



# ECC Report **276**

Thresholds for the coordination of CDMA and LTE  
broadband systems in the 400 MHz band

**27 April 2018**

**0 EXECUTIVE SUMMARY**

This Report provides technical background for cross-border coordination of systems with channel spacing greater than 1 MHz (hereafter called wideband systems) in the 400 MHz band (410-430 MHz and 450-470 MHz) and proposes a method for bilateral or multilateral agreements that allow for higher cross-border coordination thresholds for wideband systems in the 400 MHz band in situations where no or some overlap (of few hundred kHz) of narrowband and wideband assignments across the border occurs. The new coordination levels are derived from the typical signal level of narrowband preferential use for the provision of border coverage and from existing coordination thresholds of narrowband preferential use to avoid harmful interference in the border area. Two known Preferential regimes for narrowband systems were considered, both defined as the field strength threshold of 20 dB  $\mu$ V/m at 10 m height in 25 kHz at a distance inside the neighbouring country: Preferential Regime a) at 40 km and Preferential Regime b) at 50 km distance. In case of full overlap of wideband allocations of both sides of the border existing ECC Recommendations for other frequency bands were adopted.

Recommendation T/R 25-08 [1] defines frequency band-dependent indicative coordination thresholds to avoid harmful interference between stations located in neighbouring countries. . However, these thresholds are too restrictive for the provision of coverage in border areas so for narrowband systems shared spectrum arrangements based on preferential use of channels are concluded between neighbouring countries (preferential narrowband usage) in bilateral and multilateral agreements. Preferential arrangements for wideband systems, similar to narrowband arrangements, seem not to be practical.

In the case of wideband vs. wideband scenario (no-overlap between narrowband and wideband assignments), the following table shows the proposed coordination threshold values for wideband systems:

**Table 1: Trigger values of field strength (dB $\mu$ V/m /5 MHz) at a height of 3 m above ground for FDD LTE/CDMA systems, in the case of no overlap between narrowband and wideband assignments**

	Non-Preferential frequency usage		
	Centre frequencies aligned		Centre frequencies not aligned
	Preferential codes	Non-preferential codes	All codes
LTE vs. LTE or CDMA vs. CDMA	55 dB $\mu$ V/m @0km 37 dB $\mu$ V/m @10km	37 dB $\mu$ V/m @0km	55 dB $\mu$ V/m @0km 37 dB $\mu$ V/m @10km
LTE vs. CDMA	55 dB $\mu$ V/m @0km 37 dB $\mu$ V/m @10km		

Note: @ stands for "at a distance inside the neighbouring country".

The proposed new coordination thresholds for a partial overlap of few hundred kHz between narrowband and wideband assignments across the borders are:

- a) Preferential threshold at 40 km distance inside the neighbouring country
  - Preferential Regime for narrowband systems i.e. 20 dB $\mu$ V/m at 10 m height in 25 kHz at 40 km inside the neighbouring country
  - 25 dB $\mu$ V/m at 3 m height in 25 kHz at the borderline for wideband systems
- b) Preferential threshold at 50 km distance inside the neighbouring country

- Preferential Regime for narrowband systems i.e. 20 dB $\mu$ V/m at 10 m height in 25 kHz at 50 km inside the neighbouring country
- 32 dB $\mu$ V/m at 3 m height in 25 kHz at the borderline for wideband systems.

The threshold values provided in this Report are for a time probability of 10 % and a location probability of 50%.

This Report does not cover the case of full overlap between wideband and narrowband allocations and the threshold for the secondary borderline in the case of wideband vs narrowband scenario. Cases of local coverage of narrowband systems using preferential rights far away from the borderline are also not covered in this Report. Specific deployments of narrowband systems in the narrowband and wideband overlap areas in which preferential usage rights of narrowband systems are not fully executed are not considered in this Report.

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## LIST OF ABBREVIATIONS AND SYMBOLS

<b>Abbreviation</b>	<b>Explanation</b>
<b>BS</b>	Base Station
<b>CDMA</b>	Code Division Multiple Access
<b>C/I</b>	Carrier to Interference ratio
<b>D</b>	Distance
<b>DL</b>	Downlink
<b>ECC</b>	Electronic Communications Committee
<b>ECC/REC</b>	ECC Recommendation
<b>E<sub>5MHz</sub></b>	Electrical Field Strength in 5MHz bandwidth
<b>E<sub>25kHz</sub></b>	Electrical Field Strength in 25kHz bandwidth
<b>E<sub>700MHz (5MHz) 6km</sub></b>	Electrical Field Strength at 700MHz, in 5MHz bandwidth, at 6km distance inside the neighbouring country
<b>E<sub>NB, 40 km</sub></b>	Electrical Field Strength at 40km distance inside the neighbouring country emitted by narrowband system
<b>E<sub>NB, border</sub></b>	Electrical Field Strength at the border emitted by narrowband system
<b>E<sub>WB, border</sub></b>	Electrical Field Strength at the border emitted by wideband system
<b>e.i.r.p.</b>	Equivalent Isotropically Radiated Power
<b>ETSI</b>	European Telecommunications Standards Institute
<b>FDD</b>	Frequency Division Duplex
<b>hB</b>	Antenna height of base station radio site
<b>hM</b>	Antenna height of mobile station
<b>LTE</b>	Long Term Evolution
<b>MCL</b>	Minimum Coupling Loss
<b>MS</b>	Mobile Station
<b>NB</b>	Narrowband
<b>OFDMA</b>	Orthogonal Frequency Division Multiple Access
<b>PCI</b>	Physical-layer Cell Identities
<b>PL</b>	Path loss
<b>PMR</b>	Professional Mobile Radio
<b>PN</b>	Pseudo-Noise
<b>P<sub>NB, border</sub></b>	Power at the border emitted by narrowband system
<b>UL</b>	Uplink
<b>WB</b>	Wideband

## 1 INTRODUCTION

Land mobile systems with various channel spacing schemes have been deployed or are planned in the 400 MHz bands. The frequency usage in border areas requires coordination of frequency channels to provide coverage at the border areas and to avoid interference. For systems with channel spacing up to 25 kHz there are well established bilateral or multilateral agreements based on preferential use of frequencies. In the known agreements the threshold for preferential frequencies field strength is defined either at 40 km or 50 km distance inside the neighbouring country.

For wideband systems with channel spacing greater than 1 MHz a preferential regime based on preferential channels is generally not possible. However, in situations where on both sides of the border only wideband systems are considered the coordination threshold can be increased in comparison to the value of Recommendation T/R 25-08 as given in ECC Report 97 [6] or ECC Recommendation (15)01 [4]. This is because wideband systems are generally more immune to interference.

