ALCATEL

Site VELIZY	MOBILE COMMUNICATION GROUP
Originators C. Grangeat/ B. Wu	ELECTROMAGNETIC ENVIRONMENT (EME) EME compliance of WiMAX Base Station

System	:	ALCATEL MCG
Sub-system	:	
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ABSTRACT

This document is the compliance assessment report of Alcatel 9116 Light Base Station with electromagnetic environment exposure limits when this equipment are put on the market in accordance to EN50384 and EN50385. It provides the compliance boundaries not only for the maximum transmitted power in each frequency band but also for a set of transmitted powers, over the relevant frequencies, bands and modes.

Product lines reference: Alcatel 9116 Light Base Station

Compliance assessment standard ref: EN50383, EN50384, EN50385.

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REVIEW

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TABLE OF CONTENTS

INTERNATIONAL REFERENCED DOCUMENTS

3BK 10247 0008 DSZZA Full Outdoor BS 2.30-2.40 GHz/2.496-2.690 GHz/3.3-3.8 GHz Radio Specification

REFERENCED DOCUMENTS

[1] EN 50383 Basic standard for the calculation and measurement of electromagnetic field strength and SAR related to human exposure from radio base stations and fixed terminal stations for wireless telecommunication systems (110 MHz - 40 GHz)

[2] EN50384 Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to occupational exposure to radio frequency electromagnetic fields (110 MHz - 40 GHz)

[3] EN50385 Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to general public exposure to radio frequency electromagnetic fields (110 MHz - 40 GHz)

[4] Z.Altman, B.Begasse, C.Dale, A.Karwowski, J.Wiart, M.F.Wong and L.Gattoufi « Efficient Models for Base Station Antennas for Human Exposure Assessment » IEEE Transactions on EMC, Vol. 44, N°3, August 2002

RELATED DOCUMENTS

[5] COUNCIL RECOMMENDATION 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)

[6] DIRECTIVE 2004/40/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields).

[7] ICNIRP guidelines, “Guidelines for Limiting Exposure to Time Varying Electric, Magnetic and Electromagnetic Fields (up 300 GHz)”, Health Physics, Vol. 74, n°4, pp. 499–522, April 98

PREFACE

Alcatel develops, manufactures and supplies equipment for mobile and wireless networks based on the transmission of communication signals at radio frequencies. Emissions of radio waves contribute to the existing Electromagnetic Environment (EME). Alcatel takes all the precautions to ensure that its equipments comply with the local, national and international standards and regulations related to the protection of the general public and people occupationally exposed.

OPEN POINTS / RESTRICTIONS

Not applicable.

1 SCOPE

This document is the compliance assessment report of Alcatel 9116 Light Base Station according to EN50384 [2] and EN50385 [3] related to exposure to electromagnetic fields. It provides the compliance boundaries for the maximum transmitted power in the frequency band.

2 EQUIPMENT UNDER TEST

This paragraph describes the relevant characteristics of sector antennas to be considered in EME compliance assessment.

2.1 Equipment description and characteristics

In table 1 (below) can be found some information about the product dealt with in this document. A complete description can be found in referenced document Full Outdoor BS 2.30-2.40 GHz/2.496-2.690 GHz/3.3-3.8 GHz Radio Specification.

Radio Characteristic	Support by Alcatel Base station
Frequency bands	- 3.5 GHz band: 3.3 – 3.8 GHz <-prio 1 - 2.5 GHz band: 2.3 – 2.7 GHz - later evolution to 5 GHz and below 1 GHz band
Rx Sensitivity	- Sensitivity –94 dBm for QPSK ½ and 5MHz channel, measured at antenna connector. Note: This implies that noise figure + implementation loss should not exceed 4 dB.
LNA noise figure	- 3.5 dB
Implementation loss	- 0.5 dB
Channelisation	- 3.5, 5.0, 5.5, 7.0, 10 MHz
Max RF output power (at feeder input)	- 35 dBm
Target PAPR	- 7 dB
Antenna Configurations	- 4 Rx / 4Tx - 4 Rx / 2 Tx - 2 Rx / 2 Tx - 2 Rx / 1 Tx - 1 Rx / 1 Tx
Co-existence with other systems	- GSM - UMTS - CDMA
Co-existence with other WiMAX systems	- operating in other frequency band (in the same frequency band requires BS synchronization for TDD operation)
Site sharing with other WiMAX systems	- operating in other frequency band (in the same frequency band requires BS synchronization for TDD operation)

Table 1: Equipment main characteristics description

2.2 Typical configuration

Regarding the variety of the possible configuration of Alcatel WiMAX base station and according to 3BK 10247 0008 DSZZA Full Outdoor BS 2.30-2.40 GHz/2.496-2.690 GHz/3.3-3.8 GHz Radio Specification, the maximum input power of this equipment is 35 dBm per TRx, so the total emitted power for 4 Rx/ 4Tx antenna is 41 dBm under worst case conditions. For more detailed base station configuration description, please refer to product description documents provided upon request.

2.3 Typical antennas used for tests

As configurations and antennas differ according to the intended use of the equipment under test, the typical antenna in use is presented for outdoor coverage.

In table 2 (below) are provided the most relevant characteristics of antenna typically used with the equipment under test. As Alcatel 9116 Light Base Station can support 2.5 GHz and 3.5 GHz band, two kinds of adaptive antenna system are considered.

