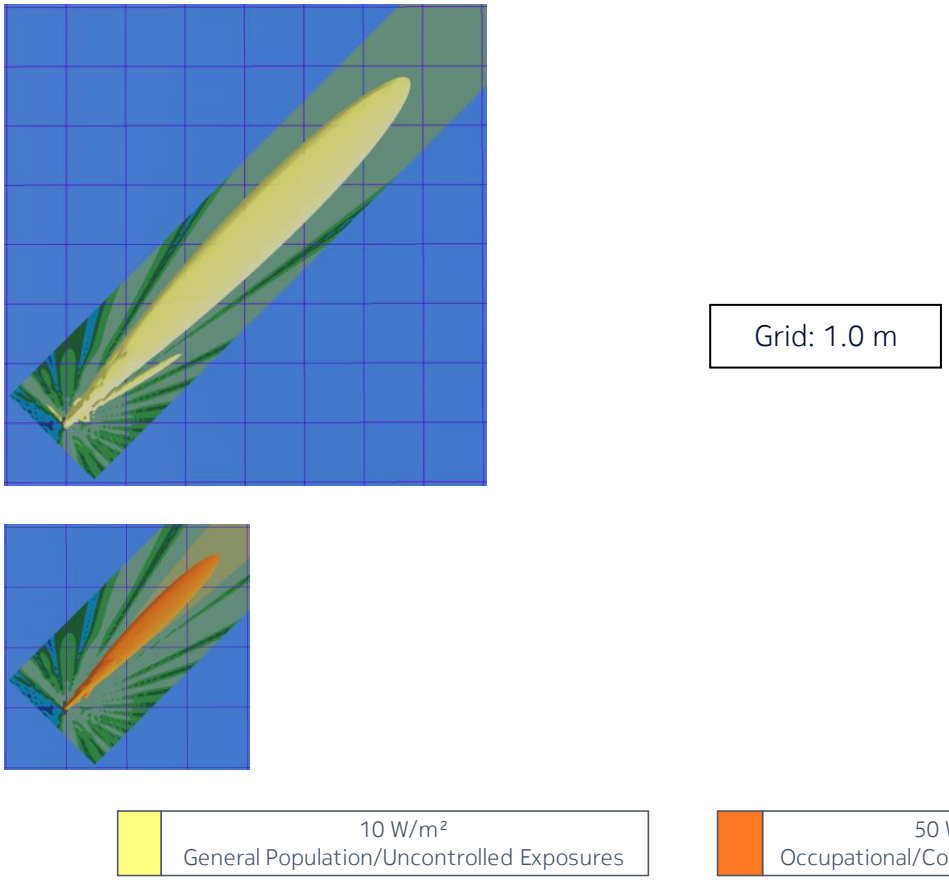


Figure 4 – Power density from AWKUA/B for the time-averaged maximum transmitted power of 16.8 W (corresponding to the time-averaged maximum EIRP of 72.25 dBm) and the beam oriented in azimuth = +45° & elevation = 0° (top view)

