RF exposure compliance assessment

LTE massive MIMO Adaptive Antenna Products – AAHF & AAHJ

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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) Products (see §2.2):

- Nokia AirScale MAA 64T64R 128 AE B41 120 W AAHF and AAHJ Radio Units

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] Nokia, “Massive MIMO Adaptive Antenna Product Description” DN207523773, Issue 02, 16-04-2018.

[12] Nokia, “AAHF – Antenna Test Report”, D566093793, 22-11-2018.
[Note: this report is also applicable to AAHJ]

[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”, (106/4673/DTR, December 2018).

3 RF exposure limits

The applicable RF exposure limits are defined by [1] and [2] 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 B41 band expressed in power density

Region of application	General Population /Uncontrolled Exposures	Occupational /Controlled Exposures
EU/ICNIRP, Australia/NZ & US/related	10 W/m²	50 W/m²
Canada	5.5 W/m²	32 W/m²

4 Description of the equipment under test (EUT)

The main technical characteristics of AAHF and AAHJ products are reproduced in Table 2 and Table 3 respectively.

Table 2 – AAHF product general technical characteristics

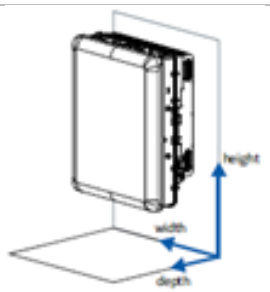
Product name	AirScale MAA 64T64R 128AE B41 120 W AAHF Radio Unit	
FCC ID.	VBNAAHF-01	
Model number	474715A	
Rated max Tx power	120 W	
Number of TXRX	64TX64RX	
Beamforming	Yes	
SW supported techno.	TD-LTE	
Frequency range	2496 – 2690 MHz (3GPP Band 41)	
Nb of antenna elements	8 (horizontal) x 8 (vertical)	
Distance between AE	57.5 mm (horizontal) x 80 mm (vertical)	
Gain	24 dBi	
EIRP	74.8 dBm	
Beam steering range	± 60° (horizontal) and ± 20° (vertical)	
Dimensions	Height: 651 mm (25.6 in.) Depth: 245 mm (9.6 in.) Width: 501 mm (19.7 in.) Note: includes front covers.	
Technology duty cycle factor	75 %	
Transmitted power tolerance	1.5 dB	

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Table 3 – AAHJ product general technical characteristics

Product name	AirScale MAA 64T64R 128AE B41 120 W AAHJ Radio Unit
FCC ID:	VBNAAHJ-01
Model number	474795A
Frequency range	2590 – 2690 MHz
The other characteristics are the same as AAHF (see Table 2).	

Antenna pattern characteristics provided in Table 4 have been derived from the antenna test report [12].

Table 4 – Measured antenna gain characteristics for various beam steering directions (from [12])

Azimuth	Elevation	Gain (dBi)			
		2496 MHz	2605 MHz	2690 MHz	Conservative value used
0°	3°	22.8	23.3	23.0	**23.3**
0°	-17°	20.4	21.3	20.6	21.3
0°	23°	20.1	20.4	19.8	**21.3**
10°	-17°	20.2	20.8	20.3	21.3
10°	23°	20.5	20.7	19.8	21.3
60°	3°	19.3	18.9	19.0	**19.9**
60°	13°	19.1	19.9	19.7	19.9

In order to provide a conservative assessment over the frequency range, we performed the calculation at the central frequency (i.e. 2605 MHz) scaled to the maximum gain over the whole frequency band (indicated in the right column in Table 4). The compliance boundary is defined by the box shape perimeter shown in Figure 1 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.

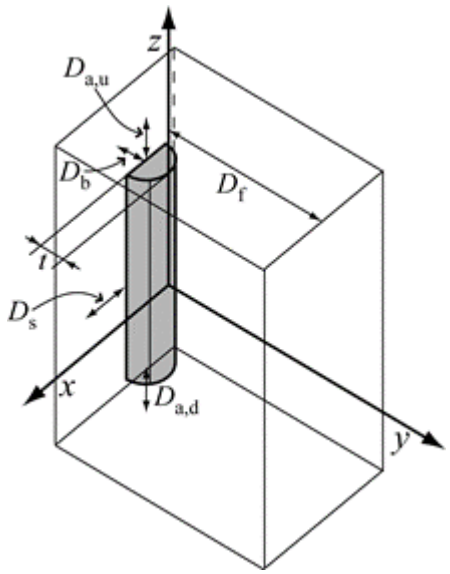

Figure 1 – Shape of the compliance boundary used for the RF exposure compliance assessment (from [4]).