Product name and type	W4A25-90ANV adaptive antenna	W4A35-90ANV adaptive antenna
Antenna shape		
Frequency range (GHz)	2.3 - 2.7	3.4 – 3.6
Antenna gain (dBi)	> 21.5 (SA0) > 20 (SA20) > 18.5 (SA40)	> 21.5 (SA0) > 20 (SA20) > 18.5 (SA40)
Horizontal Bandwidth	90° (Single Element) 22° (SA0) < 30° (SA20) < 35° (SA40)	90° (Single Element) 22° (SA0) < 30° (SA20) < 35° (SA40)
Vertical Bandwidth	6.5°	6.5°

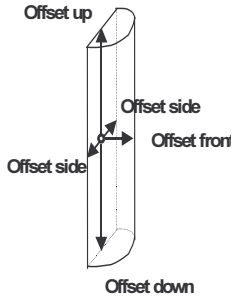
 Figure 1: mechanical offsets (m)	Front	0.12	0.12
	Side	0.16	0.16
	Up	0.5	0.4
	Down	0.5	0.4
Note: Providing the precision beam-pattern shaping, the adaptive antenna has a series of scanning angles (SA): 0°(SA0), 20° (SA20), 40° (SA40), etc.			

Table 2: WiMAX Base Station antennas for typical configurations

3 EXPOSURE LIMITS

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is formally recognized by the World Health Organization (WHO) to draft health based exposure guidelines. This commission has published reference guidelines on the thresholds of exposure to electromagnetic fields for frequencies from 0 to 300 GHz [7]. In this document, the basic restrictions for the population's exposure to electromagnetic fields are based on established health effects while reference levels are defined for practical exposure–assessment purposes to determine whether the basic restrictions are likely to be exceeded.

ICNIRP guidelines [7] define different limits for general public and occupational exposure. Occupational exposure limits apply to adults exposed under known conditions and trained to be aware of potential risk and to take appropriate precautions. The general public limits apply to everybody else. Their state of health may vary significantly from one person to the next. An additional safety margin is therefore applied. The exposure limits for the public are generally five times lower than those for workers.

In Europe, exposure limits of the general public are defined by the European recommendation 1999/519/EC of July 12th, 1999 [5], and those for occupational exposure are defined by the European Directive 2004/40/EC of April 29th, 2004 [6]. The field levels are similar to those proposed by the ICNIRP guidelines, which have been largely adopted worldwide. Alcatel along with most mobile industry has adopted these limits as a worldwide reference.

A few countries have adopted lower exposure limits. In order to give an exhaustive assessment of the compliance boundaries, the reference values to be used worldwide are summarized in table 4. Basic restrictions below 10 GHz are expressed as SAR values whereas power density is used for frequencies above 10 GHz. Reference levels are expressed as power density from 2 to 300 GHz that covers almost all frequencies used for fixed radio services. Thus compliance to the basic restrictions can be achieved by compliance to the reference levels throughout that frequency range. No compliance with reference levels does not imply exceeding the basic restrictions. In that case, SAR assessment can be performed provided that:

1. The separation between the phantom and the outer surface of the radiating structure is 40 cm or less;
2. The size of the radiating structure surface is less than 60 cm by 30 cm;
3. The frequency is in the range from 100 kHz to 10 GHz

Whole body SAR measurements are not required for transmitters that have maximum output power levels too low to result in exposure levels that can reach the whole body SAR compliance limits under any conditions. As defined in the European standard EN 50383 section 7.1.2, these whole body SAR exclusion power levels have been based on worst case assumption.

In case of human exposure to multiple frequency EM fields, the criteria defined in ICNIRP Guidelines [7] shall be used to establish compliance.

System	Tx frequencies	Whole-body average SAR (W/kg)	Localized SAR (head and trunk) (W/kg)	Localized SAR (limbs) (W/kg)	Power density (W/m^2)	Comments
All	10 MHz – 10 GHz	0.4	10	20	-	ICNIRP, basic restriction for occupational exposure
		0.08	2	4	-	ICNIRP, basic restriction for general public exposure
All	10 GHz – 300 GHz	-	-	-	50	ICNIRP, basic restriction for occupational exposure
		-	-	-	10	ICNIRP, basic restriction for general public exposure

Table 3: Basic restrictions according to ICNIRP

System	Tx frequencies (MHz)	E field (V/m)	H field (A/m)	S power density (W/m^2)	Comments
All	10-400 MHz	61	0.16	10	ICNIRP, occupational limits
		28	0.073	2	ICNIRP general public limits
All	400-2000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$f/40$	ICNIRP, occupational limits
		$1.375f^{1/2}$	$0.0037f^{1/2}$	$f/200$	ICNIRP general public limits
All	2-300 GHz	137	0.36	50	ICNIRP, occupational limits
		61	0.16	10	ICNIRP general public limits *
WiMAX	2300 – 2800 3300 – 3800	137	0.36	50	ICNIRP, occupational limits
		61	0.16	10	ICNIRP general public limits *
		6	0.0016	0.1	Italy, Russia, Poland

*These values may also be used in the US because they are conservative. In the above formulae, f is indicated as in the frequency range column.

Table 4: : Exposure limits based on ICNIRP or more stringent regulation

4 COMPLIANCE ASSESSMENT METHOD

A calculation method has been chosen to simulate the compliance boundaries of the equipment under test. The compliance boundaries define a volume outside of which the exposure limits are respected.

The software used to simulate the compliance boundary for a set of given input powers is EMF Visual V3.0.

The calculation method of the software is presented in [1]. This method is compliant with European standard EN50383 ref [1]. The validation of the calculation method is presented in appendix B and document [4].

As a matter of fact, consider these compliance boundaries as a true valid simulation result that can be subject to variations considering the surrounding electromagnetic environment.

5 REFERENCES USED FOR COMPLIANCE BOUNDARIES

Here are given the synthetic results in terms of compliance boundaries of the equipment under test.

5.1 Compliance boundaries

Compliance boundaries must be defined accurately. For the antenna types defined in table 2, the compliance boundary is defined as a parallelepiped. The parallelepiped is described by D front, D rear, D side, D up and D down. As recommended in ref [1], the center of the parallelepiped is the center of the antenna. Distance from the nearest point of the antenna is also provided (in tables between brackets) because it is also convenient. More accurate 3D pattern can be provided to customer upon request.