This Report considers the coordination thresholds for systems with channel spacing greater than 1 MHz in the 400 MHz band on both sides of the border. In addition, a case of narrowband systems on one side of the border overlapping with wideband systems on the other side of the border is considered, because those scenarios occur very often.

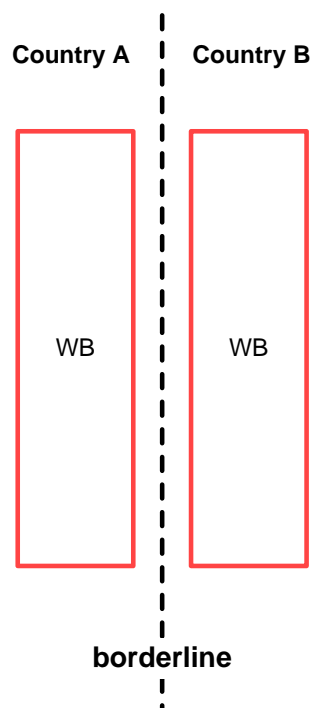
The first case of harmonised use of spectrum for wideband systems is not very likely to be achieved in the short term, because wideband assignments differ from country to country, in location, in spectrum, and size. Only in exceptional cases are the wideband allocations the same in border areas of neighbouring countries (e.g. Sweden and Norway).

Even if in most cases wideband allocations vary among different countries, the resulting overlap between wideband and narrowband allocations across the border is typically as small as a few hundred kilohertz (below 500 kHz). This means that in such cases only a few narrowband preferential channels have to be considered vis-a-vis wideband allocation on the other side of the border.

All path loss calculations in this study have been performed using the modified Okumura-Hata model (ERC Report 68, [8]). This model is also applied for antenna height correction factor in the 400 MHz band. Administrations may agree in bilateral or multilateral negotiations on other propagation models which could lead to slightly different results. However, for all calculations only one model shall be applied in order to avoid systematic errors.

## 2 COORDINATION BETWEEN SYSTEMS WITH CHANNEL BANDWIDTH GREATER THAN 1 MHz

This section provides an analysis of the coordination threshold for wideband systems in the 400 MHz band assuming that on both sides of the border either Orthogonal Frequency Division Multiple Access (OFDMA) or Code Division Multiple Access (CDMA) based systems are used, see Figure 1.



**Figure 1: Overlapping wideband assignments across the border**

This analysis is based on ECC Recommendation (16)03 [5], ECC Recommendation (15)01 [4] and ECC Recommendation (11)04 [3] which define trigger values for this case. The trigger value in the 700 MHz band is defined as  $E_{700\text{MHz}(5\text{MHz})} = 59 \text{ dB}\mu\text{V/m}$  in 5 MHz at a height of 3 m above ground level at the borderline. In cases where the centre frequencies are aligned, the whole wideband frequency spectrum in a band can be used in a manner that codes are shared between neighbouring countries, i.e. preferential and non-preferential codes are applied. This also means that preferential codes assigned to one country may only be used by the neighbouring country at the lower trigger value.

**Table 2: Trigger values of field strength (dBµV/m /5 MHz) at a height of 3 m above ground for FDD LTE/CDMA systems**

	Non-Preferential frequency usage		
	Centre frequencies aligned		Centre frequencies not aligned
	Preferential PN codes/PCIs	Non-preferential PN codes/PCIs	All PN codes/PCIs
LTE vs. LTE or CDMA vs. CDMA	55 dBµV/m @0km 37 dBµV/m @10km	37 dBµV/m @0km	55 dBµV/m @0km 37 dBµV/m @10km
LTE vs. CDMA	55 dBµV/m @0km 37 dBµV/m @10km		

Note: @ stands for “at a distance inside the neighbouring country”.

In addition to the value at the borderline, a threshold of the field strength level of  $E_{700\text{MHz} (5\text{MHz}) 6\text{km}} = 41 \text{ dB}\mu\text{V/m/5 MHz}$  at a height of 3 m above ground level is defined at a distance of 6 km inside the neighbouring country. The distance for the secondary line for the 400 MHz case should be increased from 6 km to 10 km taking into account the same propagation loss due to different frequency bands. These general coordination levels depend on the power density only and therefore can be applied for different technologies with regard to the modulation and coding schemes (OFDMA or CDMA).

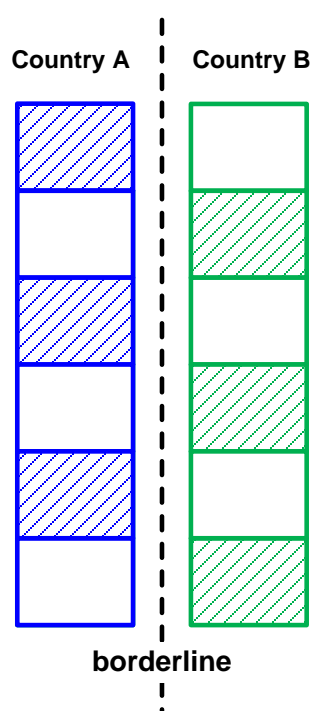
Applying the 700 MHz and 800 MHz approaches ([3], [4], [5]), the trigger values ( $E_{5\text{MHz}}$ ) for 5 MHz systems at the borderline in the 400 MHz band can be derived. The trigger level  $E_{5\text{MHz}} = 59 \text{ dB}\mu\text{V/m} + 20 \cdot \log_{10}(450/700 \text{ MHz}) \cong 55 \text{ dB}\mu\text{V/m/5 MHz}$ , where  $20 \cdot \log_{10}(450/700 \text{ MHz})$  is for the frequency conversion factor. The recalculation of this trigger value into the field strength within a 25 kHz channel using the bandwidth correction factor yields  $E_{25\text{kHz}} = 55 \text{ dB}\mu\text{V/m} + 10 \cdot \log_{10}(25/5000 \text{ MHz}) \cong 32 \text{ dB}\mu\text{V/m/25 kHz}$  at a height of 3 m above ground level.



### 3 COORDINATION OF SYSTEMS WITH PREFERENTIAL CHANNELS UP TO 25 KHZ WITH SYSTEMS OPERATING CHANNELS GREATER THAN 1 MHZ

This section considers cross-border co-existence between narrowband and wideband systems in the frequency overlap area i.e. in typically small frequency bandwidths where a wideband allocation in one country overlap with a narrowband allocation in a neighbouring country. For narrowband systems preferential channels are considered vis-a-vis a system with channel spacing greater than 1 MHz.