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 = 0° and elevation = 0°). The validation results are provided in Table 5.

Table 5 – Validation of the antenna model at 2605 MHz

	Product (from [12])	Model	Deviation
Gain	23.4 dBi	23.4 dBi	0
Horizontal half-power beamwidth	13.3°	15°	1.7°
Vertical half-power beamwidth	9.6°	10°	0.4°

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 127 W and, for information, the time-averaged actual maximum transmitted power of 32 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

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

The computed power density distributions are displayed in Figure 2 to Figure 7 for RF exposure limits defined in [1], [2] for EU/ICNIRP countries, [6] Australia/NZ and [9] for US/related countries.

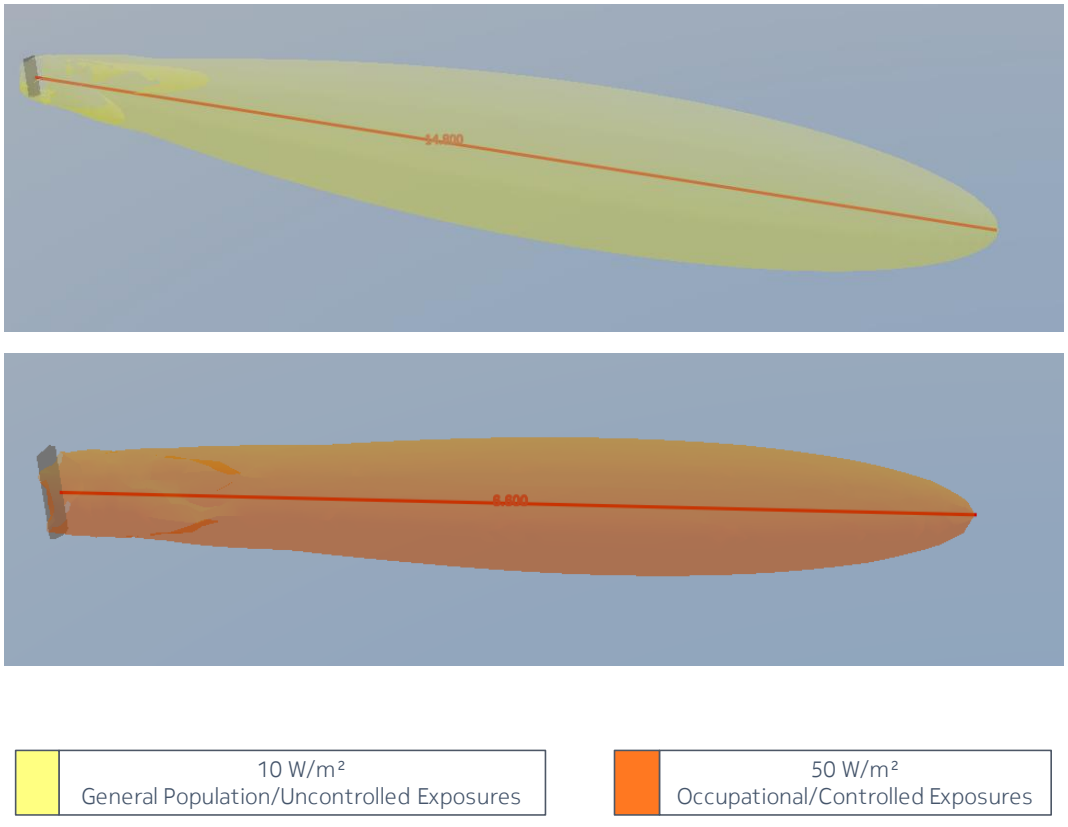

Figure 2 – Compliant distance in front (Df) for the time-averaged maximum transmitted power of 127 W and the beam oriented in azimuth = 0° & elevation = - 3°