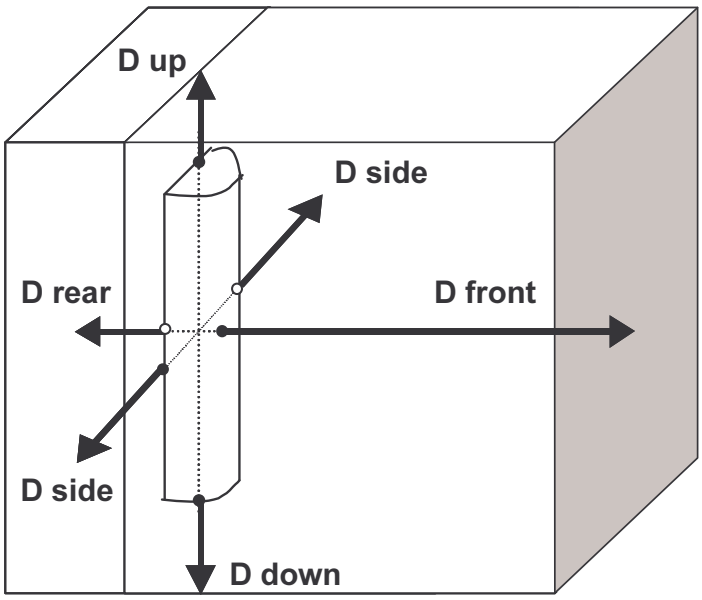


Figure 2: description of compliance distances in a parallelepiped shape

Then, for each of the exposure limits provided in table 4 and for the given transmitted power, the results will be presented in a table giving each compliance distance. If any compliance distance is below its related offset, it means that for this direction compliance touch is achieved.

5.2 Compliance boundaries of the equipment under test

For a maximum transmitted power of 41 dBm, the simulations have also been made at 2.5 GHz and 3.5 GHz band separately. Since there was no difference in this analysis for D front, D rear, D side, D up and D down at those frequencies, only central frequencies have been investigated.

Note: All the distances given in the report are in meters unless specific information is provided.

5.2.1 Compliance Distances for W4A25-90ANV adaptive antenna

5.2.1.1 ICNIRP general public exposure limits

Total transmitted power	dBm	41			
	[W]	13			
Scanning Angle (SA)		0°	15°	40°	Total
D Front [m]		3.3 (3.2)	2.3 (2.2)	1.1 (1.0)	3.3 (3.2)
D Up [m]		0.6 (0.1)	0.6 (0.1)	0.6 (0.1)	0.6 (0.1)
D Down [m]		0.6 (0.1)	0.6 (0.1)	0.6 (0.1)	0.6 (0.1)
D Side [m]		0.4 (0.3)	0.8 (0.7)	1.0 (0.9)	1.0 (0.9)

Note 1: Input power of each feeder is 35 dBm, so for the configuration of 4 feeders, the total transmitted power is 41 dBm.

Note 2: Distance from the nearest point of the antenna is provided between brackets.
* indicates that the compliance distance corresponds to the physical dimension of the antenna.

Table 5: Compliance Distances (CD) for W4A25-90ANV adaptive antenna considering ICNIRP general public exposure limits

5.2.1.2 ICNIRP occupational exposure limits

Total transmitted power	dBm	41			
	[W]	13			
Scanning Angle (SA)		0°	15°	40°	Total
D Front [m]		0.4 (0.3)	0.3 (0.2)	0.2 (0.1)	0.4 (0.3)
D Up [m]		0.5* (0)	0.5* (0)	0.5* (0)	0.5* (0)
D Down [m]		0.5* (0)	0.5* (0)	0.5* (0)	0.5* (0)
D Side [m]		0.1* (0)	0.1* (0)	0.2 (0.1)	0.2 (0.1)

Note 1: Input power of each feeder is 35dBm, so for the configuration of 4 feeders, the total transmitted power is 41dBm.

Note 2: Distance from the nearest point of the antenna is provided between brackets.
* indicates that the compliance distance corresponds to the physical dimension of the antenna.

Table 6 : Compliance Distances (CD) for W4A25-90ANV adaptive antenna considering ICNIRP occupational exposure limits

5.2.1.3 Italy, Russia, Poland exposure limits

Total transmitted power	dBm	41			
	[W]	13			
Scanning Angle (SA)		0°	15°	40°	Total
D Front [m]		39.1 (39)	31.1 (31)	22.2 (22.1)	39.1 (39)
D Up [m]		2.3 (1.8)	1.7 (1.2)	1.3 (0.8)	2.3 (1.8)
D Down [m]		2.3 (1.8)	1.7 (1.2)	1.3 (0.8)	2.3 (1.8)
D Side [m]		5.5 (5.4)	13.5 (13.4)	18.6 (18.5)	18.6 (18.5)

Note 1: Input power of each feeder is 35dBm, so for the configuration of 4 feeders, the total transmitted power is 41dBm.

Note 2: Distance from the nearest point of the antenna is provided between brackets.
* indicates that the compliance distance corresponds to the physical dimension of the antenna.