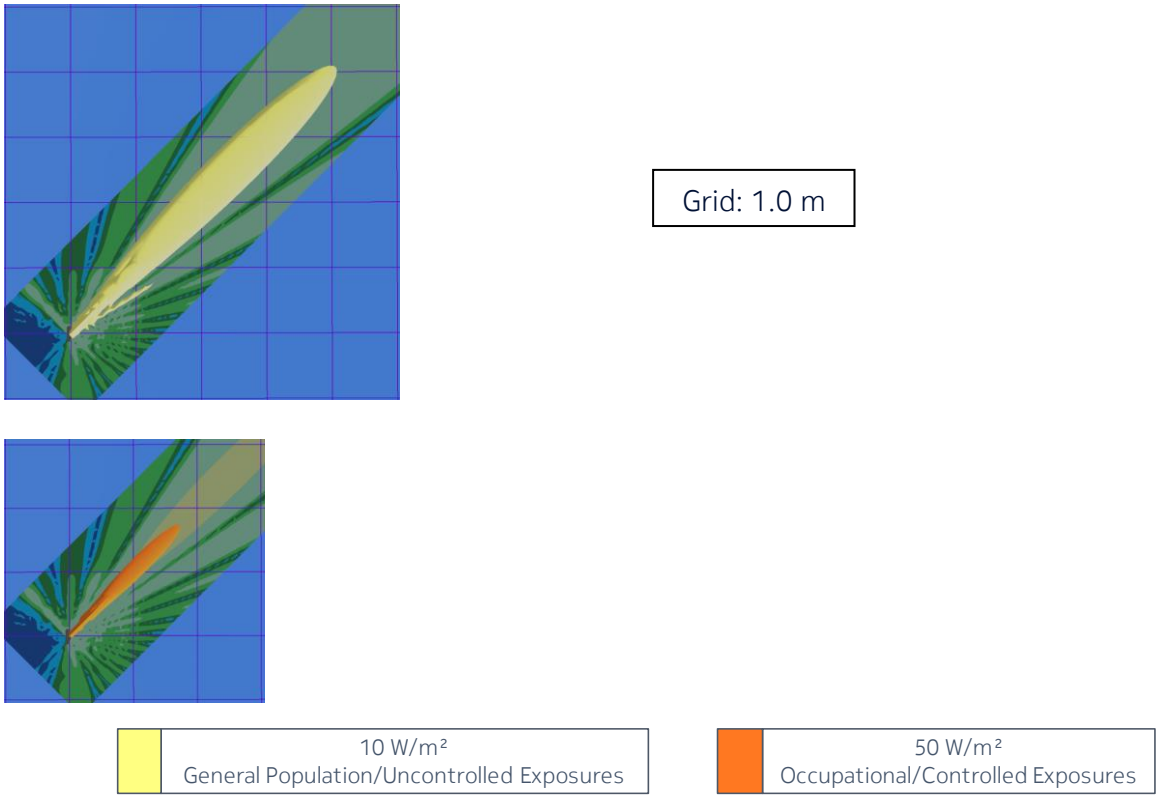


Figure 5 – Power density from AWKUA/B for the actual maximum transmitted power of 8.4 W (corresponding to the actual EIRP threshold of 66.25 dBm) and the beam oriented in azimuth = +45° & elevation = 0° (top view)