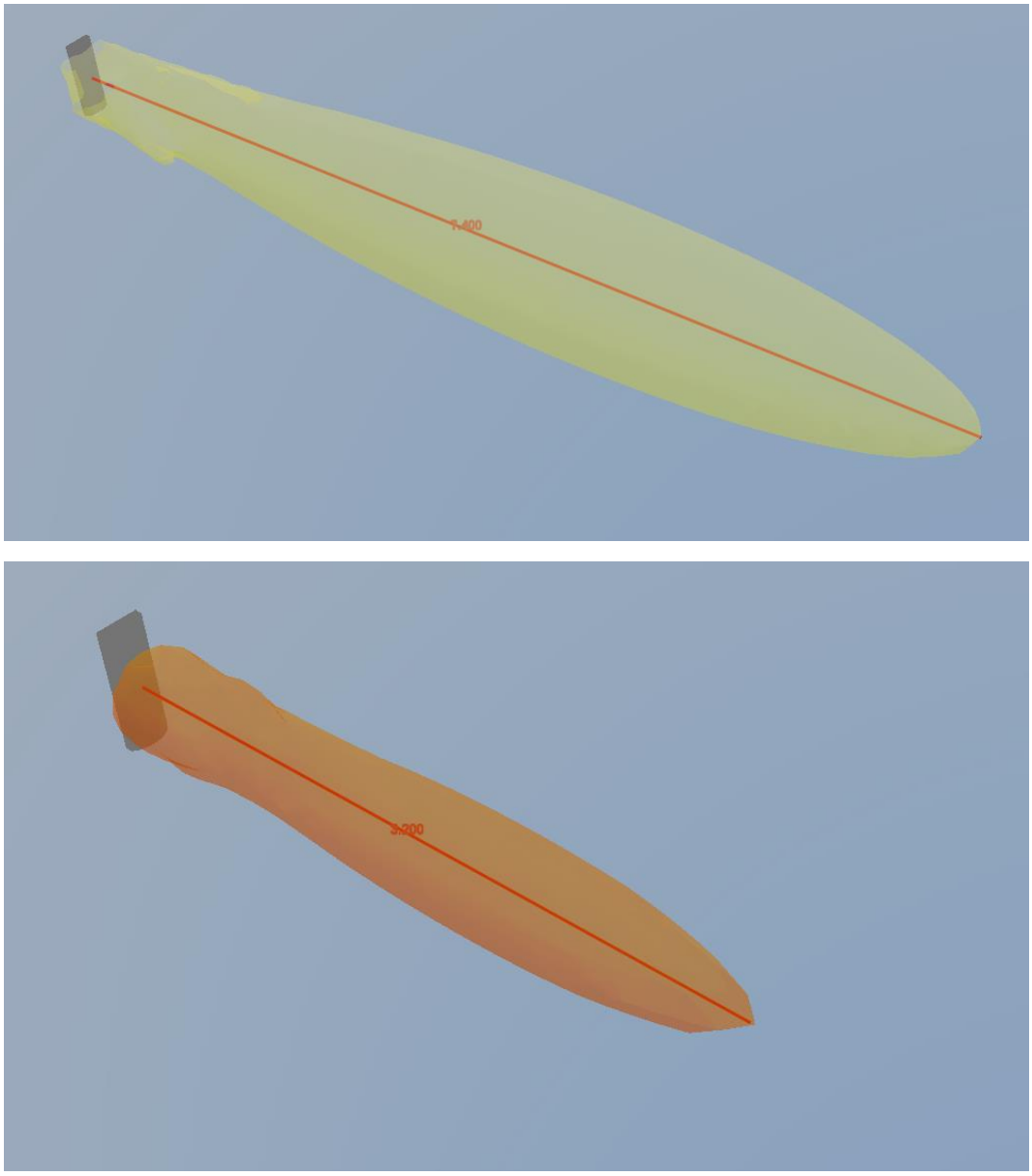

Figure 3 – Compliance distance in front (Df) for the time-averaged actual maximum transmitted power of 32 W and the beam oriented in azimuth = 0° & elevation = - 3°