Table 7: Compliance Distances (CD) for W4A25-90ANV adaptive antenna considering Italy, Russia, Poland exposure limits

5.2.2 Compliance Distances for W4A35-90ANV adaptive antenna

5.2.2.1 ICNIRP general public exposure limits

Total transmitted power	dBm	41			
	[W]	13			
Scanning Angle (SA)		0°	15°	40°	Total
D Front [m]		3.7 (3.6)	2.8 (2.7)	1.9 (1.8)	3.7 (3.6)
D Up [m]		0.5 (0.1)	0.5 (0.1)	0.5 (0.1)	0.5 (0.1)
D Down [m]		0.5 (0.1)	0.5 (0.1)	0.5 (0.1)	0.5 (0.1)
D Side [m]		0.5 (0.4)	1.1 (1.0)	1.6 (1.5)	1.6 (1.5)

Note 1: Input power of each feeder is 35dBm, so for the configuration of 4 feeders, the total transmitted power is 41dBm.

Note 2: Distance from the nearest point of the antenna is provided between brackets.
* indicates that the compliance distance corresponds to the physical dimension of the antenna.

Table 8: Compliance Distances (CD) for W4A35-90ANV adaptive antenna considering ICNIRP general public exposure limits

5.2.2.2 ICNIRP occupational exposure limits

Total transmitted power	dBm	41			
	[W]	13			
Scanning Angle (SA)		0°	15°	40°	Total
D Front [m]		0.9 (0.8)	0.5 (0.4)	0.3 (0.2)	0.9 (0.8)
D Up [m]		0.4* (0)	0.4* (0)	0.4* (0)	0.4* (0)
D Down [m]		0.4* (0)	0.4* (0)	0.4* (0)	0.4* (0)
D Side [m]		0.1* (0)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)

Note 1: Input power of each feeder is 35dBm, so for the configuration of 4 feeders, the total transmitted power is 41dBm.

Note 2: Distance from the nearest point of the antenna is provided between brackets.
* indicates that the compliance distance corresponds to the physical dimension of the antenna.

Table 9: Compliance Distances (CD) for W4A35-90ANV adaptive antenna considering ICNIRP occupational exposure limits

5.2.2.3 Italy, Russia, Poland exposure limits

Total transmitted power	dBm	41			
	[W]	13			
Scanning Angle (SA)		0°	15°	40°	Total
D Front [m]		39.6 (39.5)	31.1 (31)	21.7 (21.6)	39.6 (39.5)
D Up [m]		2.3 (1.9)	1.7 (1.3)	(1.3) 0.9	2.3 (1.9)
D Down [m]		2.3 (1.9)	1.7 (1.3)	(1.3) 0.9	2.3 (1.9)
D Side [m]		5.4 (5.3)	13.5 (13.4)	19.0 (18.9)	19.0 (18.9)

Note 1: Input power of each feeder is 35dBm, so for the configuration of 4 feeders, the total transmitted power is 41dBm.

Note 2: Distance from the nearest point of the antenna is provided between brackets.
* indicates that the compliance distance corresponds to the physical dimension of the antenna.

Table 10: Compliance Distances (CD) for W4A35-90ANV adaptive antenna considering Italy, Russia, Poland exposure limits

6. INSTALLATION INSTRUCTIONS

This equipment must be installed according to EN50400 and EN50401, which may require modifications of compliance boundaries according to the possible surrounding RF emitters or perturbators.

This equipment is a radio transmitter emitting EM fields which may exceed exposure limits when a person is inside the compliance boundary. Do not enter the compliance boundary when the equipment is emitting. Make sure that the general public has no access inside that boundary. If necessary, place warning labels and marking signs. If the equipment has no warning labels, compliance assessment results have shown that it can be touched without infringing exposure limits. However, it is still recommended to place it out of reach. If the equipment is wearing radio label, please refer to the installation guide which defines the compliance boundary. If people may access this compliance boundary, it is recommended to place access restrictions (plastic chains on little pylon) and warning signs such as ”this equipment is emitting electromagnetic waves, do not stay inside the marked out area”.

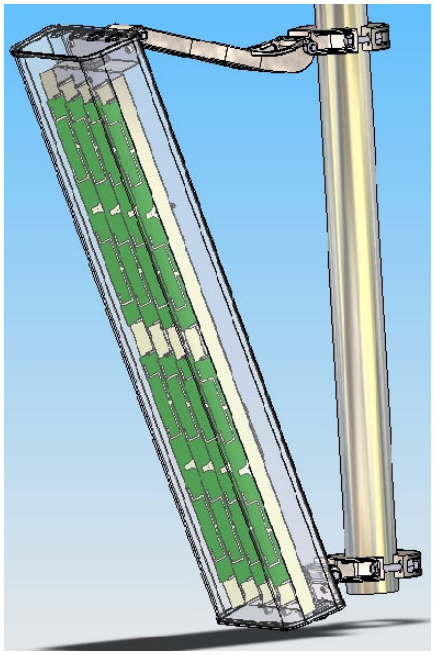
If you need to operate or perform installation or maintenance procedures within the compliance boundary, make sure that all transmitters in the area are switched off, or contact the operator to switch off emissions. The installation engineer needs to be aware of the potential risk and how to protect him/ herself against EM fields. Workers exposure should comply with local regulation, and the European Directive 2004/40/EC “EMF at work” [6].

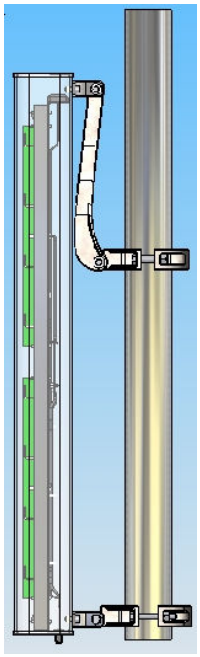
7. GLOSSARY AND ABBREVIATIONS

BS	:	Base Station
CB	:	Compliance Boundaries
CD	:	Compliance Distance
CENELEC	:	Comité Européen de Normalisation Electrotechnique
CT	:	Compliance Touch
EME	:	Electromagnetic Environment
EMF	:	Electromagnetic Field
ICNIRP	:	International Commission on Non-Ionizing Radiation Protection
RF	:	Radio Frequency
R_0	:	Boresight compliance distance
Rx	:	Receiver
SA	:	Scanning Angle
SAR	:	Specific Absorption Rate (expressed in W/kg)
TRX	:	Transceiver
Tx	:	Transmitter
WHO	:	World Health Organization
WiMAX	:	Worldwide Interoperability for Microwave Access