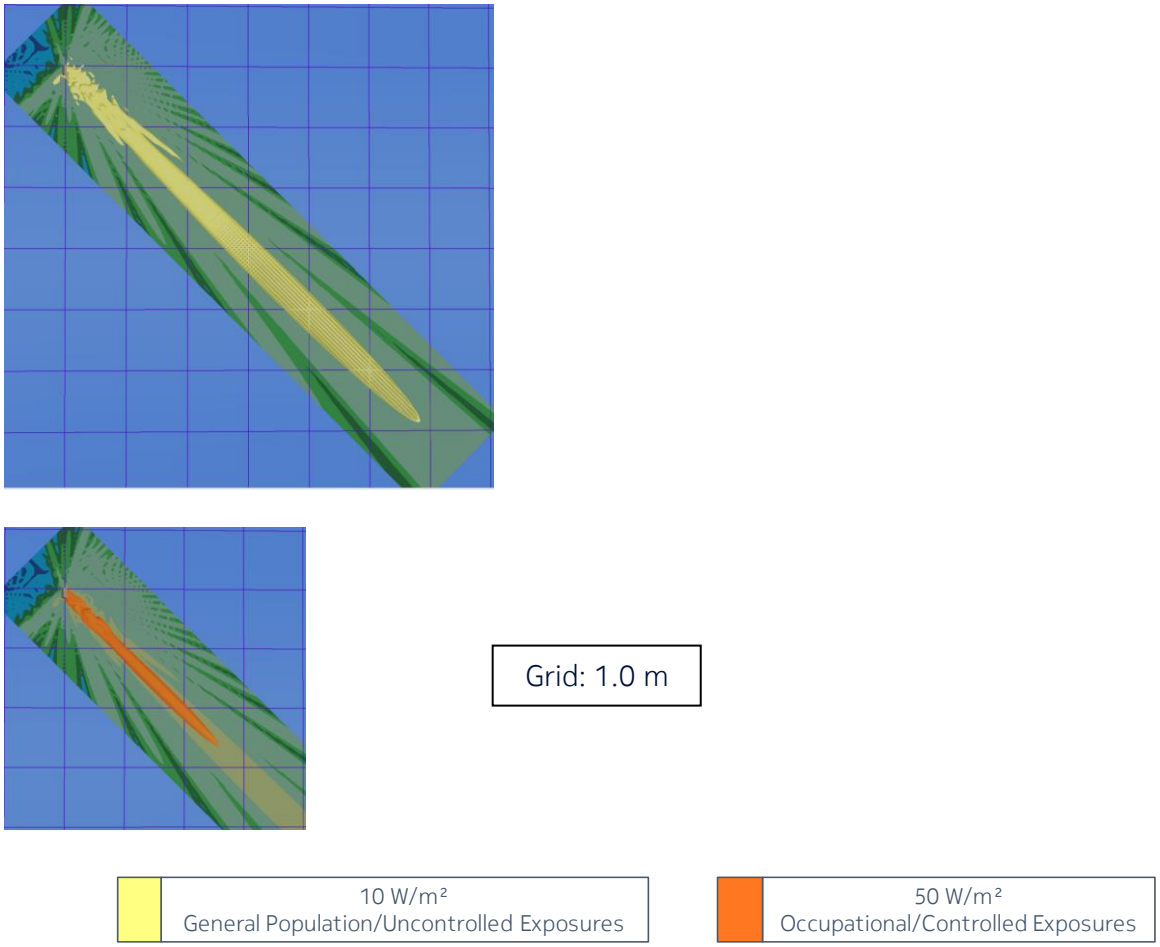


Figure 6 – Power density from AWKUA/B for the time-averaged maximum transmitted power of 16.8 W (corresponding to the time-averaged maximum EIRP of 72.25 dBm) and the beam oriented in azimuth = 0° & elevation = +45° (side view)

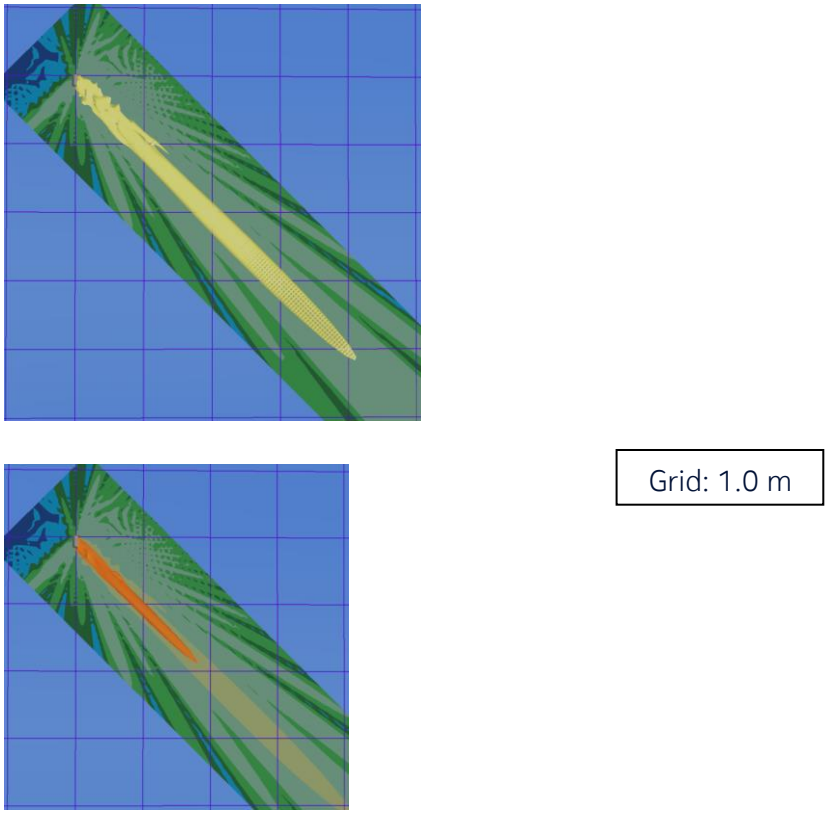


Figure 7 – Power density from AWKUA/B for the actual maximum transmitted power of 8.4 W (corresponding to the actual EIRP threshold of 66.25 dBm) and the beam oriented in azimuth = 0° & elevation = +45° (side view)