The preferential regime for narrowband systems in the 400 MHz band was developed for the provision of coverage in border areas. Bilateral and multilateral agreements define frequency channels with preferential usage rights (higher field strength) to provide good coverage in border areas. The whole available spectrum is divided into preferential frequency blocks as shown in Figure 2 for a two country case. Green and blue blocks represent alternating allocation of preferential frequency usage rights between country A (blue) and B (green).



**Figure 2: Current channel arrangements at border areas (preferential channels are represented by blue blocks for country A and green blocks for country B)**

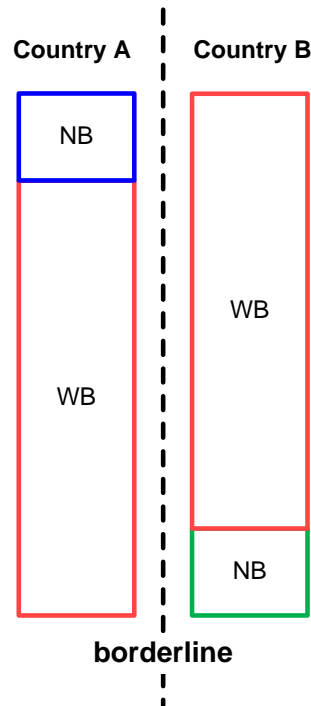
Each frequency block which consists of few narrowband channels is either defined as a preferential block for one country or another. In case where more countries have a joint border area (e.g. border areas where more than two countries are involved), the preferential usage rights are shared between all involved countries.

It is important to mention that the use of non-preferential channels is limited by the threshold value given in Recommendation T/R 25-08 which does not allow for useful coverage in border areas. Furthermore, the use of non-preferential channels is further limited due to the high field strength of preferential channels in the neighbouring country. It means that this sharing arrangement allows for the use of spectrum in border areas on preferential channels, but also provides higher interference power on the non-preferential channels.

Since the preferential frequency regime for systems with channel spacing greater than 1 MHz is neither frequency efficient nor generally applicable in the 400 MHz band, an alternative coordination method is required. In cases where wideband allocations in neighbouring countries do not have the same size or are not aligned (due to a lack of European harmonisation), there are some overlapping frequency ranges of

wideband allocations on one side of the border with allocations using channel bandwidths up to 25 kHz on the other side (see Figure 3).

Wideband allocations in the 400 MHz band in Europe are typically in the range of 3–5 MHz and the frequency offset between these allocations in neighbouring countries is rather small. Thus the overlapping ranges between wideband and narrowband allocations are typically only in the range of a few hundred kilohertz.



**Figure 3: Overlapping narrowband and wideband assignment across the border**

### 3.1 USE OF PREFERENTIAL FREQUENCIES

In this Report, the following typical Preferential Regimes for narrowband systems are considered:

- Preferential Regime a): the preferential frequency use is defined as a threshold of 20 dB $\mu$ V/m at a distance of 40 km behind the border, at 10 m height, in 25 kHz bandwidth;
- Preferential Regime b): the preferential frequency usage rights are defined as a threshold of 20 dB $\mu$ V/m at a distance of 50 km behind the border, at 10 m height, in 25 kHz bandwidth.

Historically, land mobile systems with smaller channel spacing were implemented earlier than wideband systems and some of them already enjoy preferential rights for the provision of border coverage, also in overlapping frequency ranges with wideband systems. On the other hand, wideband systems cannot provide any services in border areas if their operation is limited by the general coordination threshold as specified in [1].

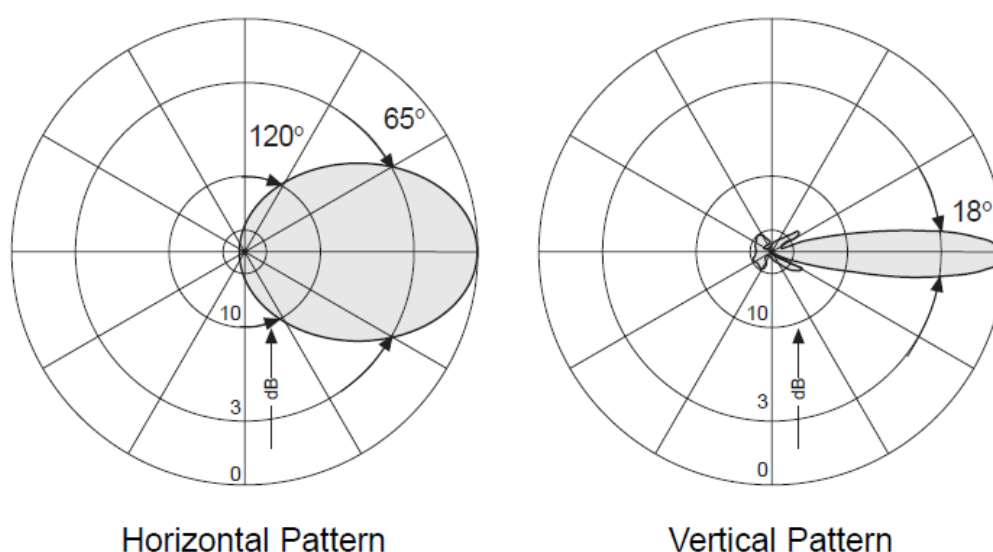
In this study, it is assumed that narrowband stations make use of the full potential of preferential usage rights for provision of the border coverage. This means that the interference level of 20 dB $\mu$ V/m at a distance of 40 km or 50 km (secondary line) will be achieved.

The common deployments of narrowband systems in the narrowband and wideband systems overlap areas in which preferential usage rights are not fully executed are not considered in this report. These are deployments which are not made for the coverage of border areas but rather for local area coverage (industry areas, harbours, airports, etc.) at a certain distance from the border and deployments of temporary use of mobile PMR/PMSE networks sometimes with low power/low tower base stations with usage up to the

border. For such cases, the protection ratio at the edge of the coverage has to be individually studied, case by case, in bilateral and multilateral agreements.

For the provision of border coverage narrowband base station deployments close to the border are necessary. Typical cell ranges of narrowband systems in the 400 MHz band vary between 3 km (urban areas) and 25 km (open areas). However, under the agreed preferential regime these ranges cannot always be achieved. The preferential regime condition defined as the field strength threshold at 40 km or 50 km inside the neighbouring country limits the effective radiated power towards the neighbouring country.

Therefore, in order to provide radio coverage in border areas, network operators usually deploy base stations close to the borderline using sector antennas that are directed away from the borderline. Such a deployment is recommended in Recommendation T/R 25-08. The coverage benefits from a relatively sharp field strength decrease provided by the directional antenna pattern (see Figure 4). The antenna directivity provides an improvement since the wanted power is radiated towards the intended area with high transmitter power and the unwanted radiation towards the neighbouring country which might cause interference is greatly reduced.