APPENDIX A: RFS WIMAX BASE STATION ANTENNA

A.1. RFS : W4A25-90ANV - WiMAX Antenna Array, 2.3-2.7 GHz, Vertical Polarized





Preliminary Technical Data Sheet		W4A25-90ANV
Wimax Antenna Array	2.4-2.7 GHz	Vertical Polarised

Electrical Specification	W4A25-90ANV		
Frequency Range (GHz) :	2.4-2.7		
Polarisation :	V		
Vertical 3dB Beamwidth :	6.5°		
Gain (dBi) :	>21.5	(SA0)	
	>20	(SA20)	
	>18.5	(SA40)	
Horizontal 3dB Beamwidth :	90°	(Single Element)	
	22°	(SA0)	
	<30°	(SA20)	
	<35°	(SA40)	
Horizontal side lobes suppression (dB) :	22	(SA0)	*(With half power on outer elements)*
	18	(SA15)	
Cross Polar Discrim. (dB) :	>25	(SA0)	
	>22	(SA40)	
VSWR / Return Loss, min. (dB) :	1.38/16		
Front to Back Ratio (dB) :	>30		
Inter Port Isolation (dB) :	>20		
Input power rating (W) :	50		
Array Columns Separation (Wave Lenght) :	0.55		

SA0, SA15, SA20, SA40 : Scanning Angles : 0°, 15°, 20° and 40°.

Mechanical Specification	W4A25-90ANV
Dimensions (mm) :	1100x320x130
Net Weight approx. (Kg)	9.5
Mechanical Tilt :	0 up to 15°
Radome Material :	UV-resistant Fiber-glas
Survival Wind Speed	250 Km/h
Connector :	N-Female (50Ω)

Options	W4A35-90ANV
Connector :	7-16 Female

Note: This antenne will be redesigned to cover the full band 2.3 – 2.7 GHz and the performances will be identical.

Figure 3: Detailed description of W4A25-90ANV Antenna

A.2. RFS : W4A35-90ANV - WiMAX Antenna Array, 3.4-3.6 GHz, Vertical Polarized

Preliminary Technical Data Sheet		W4A35-90ANV
Wimax Antenna Array	3.4-3.6 GHz	Vertical Polarised

Electrical Specification	W4A35-90ANV		
Frequency Range (GHz) :	3.4-3.6		
Polarisation :	V		
Vertical 3dB Beamwidth :	6.5°		
Gain (dBi) :	>21.5	(SA0)	
	>20	(SA20)	
	>18.5	(SA40)	
Horizontal 3dB Beamwidth :	90°	(Single Element)	
	22°	(SA0)	
	<30°	(SA20)	
	<35°	(SA40)	
Horizontal side lobes suppression (dB) :	22	(SA0)	*(With half power on outer elements)*
	18	(SA15)	
Cross Polar Discrim. (dB) :	>25	(SA0)	
	>22	(SA40)	
VSWR / Return Loss, min. (dB) :	1.38/16		
Front to Back Ratio (dB) :	>30		
Inter Port Isolation (dB) :	>20		
Input power rating (W) :	50		
Array Columns Separation (Wave Lenght) :	0.55		

SA0, SA15, SA20, SA40 : Scanning Angles : 0°, 15°, 20° and 40°.

Mechanical Specification	W4A35-90ANV
Dimensions (mm) :	820x320x120
Net Weight approx. (Kg)	9.5
Mechanical Tilt :	0 up to 15°
Radome Material :	UV-resistant Fiber-Glass
Survival Wind Speed	250 Km/h
Connector :	N-Female (50Ω)

Options	W4A35-90ANV
Connector :	7-16 Female

Figure 4 : Detailed description of W4A35-90ANV Antenna

APPENDIX B: VALIDATION RESULTS OF ANTENNA MODEL

B.1. Characteristics of antenna W4A25-90ANV (2.5GHz) at its verification in EMF Visual

Characteristics of antenna	Gain	Horizontal 3dB Beamwidth	Vertical 3dB Beamwidth
Value EMF Visual	21.6 dBi	22°	7°
Value Datasheet	21.5 dBi	22°	6.5°
Variation	0.1 dB	0°	0.5°

Table 11: Verification of characteristics of antenna W4A25-90ANV in EMF Visual

Characteristics of antenna	Scanning Angle	Gain (SA15)	Horizontal 3dB Beamwidth (SA15)	Vertical 3dB Beamwidth
Value EMF Visual	17°	19.8 dBi	35°	6.65°
Value Datasheet	15°	20 dBi	30°	6.5°
Variation	2°	0.2 dB	5°	0.15°
Note: In this research, it is considered that the datasheet value of SA20 is the same as that of SA15 which is authorized by EMF Visual.				

Table 12: Verification of characteristics of antenna W4A25-90ANV with SA 15°

Characteristics of antenna	Scanning Angle	Gain (SA40)	Horizontal 3dB Beamwidth (SA40)	Vertical 3dB Beamwidth
Value EMF Visual	39.3°	18.5 dBi	34.6°	6.2°
Value Datasheet	40°	18.5 dBi	35°	6.5°
Variation	0.7°	0 dB	0.4°	0.3°
Note: Because of the limit of the software, firstly an antenna model with a scanning angle of 35° is obtained, and then another 5° is added by rotating it.				