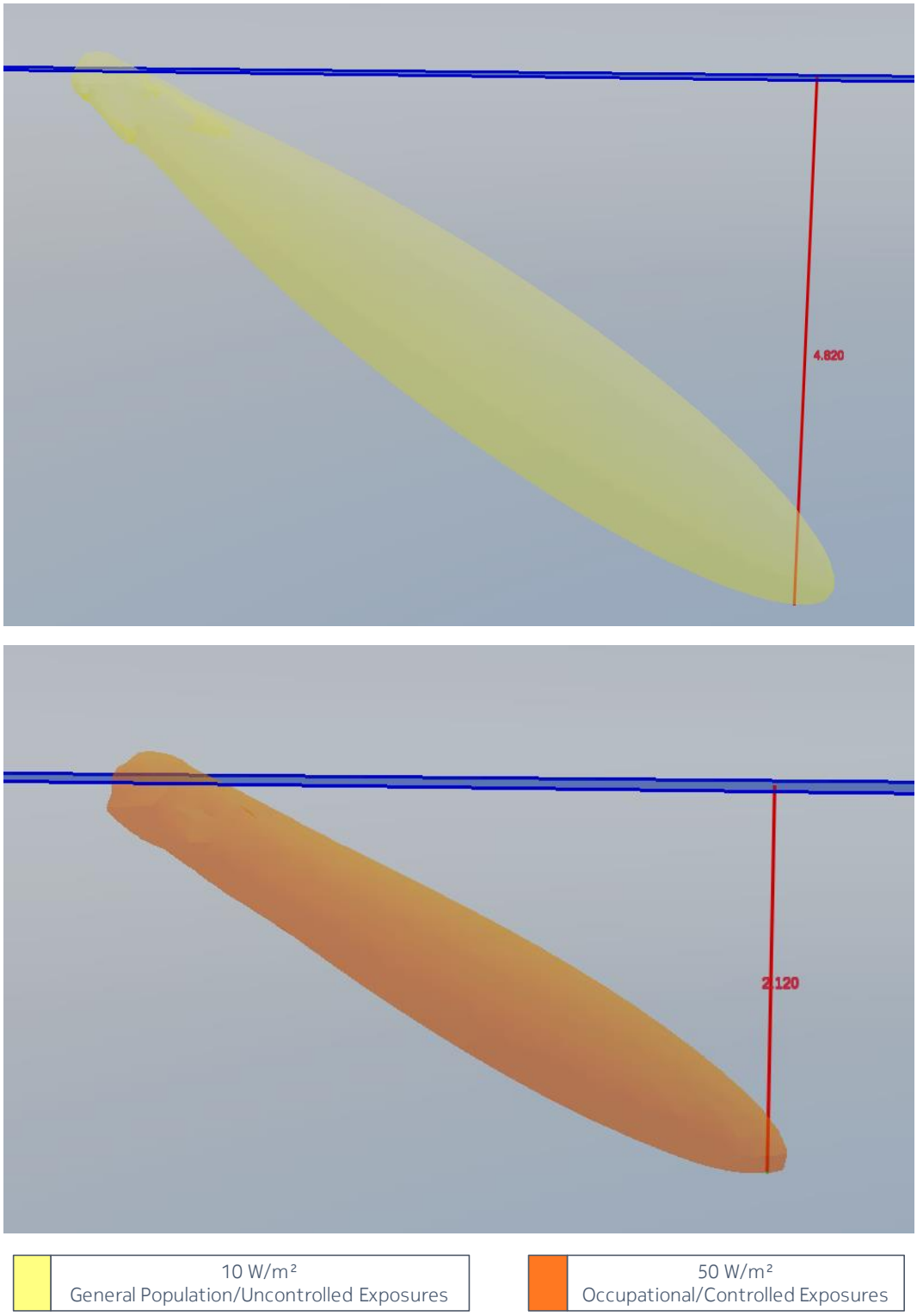

Figure 4 – Compliance distance down (Dd,c) for the time-averaged maximum transmitted power of 127 W and the beam oriented in azimuth = 0° & elevation = - 23°