**Figure 4: Example of horizontal and vertical radiation pattern of a typical 400 MHz directional antenna (taken from Kathrein data sheet of 741 516, see <https://www.kathrein.com>)**

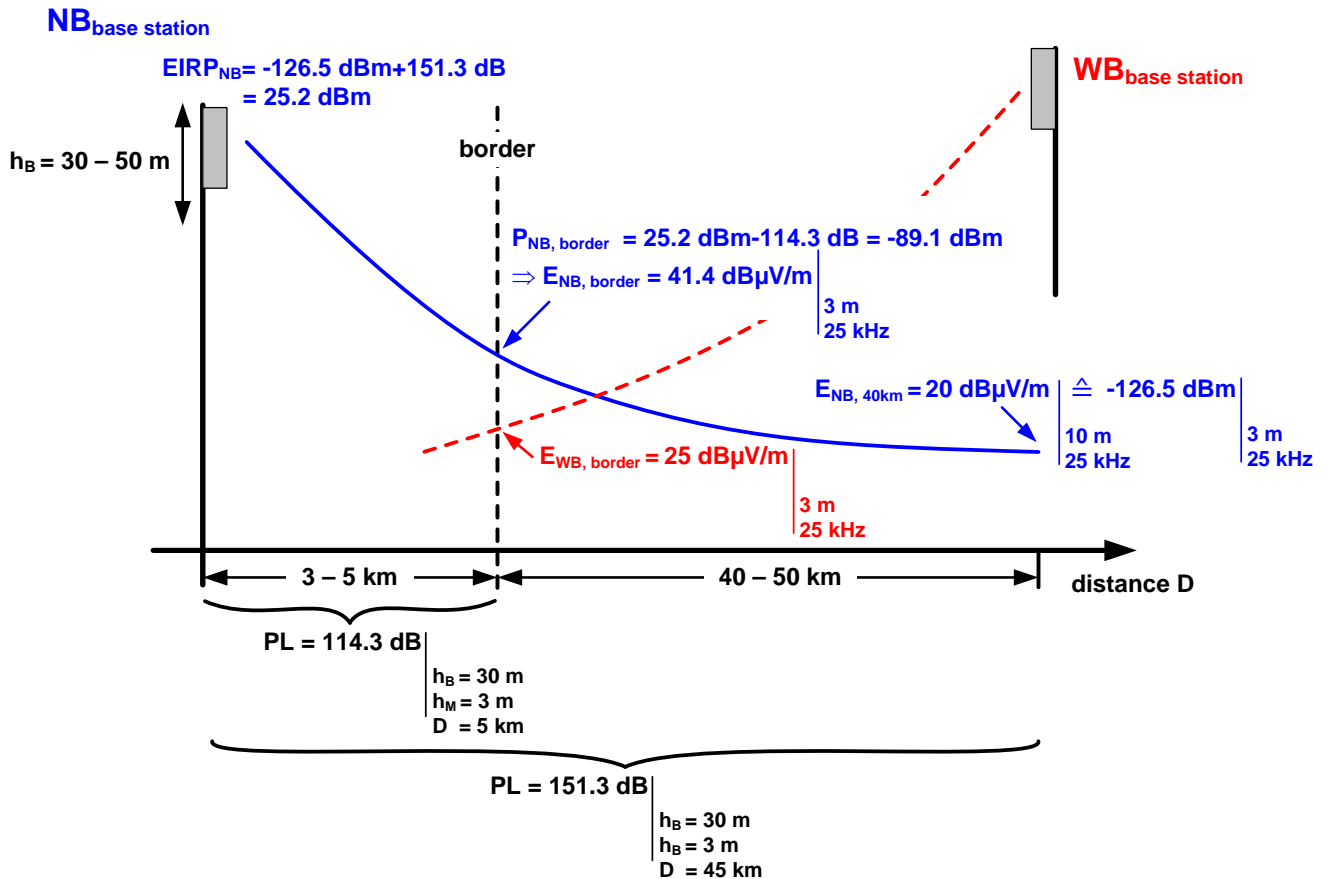
In order to study the co-existence of systems across the border, the field strength of the considered systems at the borderline has to be derived. If the co-existence is achieved at the borderline, it can be assumed that the co-existence is also achieved inside the country, since at a greater distance from the border, typically the wanted signal increases and the interference signal decreases.

In the overlapping range of wideband systems, the derived trigger value of the field strength in section 2, i.e.  $E_{25\text{kHz}} = 32 \text{ dB}\mu\text{V/m}$  at the border measured in 25 kHz at 3 m height, can be used. Lower trigger values providing a smaller impact on the systems in neighbouring country (the main impact is a capacity reduction) are also possible.

In order to compare the field strength of wideband systems with the field strength of preferential channels at the borderline, the preferential condition defined as a threshold at 40 km (Preferential Regime a)) or 50 km (Preferential Regime b)) distance inside the neighbouring country, the field strength of preferential channels have to be calculated at the borderline. This calculation depends on the distance from the border at which the threshold is defined, on the height of the base station antenna, on its distance from the border and on the propagation environment.

### 3.1.1 Preferential usage rights for provision of border coverage

The field strength at the borderline can be derived by applying the modified Okumura-Hata propagation model (ERC Report 68 [8]). The field strength calculation at the borderline method is depicted in Figure 5, with values given for a case where the threshold of the preferential frequency is defined at a 40 km line beyond the border and the base station antenna at 30 m height at 5 km from the border in an open area. The values for other cases are given in Table 3 to Table 6.



**Figure 5: Calculation of field strength of preferential channel at the borderline from the threshold defined in 40 – 50 km distance inside the neighbouring country (narrowband BS close to border) Pathloss values are calculated here for NB Base station at 5 km from the border, height 30 m, threshold of the preferential frequency at 40 km line**

The threshold at the defined distance determines the effective radiated power of the radio site operating on the preferential channel towards the borderline. This radiated power depends on the transmission power of the base station, cable losses, and antenna gain towards the borderline. This radiated power is used for the calculation of the field strength at the borderline under the condition that the threshold level at the defined distance is not exceeded.

In order to find general threshold values at the borderline for the wideband systems, the above described calculation was performed for typical base station heights between 30 m and 50 m, typical distances of narrowband systems from the border, various environments, and distances of the threshold for preferential frequencies. The following tables summarise the results of the calculation for typical cases (other base station antenna heights are considered in Annex 1).