Table 13: Verification of characteristics of antenna W4A25-90ANV with SA 40°

B.2. Characteristics of antenna W4A35-90ANV (3.5GHz) at its verification in EMF Visual

Characteristics of antenna	Gain	Horizontal 3dB Beamwidth	Vertical 3dB Beamwidth
Value EMF Visual	21.6 dBi	22°	6.48°
Value Datasheet	21.5 dBi	21°	6.5°
Variation	0.1 dB	1°	0.02°

Table 14: Verification of characteristics of antenna W4A35-90ANV in EMF Visual

Characteristics of antenna	Scanning Angle	Gain (SA15)	Horizontal 3dB Beamwidth (SA15)	Vertical 3dB Beamwidth
Value EMF Visual	17.2°	19.8 dBi	35°	6.9°
Value Datasheet	15°	20 dBi	30°	6.5°
Variation	2.2°	0.2 dB	5°	0.4°
Note: In this research, it is considered that the datasheet value of SA20 is the same as that of SA15 which is authorized by EMF Visual.				

Table 15: Verification of characteristics of antenna W4A35-90ANV with SA 15°

Characteristics of antenna	Scanning Angle	Gain (SA40)	Horizontal 3dB Beamwidth (SA40)	Vertical 3dB Beamwidth
Value EMF Visual	40.4°	18.4 dBi	37°	6.4°
Value Datasheet	40°	18.5 dBi	35°	6.5°
Variation	0.4°	0.1 dB	2°	0.1°
Note: Because of the limit of the software, firstly an antenna model with a scanning angle of 35° is obtained, and then another 5° is added by rotating it.				

Table 16: Verification of characteristics of antenna W4A35-90ANV with SA 40°

APPENDIX C: VISUALIZED SIMULATION RESULTS

C.1. Visualized Compliance Distances for W4A25-90ANV adaptive antenna (2.5 GHz)

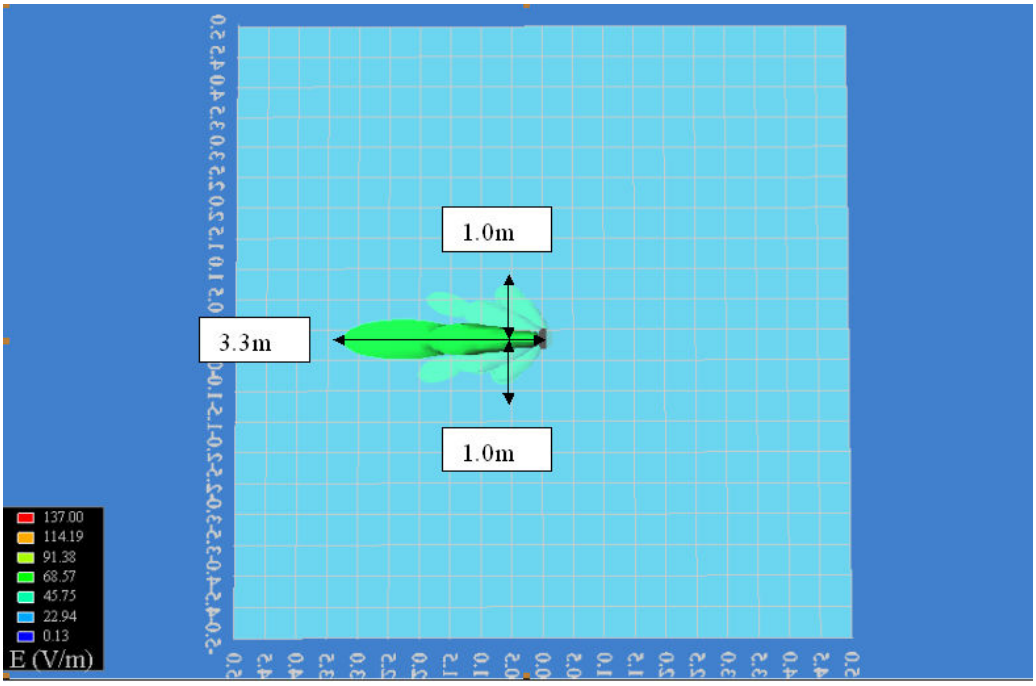


Figure 5: Compliance Distances (CD) for W4A25-90ANV adaptive antenna considering ICNIRP general public exposure limits

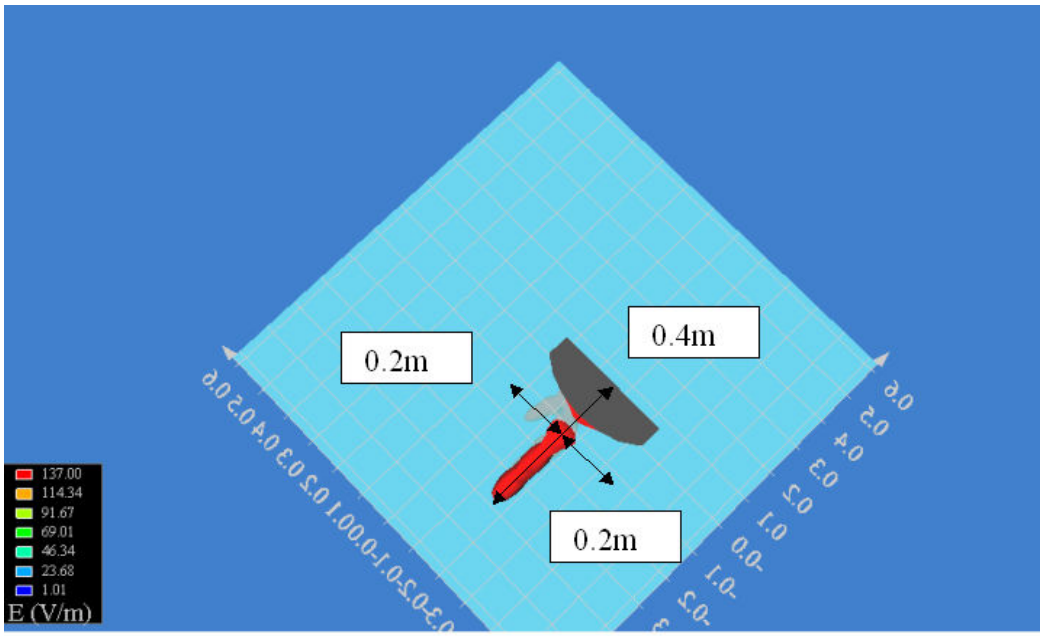


Figure 6: Compliance Distances (CD) for W4A25-90ANV adaptive antenna considering ICNIRP occupational exposure limits