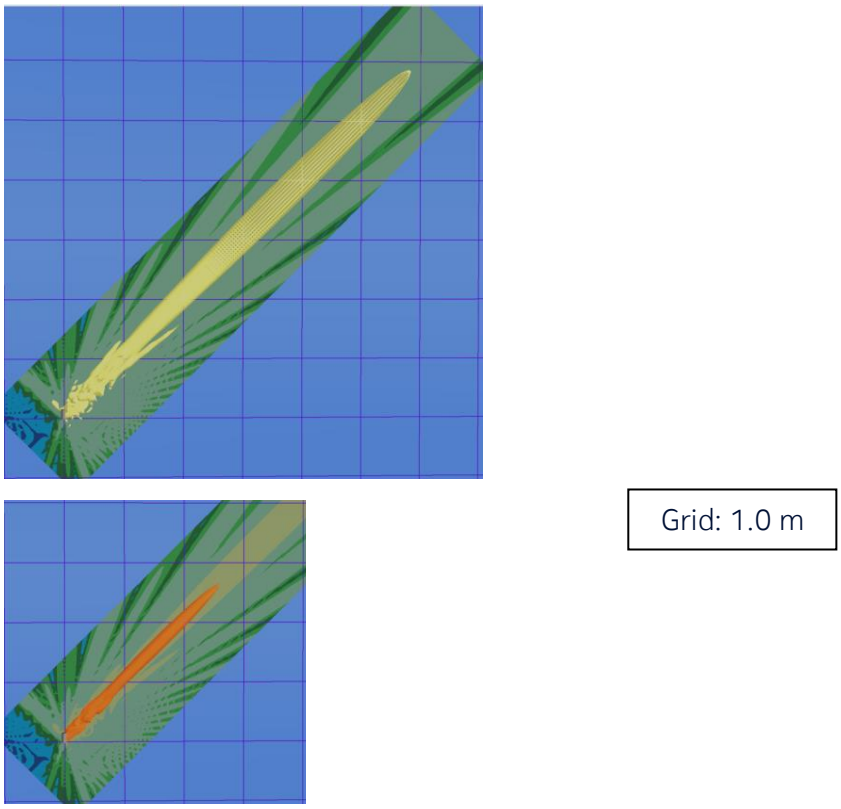


Figure 8 – Power density from AWKUA/B for the time-averaged maximum transmitted power of 16.8 W (corresponding to the time-averaged maximum EIRP of 72.25 dBm) and the beam oriented in azimuth = 0° & elevation = -45° (side view)