**Table 3: Signal level of preferential channel at the borderline at 3 m height in 25 kHz band limited by the threshold 40 km behind the border for BS at 5 km distance**

Environment	BS height	Path loss at 45 km	Path loss at 5 km	e.i.r.p.	Signal level at 3 m in 25 kHz	
Unit	m	dB	dB	dBm	dBm	dB $\mu$ V/m
Open	30	151.3	114.3	25.2	-89.1	41.4
	40	148.9	112.0	22.8	-89.2	41.3
	50	146.0	110.2	19.9	-90.3	40.2
Suburban	30	169.0	132.0	42.9	-89.1	41.4
	40	166.0	129.7	39.9	-89.8	40.7
	50	163.6	127.9	37.5	-90.4	40.1
Urban	30	177.4	140.4	51.3	-89.1	41.4
	40	174.3	138.1	48.2	-89.9	40.6
	50	172.0	136.3	45.9	-90.4	40.1
<b>Average</b>					<b>-89.7</b>	<b>40.8</b>
<b>Variance</b>					<b>0.34</b>	

**Table 4: Signal level of preferential channel at the borderline at 3 m height in 25 kHz band limited by the threshold 40 km behind the border for BS at 3 km distance**

Environment	BS height	Path loss at 43 km	Path loss at 3 km	e.i.r.p.	Signal level at 3 m in 25 kHz	
Unit	m	dB	dB	dBm	dBm	dB $\mu$ V/m
Open	30	134.7	90.8	8.6	-82.3	48.2
	40	131.7	88.7	5.6	-83.1	47.4
	50	129.4	87.1	3.3	-83.8	46.7
Suburban	30	152.4	108.5	26.3	-82.3	48.2
	40	149.4	106.4	23.3	-83.1	47.4
	50	147.1	104.8	21.0	-83.8	46.7
Urban	30	160.7	116.9	34.6	-82.3	48.2
	40	157.7	114.8	31.6	-83.1	47.4
	50	155.4	113.1	29.3	-83.8	46.7
<b>Average</b>					<b>-83.1</b>	<b>47.4</b>
<b>Variance</b>					<b>0.46</b>	

**Table 5: Signal level of preferential channel at the borderline at 3 m height in 25 kHz band limited by the threshold 50 km behind the border for BS at 5 km distance**

Environment	BS height	Path loss at 55 km	Path loss at 5 km	e.i.r.p.	Signal level at 3 m in 25 kHz	
Unit	m	dB	dB	dBm	dBm	dB $\mu$ V/m
Open	30	155.7	114.3	29.6	-84.7	45.8
	40	152.6	112.0	26.5	-85.5	45.0
	50	150.3	110.2	24.2	-86.0	44.5
Suburban	30	173.4	132.0	47.3	-84.7	45.8
	40	170.3	129.7	44.2	-85.5	45.0
	50	168.0	127.9	41.9	-86.0	44.5
Urban	30	181.8	140.4	55.7	-84.7	45.8
	40	178.7	138.1	52.6	-85.5	45.0
	50	176.4	136.3	50.3	-86.0	44.5
<b>Average</b>					<b>-85.4</b>	<b>45.1</b>
<b>Variance</b>					<b>0.32</b>	

**Table 6: Signal level of preferential channel at the borderline at 3 m height in 25 kHz band limited by the threshold 50 km behind the border for BS at 3 km distance**

Environment	BS height	Path loss at 53 km	Path loss at 3 km	e.i.r.p.	Signal level at 3 m in 25 kHz	
Unit	m	dB	dB	dBm	dBm	dB $\mu$ V/m
Open	30	154.9	90.8	28.8	-62.1	68.4
	40	151.8	88.7	25.7	-63.0	67.5
	50	149.5	87.1	23.4	-63.7	66.8
Suburban	30	172.6	108.5	46.5	-62.1	68.4
	40	169.5	106.4	43.4	-63.0	67.5
	50	167.2	104.8	41.1	-63.7	66.8
Urban	30	180.9	116.9	54.8	-62.1	68.4
	40	177.9	114.8	51.8	-63.0	67.5
	50	175.5	113.1	49.4	-63.7	66.8
<b>Average</b>					<b>-62.9</b>	<b>67.6</b>
<b>Variance</b>					<b>0.50</b>	

### 3.1.2 Other cases of preferential channel use

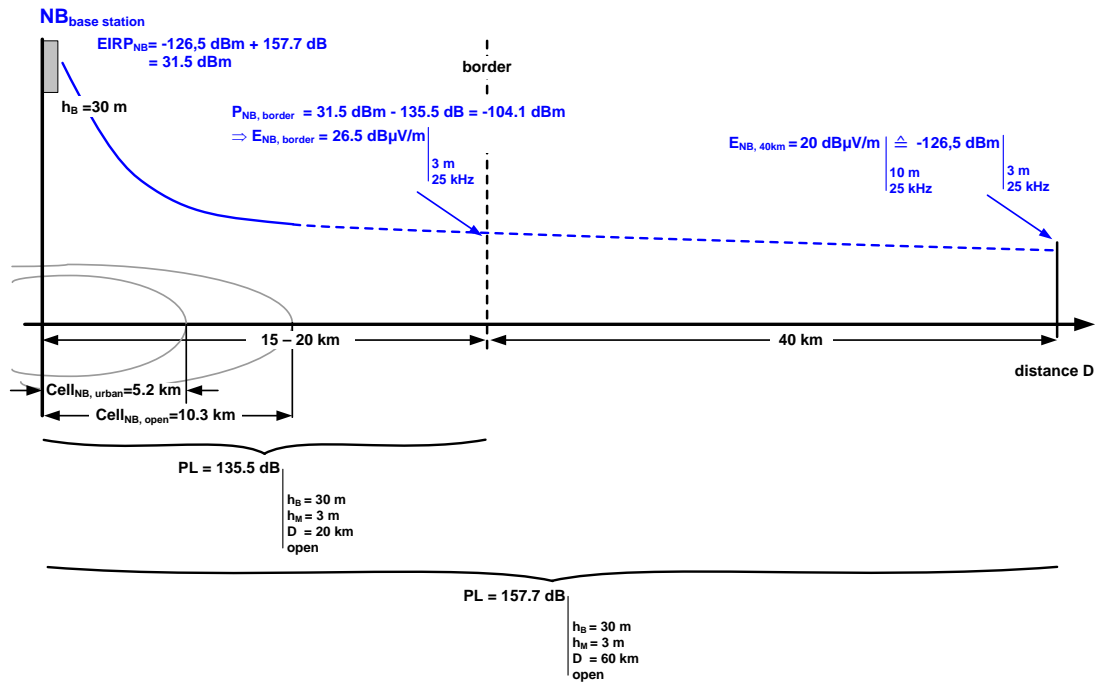
Narrowband systems far away from the border (15–20 km distance) are not deployed to cover border areas. Typical cell ranges of narrowband deployments for outdoor coverage in urban, suburban and open areas are calculated in Table 7.