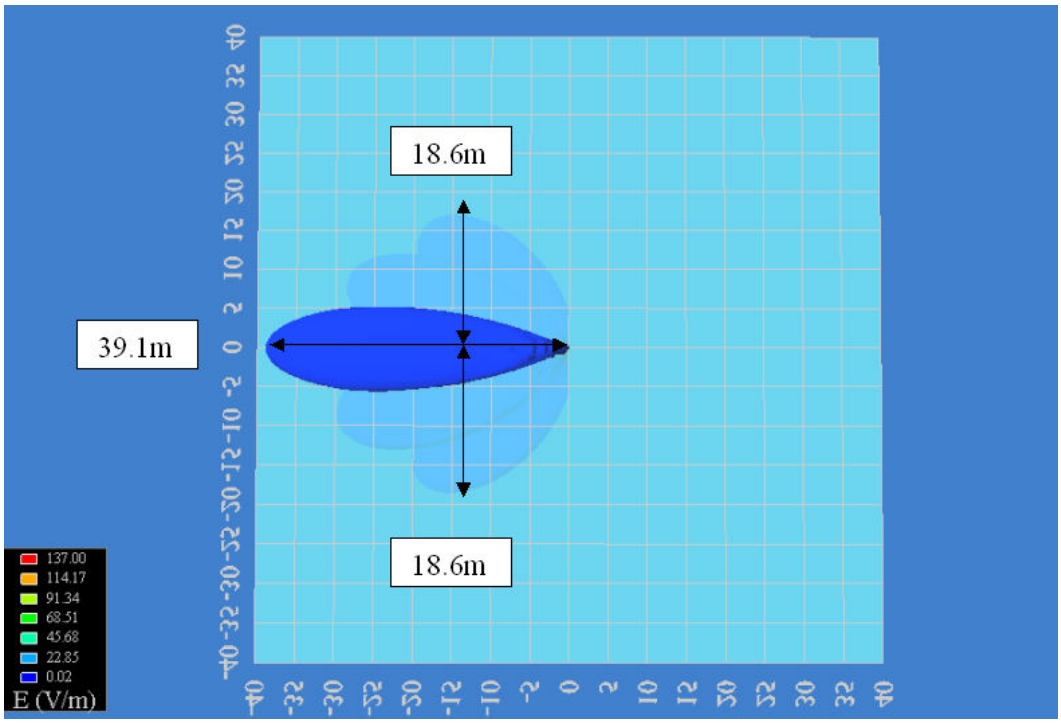


Figure 7 : Compliance Distances (CD) for W4A25-90ANV adaptive antenna considering Italy, Russia, Poland exposure limits

C.2. Visualized Compliance Distances for W4A35-90ANV adaptive antenna (3.5 GHz)

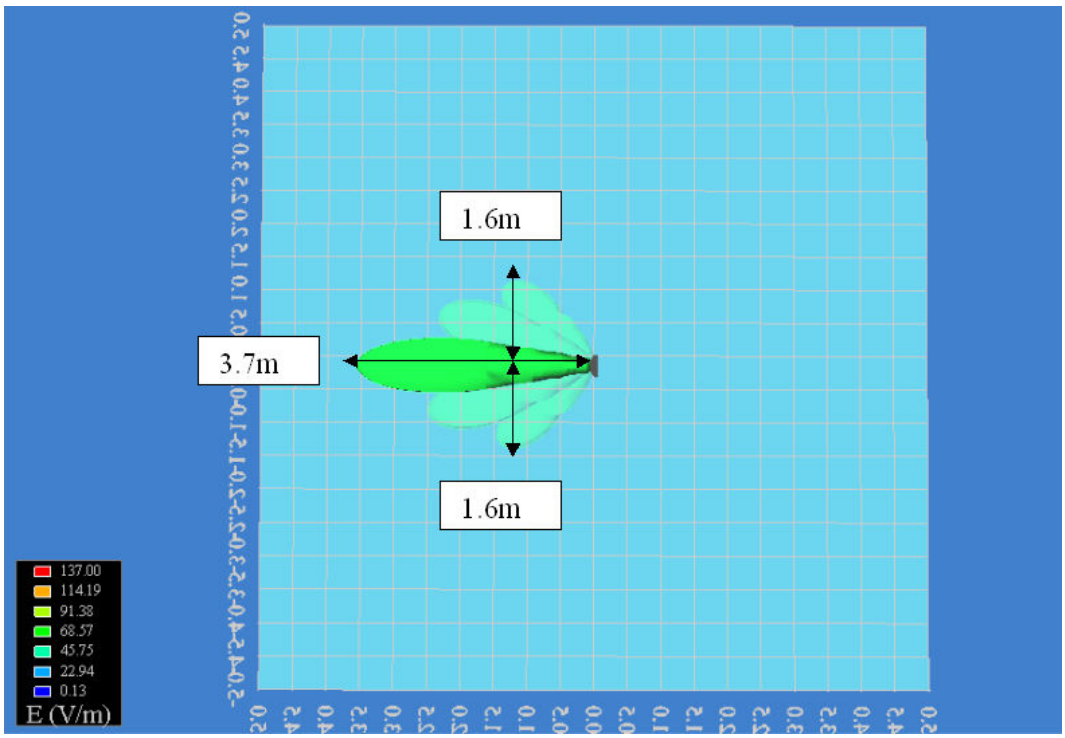


Figure 8 : Compliance Distances (CD) for W4A35-90ANV adaptive antenna considering ICNIRP general public exposure limits