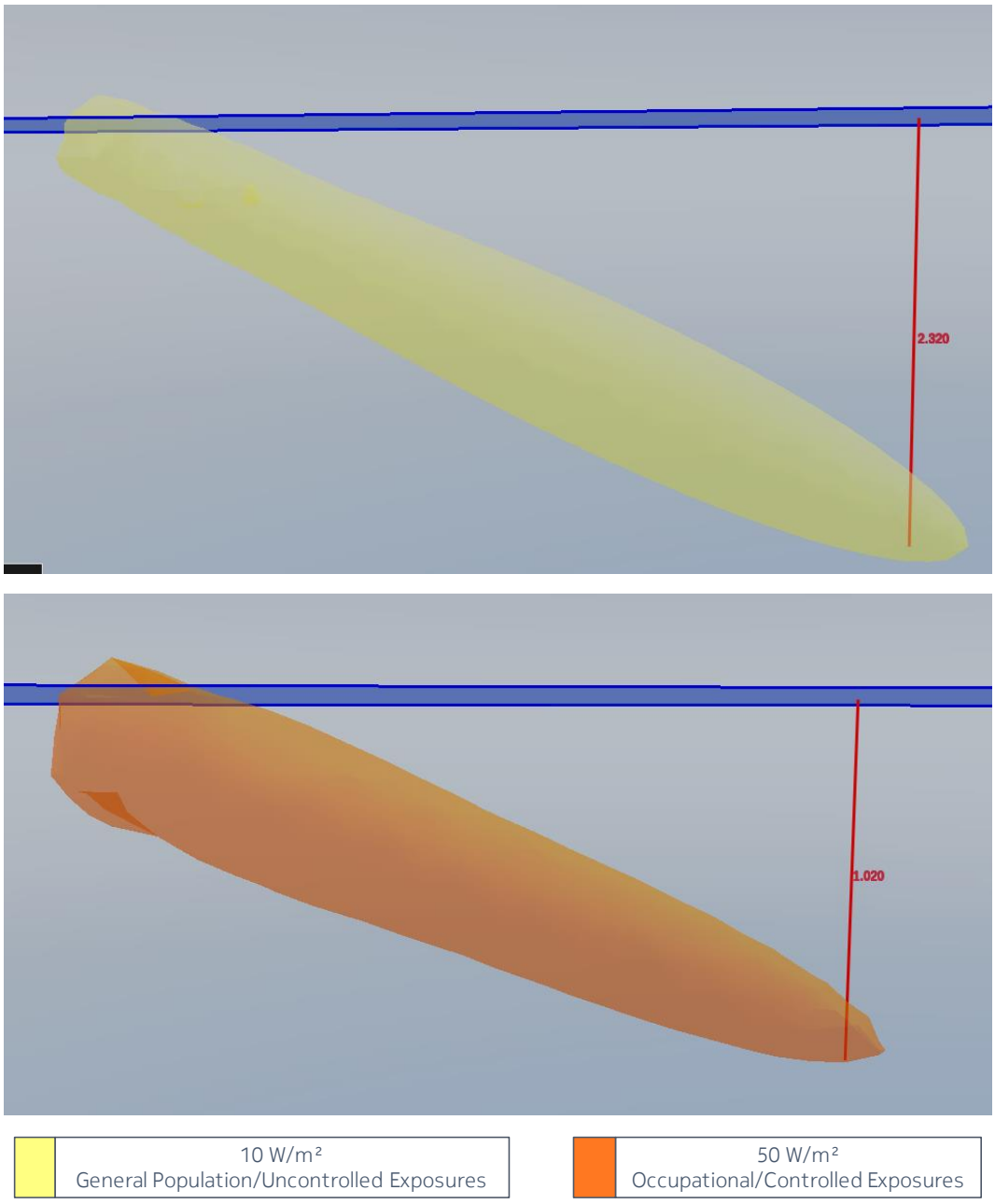

Figure 5 – Compliance distance down (Dd,c) for the time-averaged actual maximum transmitted power of 32 W and the beam oriented in azimuth = 0° & elevation = - 23°