**Table 7: Calculation of narrowband cell ranges**

Uplink					
Area type	Unit	Urban	suburban	open	Comment
MCL (DL)	dB	152	152	152	Table 99, ECC Report 240 assuming $TX_{pwr, BS} = 40$ dBm, $gain_{BS}=9$ dBi (omni) => $e.i.r.p.-BS=49$ dBm, $gain_{MS}=0$ dBi, $MS_{sens}=-103$ dBm,
MCL (UL)	dB	150	150	150	Table 99, ECC Report 240 assuming $TX_{pwr, MS} = 35$ dBm, $BS_{sens}=-106$ dBm, $gain_{BS}=9$ dBi (omni), $gain_{MS}=0$ dBi
min. MCL $\triangleq$ MCL (UL)	dB	150	150	150	min. MCL for cell range calculation
BS height	m	30	30	30	Table 73, ECC Report 240
MS height	m	1.5	1.5	1.5	Table 73, ECC Report 240
Frequency	MHz	465	465	465	
Standard deviation Slow fading	dB	8.5	8.5	8.5	Table 98, ECC Report 240
Cell edge availability	%	75	75	75	Table 98, ECC Report 240
Slow fading margin	dB	5.7	5.7	5.7	
Max. path loss (UL)	dB	144.3	144.3	144.3	Calculated
Cell range	km	5.2	9.0	26.8	Calculated

From Table 7, it could be concluded that the service area of narrowband systems in open areas extend beyond the borderline, whereas the service area in suburban and urban areas ends significantly before the borderline.

However, the preferential regime condition limits the effective radiated power of the base station as shown in Figure 6. The field strength calculation at the borderline assuming a narrowband system in open areas at 20 km distance is calculated using the modified Okumura-Hata propagation model. In this illustration, the preferential frequency threshold at 40 km beyond the border shall apply.



**Figure 6: Calculation of field strength of preferential channel at the border (Narrowband BS far away from border, 20 km, BS height  $h_B = 30$  m)**

The calculated radiated power of the narrowband system by considering the Preferential Regime a) i.e. the threshold at 40 km is limited by  $P_{NB} = 31.5$  dBm e.i.r.p. which is approx. 18 dB less than assumed in Table 6. If reducing the initially assumed radiated power by 18 dB in order to meet the threshold condition at 40 km distance, the resulting cell range will be reduced to 10.3 km. This means that the serving area of narrowband systems in open areas ends significantly before the borderline as in the case of suburban and urban environments.

Base stations far away from the border with omnidirectional or directional antennas directed to the borderline do not benefit from the preferential rights for the provision of coverage in border areas. With such base station deployment the coverage of border areas is not possible. In order to achieve coverage in borderline areas in urban, suburban and also open areas, additional sites need to be added close to the borderline as shown in section 3.1.1.

In some other cases narrowband PMR systems are built using low radiation powers and low base station heights in some distance from the borderline aiming at a local coverage only e.g. of company premises. In such cases sites are designed to cover a local area of limited size of few hundred meters only but because of the proximity to international border in a range of a few kilometres preferential channels have to be used. In such cases it might happen, that the preferential usage rights are not fully executed i.e. the field strength at the agreed distance is not reached. However, also in this case the protection criterion has to be met at the edge of coverage and not at the borderline.

### 3.1.3 Observations

The calculations above show that the preferential channel usage for border coverage leads to relatively high signal levels at the borderline. However, the related e.i.r.p values towards the neighbouring country are lower than typical e.i.r.p values (in open areas below 30 dBm or 1 W accordingly for both preferential regimes, refer to Table 3 – Table 6) in some scenarios because of the restriction of the field strength at 40 or 50 km distance from the border. The low radiation power towards the neighbouring country can be achieved by using sector antennas with high front to back ratio.

For smaller distances to the border, the field strength at the border increases. This means that the preferential regime allows different network designs with outdoor or indoor coverage up to the border area.



Furthermore, the field strength at the border does not depend on the antenna height and the propagation environment. The variance of the signal level is below 0.5 dB for different antenna heights and propagation environments. This means that a single value can be defined for the coordination of preferential narrowband usage and wideband systems.

For base station deployments using preferential usage rights at long distances from the border, the coverage ends far before the borderline even when fully executing preferential rights. In other situations narrowband base stations use a low e.i.r.p. power (in the order of 1 W) or low base station antenna heights. Such base stations are typically used for the provision of local area coverage in some distance to the border without reaching the threshold level at distances agreed in bilateral or multilateral agreements. In all such cases the protection requirement has to be studied at the coverage edge which is unknown and therefore not covered in this general cross-border study.

Table 8 summarises the results from above calculations by presenting the average signal level at the borderline for Preferential Regime a), i.e. for field strength threshold at 40 km distance, and for Preferential Regime b), i.e. for field strength threshold at 50 km distance, with a BS implementation in distance of 3–5 km assuming a full execution of the preferential usage rights.

**Table 8: Summary of average signal level at the borderline**

Threshold line behind borderline	BS distance to borderline	Average signal level at 3 m in 25 kHz [dB $\mu$ V/m]
40 km	3–5 km	44.1
50 km	3–5 km	56.4

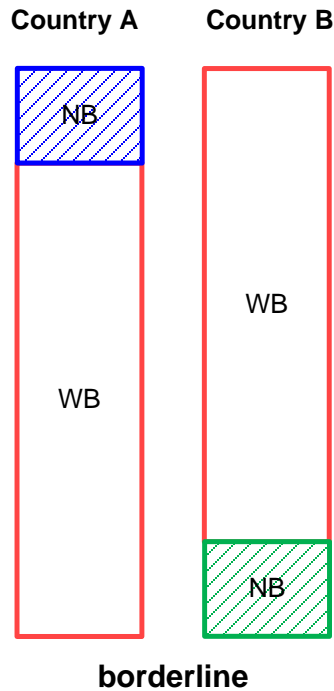
### 3.2 COORDINATION LEVEL FOR SYSTEMS WITH CHANNEL SPACING GREATER THAN 1 MHz VIS-A-VIS PREFERENTIAL CHANNELS

The coordination threshold for wideband land mobile systems can be derived from the coverage levels of systems using a preferential frequency regime. For the simplicity of the coordination procedure, the coordination threshold for systems with channels greater than 1 MHz can be defined at the borderline. This coordination approach is conservative from the perspective of the co-channel preferential use since the signal to interference ratio increases with the distance from border (wanted signal increases and unwanted interference decreases). Like other mobile systems this trigger threshold can be defined at 3 m height.