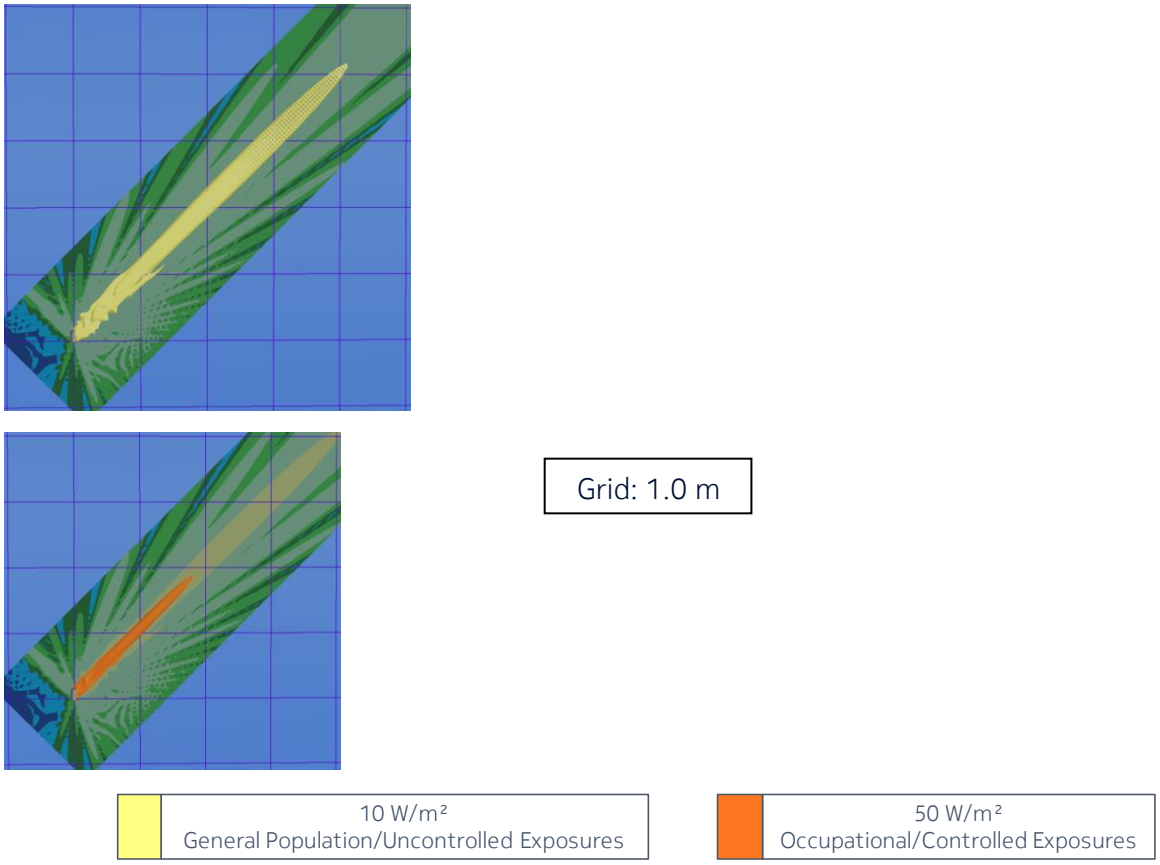


Figure 9 – Power density from AWKUA/B for the actual maximum transmitted power of 8.4 W per antenna module (corresponding to the actual EIRP threshold of 66.25 dBm) and the beam oriented in azimuth = 0° & elevation = -45° (side view)

7 Conclusion and installation recommendations

The RF exposure compliance distances applicable Nokia AWKUA/B AirScale mmWave 4T4R n257 63 dBm EIRP products, are summarized in Table 7 for US/related [1] requirements.

Table 7 – AWKUA/B RF exposure compliance distances based on the time-averaged maximum EIRP of 72.25 dBm

Region of application: US/related	General Population/Uncontrolled Exposures	Occupational/ Controlled Exposures
RF-EMF power density exposure limits	10 W/m²	50 W/m²
Distance in front (CD_f)	11.7 m	5.2 m
Distance to the side ($CD_{s,a}$)	5.7 m	2.5 m
Distance below and above ($CD_{d,a}$) ($CD_{u,a}$)	5.7 m	2.5 m
Distance to the side from the center ($CD_{s,c}$)	5.8 m	2.6 m
Distance below and above from the center ($CD_{d,c}$) ($CD_{u,c}$)	5.8 m	2.6 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], [5] and [6].

Table 8 – AWKUA/B RF exposure compliance distances based on the actual EIRP threshold of 66.25 dBm

For information in US/related countries based on IEC/EN 62232:2022 [6] and IEC TR62669 [5]	General Population/Uncontrolled Exposures	Occupational/ Controlled Exposures
RF-EMF power density exposure limits	10 W/m²	50 W/m²
Distance in front (CD_f)	5.9 m	2.6 m
Distance to the side ($CD_{s,a}$)	4.1 m	1.8 m
Distance below and above ($CD_{d,a}$) ($CD_{u,a}$)	4.1 m	1.8 m
Distance to the side from the center ($CD_{s,c}$)	4.2 m	1.9 m
Distance below and above from the center ($CD_{d,c}$) ($CD_{u,c}$)	4.2 m	1.9 m

Installation of the Nokia AWKUA/B AirScale mmWave 4T4R n257 63 dBm EIRP, 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 assessed 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 ---------