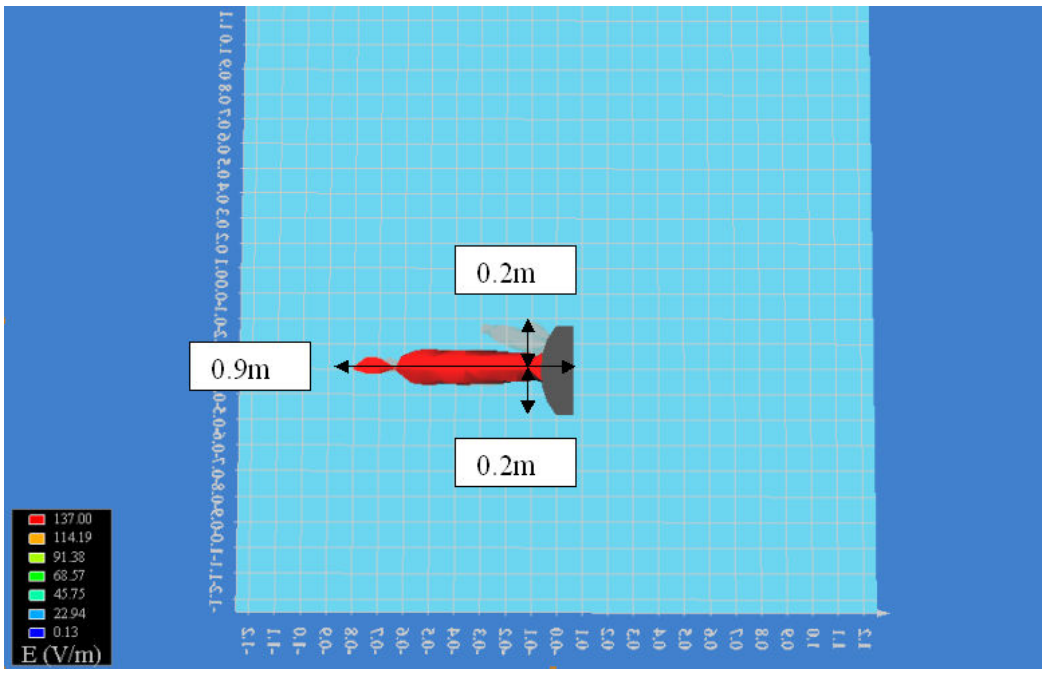


Figure 9: Compliance Distances (CD) for W4A35-90ANV adaptive antenna considering ICNIRP occupational exposure limits

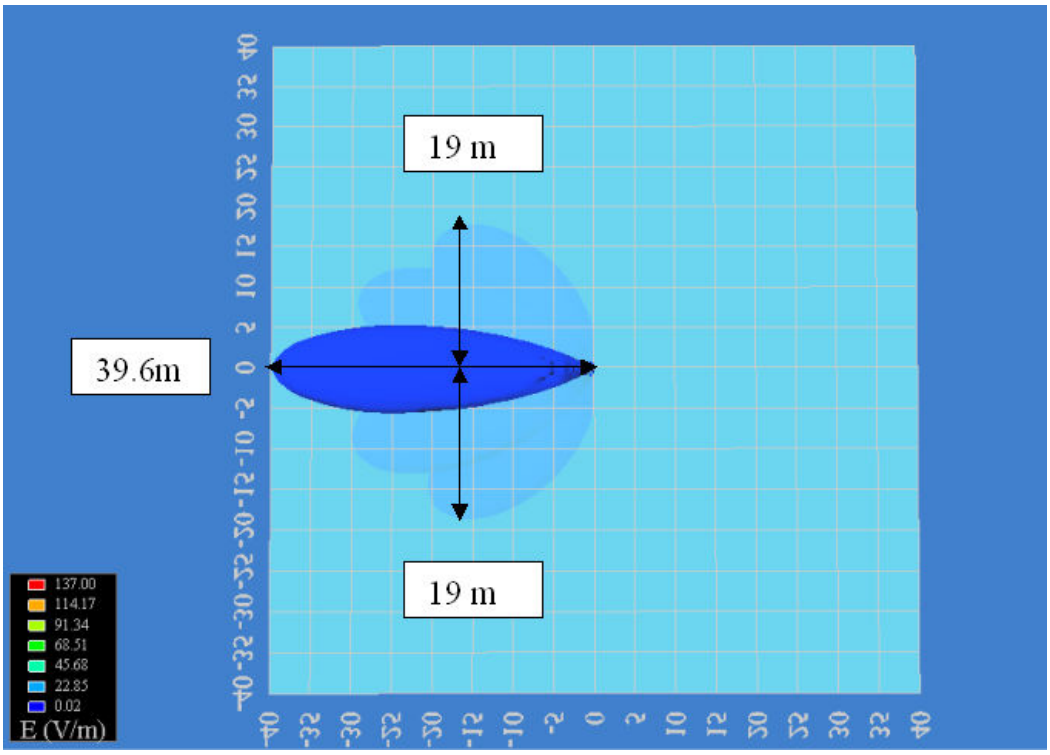


Figure 10: Compliance Distances (CD) for W4A35-90ANV adaptive antenna considering Italy, Russia, Poland exposure limits