Two cases of coordination between preferential use and wideband systems are considered further to reflect different preferential agreements:

- Preferential Regime a): the preferential frequency use is defined as a threshold of 20 dB $\mu$ V/m at a distance of 40 km behind the border (at 10 m height, in 25 kHz bandwidth). In this case the field strength at the border is app. 44 dB $\mu$ V/m at 3 m height in 25 kHz. Implementing the wideband threshold value at the borderline based on ECC Recommendation (15)01 [4], i.e. 32 dB $\mu$ V/m at 3 m, would result in a C/I for preferential channels of about 12 dB. This value is sufficient for most narrowband systems (for example ETSI EN 300 113-1 [9]). However, some administrations may agree to higher protection ratios for narrowband systems vis-a-vis wideband systems. Reducing the coordination threshold down to 25 dB $\mu$ V/m in 3 m height in 25 kHz bandwidth results in a protection ratio (C/I) of 19 dB, which is sufficient for interference free operation of narrowband systems. In this case wideband systems can also provide some limited service to border areas. The coverage level of wideband systems at the borderline can be calculated to -85 dBm in 3 MHz channel using field strength into power conversion factor for 450 MHz (-130.5 dB) and the bandwidth conversion factor  $10 \cdot \log(3000/25) = 20.8$  dB which is sufficient for coverage in border areas;
- Preferential Regime b): the preferential frequency usage rights are defined as a threshold of 20 dB $\mu$ V/m at a distance of 50 km behind the border (10 m height, 25 kHz). In this case the field strength at the border is app. 56 dB $\mu$ V/m at 3 m height in 25 kHz. The implementation of the same field strength threshold as derived for wideband vs. wideband case, see section 1.(i.e. 32 dB $\mu$ V/m in 3 m height in 25 kHz bandwidth) results in the protection ratio of app. 22 dB for narrowband system which is sufficient for interference free operation for all known systems. The field strength level of 32 dB $\mu$ V/m in 3 m height

in 25 kHz bandwidth leads to a coverage level of wideband systems at the borderline of -78 dBm in a 3 MHz channel, which is higher than in the case of the Preferential Regime a) and sufficient for the provision of coverage in border areas.



**Figure 7: Cross-border coordination of NB preferential frequencies and WB channels**

For both considered Preferential Regime cases, coordination thresholds for wideband systems at the borderline could be derived by taking into account both the co-existence of preferential channel use and wideband systems. This method of coordination can be implemented in bilateral and multilateral agreements for coordination for the examined cases. The coordination thresholds for wideband systems in the range from 25 to 32 dB $\mu$ V/m, at 3 m height, in 25 kHz on one side of the border and the assignment of preferential channel use on the other side of the border leads to a balanced cross-border situation allowing a more efficient use of the spectrum.

#### 4 COMPARISON WITH TRIGGER VALUES OF RECOMMENDATION T/R 25-08

In this section a comparison between the threshold in accordance with Recommendation T/R 25-08 [1] and the results of this study is made. For historical reasons the Recommendation T/R 25-08 defines the trigger value at 10 m height. However, typically 3 m heights are considered for coordination of land mobile systems since the coverage is usually assumed for mobile user equipment. Furthermore, the definition of the trigger value at 3 m height is also easy applicable for drive tests (antenna at a vehicle's roof).

Recalculation of the derived thresholds from 3 m to 10 m height increases the coordination threshold by 15.6 dB, following the modified Okumura-Hata model [8] leads to the following trigger values for wideband systems at the borderline for the considered Preferential Regimes:

- 41 dB $\mu$ V/m in 25 kHz bandwidth for Preferential Regime a) for narrowband systems i.e. threshold in 40 km distance;
- 48 dB $\mu$ V/m in 25 kHz bandwidth for Preferential Regime b) for narrowband systems i.e. threshold in 50 km distance.

The resulting power within a wideband channel at the borderline can be calculated using the bandwidth conversion factor:

$$\text{BC} = 10 \times \log_{10} (\text{channel spacing} / 25 \text{ kHz}) \text{ dB.}$$

In order to obtain the power level in wideband channel bandwidth, the BC resulting from the formula above should be added to the calculated threshold level (at 3 m or 10 m height) as calculated in 25 kHz bandwidth for the applicable preferential channel distance.

## 5 CONCLUSIONS

This Report considers a possible improvement of the spectrum utilisation in border areas and proposes coordination levels for broadband technologies addressing the following two cases:

- Mutual coordination of wideband systems using the same frequency band;
- A Preferential Regime used for systems with channels up to 25 kHz bandwidth on the one side of the border and wideband systems on the other side of the border.

Mutual coordination of wideband systems using the same frequency band can be derived from the existing ECC Recommendation (16)03 for the coordination of broadband systems in the 700 MHz band. The threshold level given in this recommendation can be recalculated for 400 MHz band yielding 32 dB $\mu$ V/m at the borderline at 3 m height in 25 kHz.

In case of an overlap of wideband and narrowband allocation across the border, the narrowband systems can receive preferential rights for providing coverage in border areas. Wideband systems from the other side of the border will receive higher interference levels, but they are generally more immune to interference. An increase of the narrowband field strength in some overlapping frequencies at the wideband channel edge reduces capacity but does not lead to service outage.

On the other hand the threshold of the wideband systems in these overlapping frequency bands can also be increased without performance reduction of the narrowband systems for the examined co-existence scenarios. In these scenarios, deployments of narrowband networks close to the border using sector antennas as recommended in the Recommendation T/R 25-08 were assumed. An example calculation for the usage of preferential rights by base stations deployed at larger distances from the border shows that service areas of such deployments ends at long distances to the border.

Two known Preferential Regimes for narrowband systems were considered both defined as the field strength threshold 20 dB $\mu$ V/m at 10 m height in 25 kHz at a distance inside the neighbouring country: Preferential Regime a) at 40 km and Preferential Regime b) at 50 km distance. The calculations of the threshold values for the considered regimes lead to the following rules:

The proposed new coordination thresholds for a partial overlap of few hundred kHz between narrowband and wideband assignments across the borders are:

- a) Preferential threshold at 40 km distance inside the neighbouring country
  - Preferential Regime for narrowband systems i.e. 20 dB $\mu$ V/m at 10 m height in 25 kHz 40km inside the neighbouring country
  - 25 dB $\mu$ V/m at 3 m height in 25 kHz at the borderline for wideband systems
- b) Preferential threshold at 50 km distance inside the neighbouring country
  - Preferential Regime for narrowband systems i.e. 20 dB $\mu$ V/m at 10 m height in 25 kHz 50km inside the neighbouring country
  - 32 dB $\mu$ V/m at 3 m height in 25 kHz at the borderline for wideband systems.

The threshold values provided in this Report are for a time probability of 10 % and a location probability of 50 %.