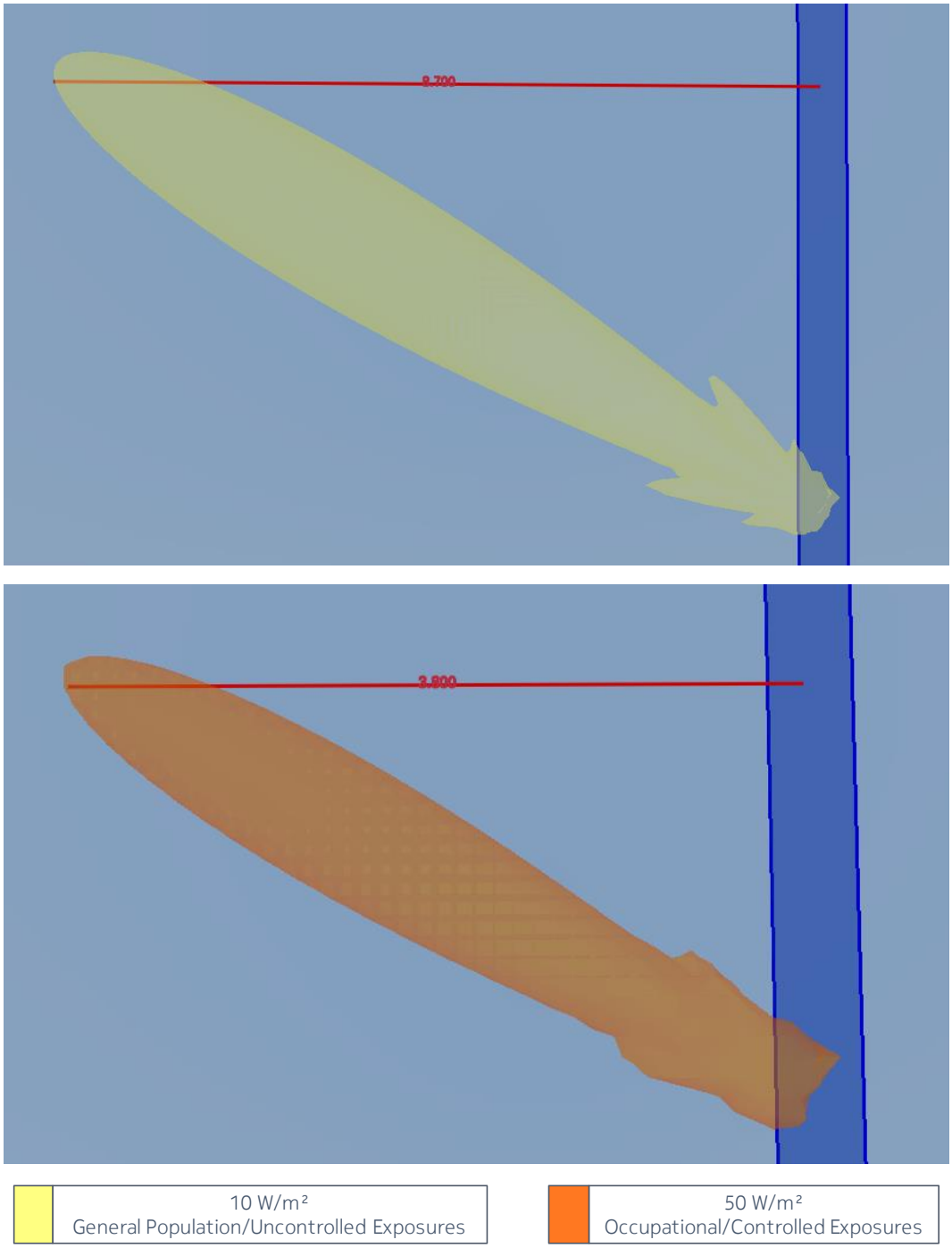

Figure 6 – Compliance distance on the side (Ds,c) for the time-averaged maximum transmitted power of 127 W and the beam oriented in azimuth = 60° & elevation = - 3°

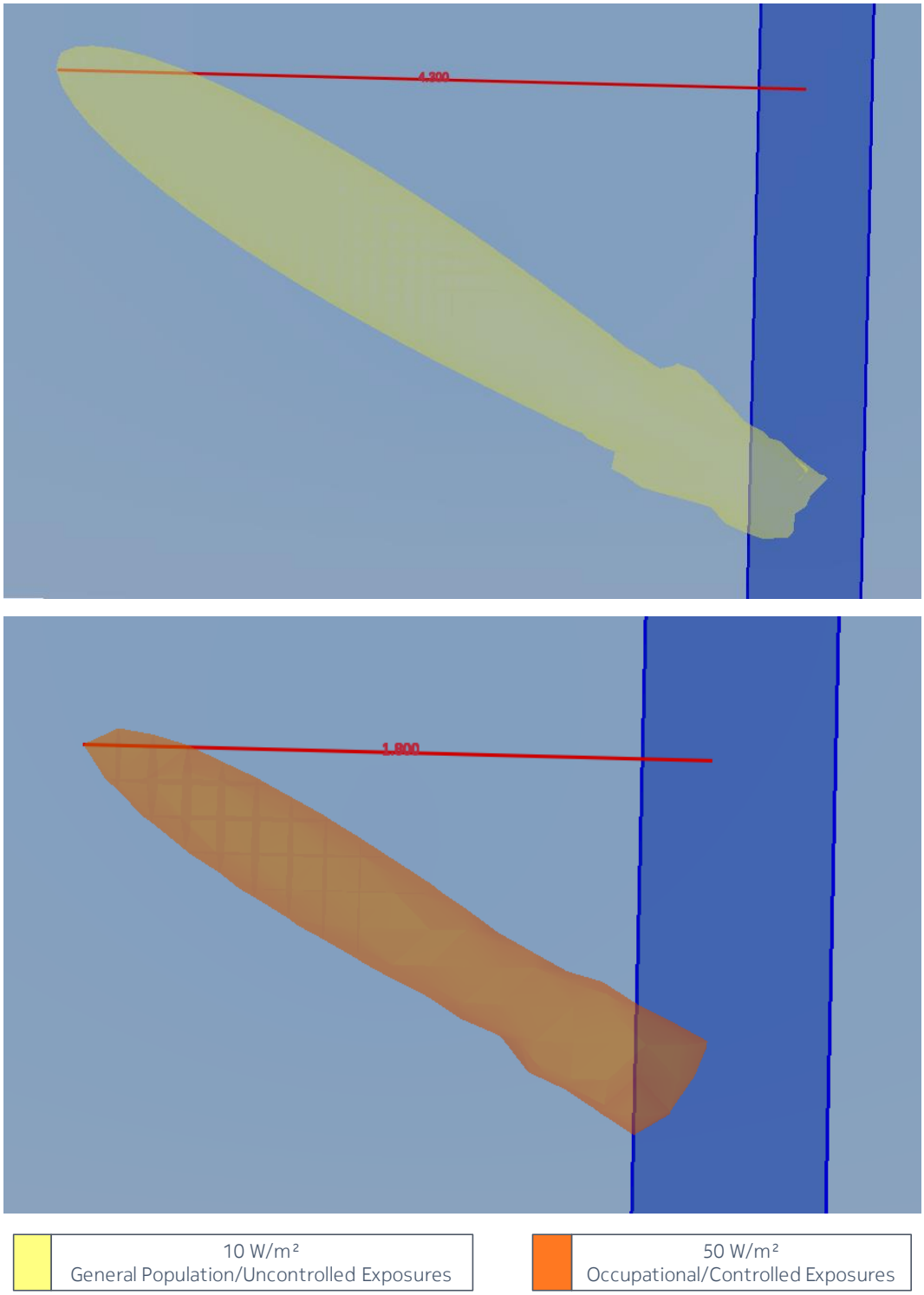

Figure 7 – Top view of the power density for the time-averaged actual maximum transmitted power of 32 W and the beam oriented in azimuth = 60° & elevation = - 3°

6.2 Regions of application: Canada

Not yet available.

7 Conclusion and installation recommendations

The RF exposure compliance distances for the Nokia AirScale MAA 64T64R 128 AE B41 120 W AAHF and AAHJ products are summarized in Table 6 for compliance to EU/ICNIRP [1], [2], to Australia/NZ [6] and US/related countries [9] requirements.

Table 6 – AAHF/AAHJ RF exposure compliance distances based on the time-averaged maximum transmitted power of 127 W (corresponding to 120 W rated max transmitted power)

Region of application: EU/ICNIRP and US/related	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
Power density RF-EMF exposure limits	10 W/m²	50 W/m²
Distance in front (Df)	14.8 m	6.6 m
Distance to the side (Ds)	8.5 m	3.6 m
Distance below and above (Da,d and Da,u)	4.5 m	1.8 m
Distance to the side (Dsc)	8.7 m	3.8 m
Distance below and above (Ddc and Duc)	4.8 m	2.1 m

The AAHF/AAHJ RF exposure compliance distances based on the actual maximum transmitted power considering a 95th percentile approach are summarized in Table 7. 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 [15] and [16].

Table 7 – AAHF/AAHJ RF exposure compliance distances based on the time-averaged actual maximum transmitted power of 32 W (corresponding to 120 W rated max transmitted power)

For information in EU/ICNIRP, Australia/NZ and US/related countries based on IEC/EN 62232:2017 [4] and IEC TR62669 [16]	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
Power density RF-EMF exposure limits	10 W/m²	50 W/m²
Distance in front (Df)	7.4 m	3.2 m
Distance to the side (Ds)	4.1 m	1.6 m
Distance below and above (Da,d and Da,u)	2.0 m	0.8 m
Distance to the side (Dsc)	4.3 m	1.8 m
Distance below and above (Ddc and Duc)	2.3 m	1.0 m

Installation of the Nokia AirScale MAA 64T64R 128 AE B41 120 W AAHF and AAHJ 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 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 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.

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