Cases in which either the coverage area of the preferential narrowband usage ends in far distance (e.g. some kilometres) before the borderline or the preferential rights are not executed to the extent possible, are not covered by this study. If the overlap between narrowband and wideband allocations across the border is relatively small, then these individual cases could be very limited in number. In those cases some interference to the existing narrowband systems is possible, assuming that the wideband stations from the other side of the border would provide the coverage to the maximum level as stated in this Report. Those cases have to be considered in bilateral and multilateral cross-border agreements which could require a local reduction of the radiation power of the wideband base stations.

## ANNEX 1: CALCULATIONS FOR LOWER ANTENNA HEIGHTS

### A1.1 SIGNAL LEVEL AT THE BORDER FOR LOW ANTENNA HEIGHTS

The following tables show the signal levels of narrowband base station in open environment at the border line for lower antenna heights than assumed in the report. Instead of antenna heights ranging from 30 m to 50 m, antenna heights ranging from 10 m to 20 m are assumed.

**Table 9: Signal level of NB preferential channel in open environment at the borderline at 3 m height in 25 kHz band limited by the threshold 40 km behind the border for BS at 5 km distance for lower antenna heights**

BS height	Path loss at 45 km	Path loss at 5 km	e.i.r.p.	Signal level at 3 m in 25 kHz	
m	dB	dB	dBm	dBm	dB $\mu$ V/m
10m	160.6	123.8	34.5	-89.4	41.1
15m	157.1	120.3	31.0	-89.3	41.2
20m	154.7	117.8	28.6	-89.2	41.3
Average				-89.3	41.2

**Table 10: Signal level of NB preferential channel in open environment at the borderline at 3 m height in 25 kHz band limited by the threshold 40 km behind the border for BS at 3 km distance for lower antenna heights**

BS height	Path loss at 43 km	Path loss at 3 km	e.i.r.p.	Signal level at 3 m in 25 kHz	
m	dB	dB	dBm	dBm	dB $\mu$ V/m
10	159.6	116.0	33.5	-82.5	48.0
15	156.1	112.5	30.0	-82.5	48.0
20	153.7	110.0	27.6	-82.4	48.1
Average				-82.5	48.0

**Table 11: Signal level of NB preferential channel in open environment at the borderline at 3 m height in 25 kHz band limited by the threshold 50 km behind the border for BS at 5 km distance for lower antenna heights**

BS height	Path loss at 55 km	Path loss at 5 km	e.i.r.p.	Signal level at 3 m in 25 kHz	
m	dB	dB	dBm	dBm	dB $\mu$ V/m
10	164.8	123.8	38.75	-85.1	45.4
15	161.4	120.3	35.33	-85.0	45.5
20	159.0	117.8	32.93	-84.9	45.6

BS height	Path loss at 55 km	Path loss at 5 km	e.i.r.p.	Signal level at 3 m in 25 kHz	
m	dB	dB	dBm	dBm	dBµV/m
Average				-85.0	45.5

**Table 12: Signal level of NB preferential channel at the borderline in open environment at 3 m height in 25 kHz band limited by the threshold 50 km behind the border for BS at 3 km distance for lower antenna heights**

BS height	Path loss at 53 km	Path loss at 3 km	e.i.r.p.	Signal level at 3 m in 25 kHz	
m	dB	dB	dBm	dBm	dBµV/m
10	164.0	116.0	37.9	-78.1	52.4
15	160.6	112.5	34.5	-78.0	52.5
20	158.2	110.0	32.1	-77.9	52.6
Average				-78.0	52.5

**Table 13: Summary of average signal level in open environment at the borderline for low antenna heights**

Threshold line behind borderline	BS distance to borderline	Average signal level at 3 m in 25 kHz [dBµV/m]
40 km	3–5 km	44.6
50 km	3–5 km	49.0

The average signal level of the narrowband base station with antenna height in the range from 10 m to 20 m is in case of the threshold line at 40 km distance comparable (just 0.5 dB higher) and 7.4 dB lower in case of the threshold line at 50 km distance for higher base station antenna heights (compare with Table 8). Therefore, from the protection perspective of the narrowband systems, the threshold level for wideband systems at the border line can be kept at the same level for the preferential threshold line 40 km behind the border. In case of a preferential threshold line 50 km behind the border, the level of the wideband system could be reduced by 7.4 dB if a 22 dB protection ratio at the border line is required. For the protection ratio for narrowband systems of C/I of 15 dB or less the threshold value for wideband systems can also be kept at the same level as calculated in the report.

Due to propagation properties in the 400 MHz bands, in case of low base station antenna heights the threshold value at the threshold line for preferential frequency is reached with low base stations radiation power. Table 9 to Table 12 show that the base station's radiation power towards the border line is limited to an e.i.r.p in the range from 27 to 38 dBm. This means that the e.i.r.p. has to be restricted to this limit in order to fulfil the signal level threshold at the respective distance, i.e. at 40 km or 50 km behind the border line, and preferential usage rights are fully executed.

**ANNEX 2: LIST OF REFERENCE**

- [1] ECC Recommendation T/R 25-08, Planning criteria and coordination of frequencies for land mobile systems in the range 29.7-470 MHz, January 1990, amended May 2016.
- [2] ECC Recommendation (05)08, Frequency planning and cross-border coordination between GSM Land Mobile Systems (GSM 900, GSM 1800 and GSM-R), February 2006, amended February 2017
- [3] ECC Recommendation (11)04, Cross-border Coordination for Mobile/Fixed Communications Networks (MFCN) in the frequency band 790-862 MHz, May 2011, amended February 2017
- [4] ECC Recommendation (15)01, Cross-border coordination for mobile/fixed communications networks (MFCN) in the frequency bands: 694-790 MHz, 1452-1492 MHz, 3400-3600 MHz and 3600-3800 MHz, February 2015, amended February 2016
- [5] ECC Recommendation (16)03, Cross-border coordination for Broadband Public Protection and Disaster Relief (BB-PPDR) systems in the frequency band 698 to 791 MHz, October 2016
- [6] ECC Report 97, Cross Border Interference for Land Mobile Technologies, February 2007
- [7] ECC Report 108, Border code coordination between CDMA2000 systems in 450 MHz band, October 2007
- [8] ERC Report 68, Monte-Carlo Radio Simulation Methodology for the use in sharing and compatibility studies between different radio services or systems, February 2000, revised May 2001 and June 2002
- [9] ETSI EN 300 113-1 V1.7.1, Land mobile service; Radio equipment intended for the transmission of data (and/or speech) using constant or non-constant envelope modulation and having an antenna connector; Part 1: Technical characteristics and methods of measurement, November 2011