CEPT ECC
Electronic Communications Committee

ECC Recommendation (08)02

Frequency planning and frequency coordination for GSM / UMTS / LTE / WiMAX Land Mobile systems operating within the 900 and 1800 MHz bands

21 February 2008

amended 27 April 2012

Edition 27 April 2012

"The European Conference of Postal and Telecommunications Administrations,

considering

a) That the ECC/REC/(05)08 addresses "Frequency planning and frequency coordination for the GSM 900, GSM 1800, E-GSM and GSM-R land mobile systems" and the ERC/REC/(01)01 addresses "Border coordination of UMTS";

b) that ECC/REC/(11)04 addresses "Frequency planning and frequency coordination for the MFCN in the 790-862 MHz band" and the ECC/REC/(11)05 addresses "Frequency planning and frequency coordination for the MFCN in the 2500-2690 MHz band";

c) that the Radio Regulations identify the frequency bands 880-915 MHz/925-960 MHz (RR 5.317A) and 1710-1785 MHz/1805-1880 MHz (RR 5.384A) for terrestrial IMT;

d) that ERC/DEC/(94)01, ERC/DEC/(97)02 and ERC/DEC/(95)03 designate the bands 880-915 MHz, 925-960 MHz and 1710-1785 MHz/1805-1880 MHz for GSM systems;

e) that ECC/DEC/(06)13 designates the bands 880-915 MHz, 925-960 MHz, 1710-1785 MHz and 1805-1880 MHz for terrestrial IMT-2000/UMTS systems;

f) that the amending Decision 2009/766/EC (dated 18th April 2011) on the harmonisation of the 900 MHz and 1800 MHz frequency bands for terrestrial systems capable of providing pan-European electronic communications services in the Community has included the technical conditions for UMTS/LTE/WiMAX in its annex;

g) that in the implementation of the GSM and/or UMTS and/or LTE/WiMAX systems it is necessary to take account of national policies for the use of the frequency bands in question;

h) that frequency (GSM and UMTS/LTE/WiMAX) and code (only for UMTS) planning in border areas will be based on coordination between national administrations in cooperation with their operators;

i) that Physical Cell Identifier (PCI) coordination is necessary for LTE systems to avoid unnecessary signalling load and handover failures;

j) that other radio parameters may need to be co-ordinated for LTE systems on a bi/multi-lateral basis;

k) that coordination is necessary between countries operating the GSM, UMTS/LTE/WiMAX systems in the same frequency band;

l) that many agreements for GSM border coordination have been signed between administrations and administrations continue the operation and development of GSM networks;

m) that GSM and UMTS/LTE/WiMAX systems use frequency arrangements with different channel bandwidths;

n) that the coordination procedure depends on a great number of parameters (technical, operational or topographical);

o) that where practicable and only for UMTS systems soft-handover between neighbouring networks may provide an option to facilitate coordination in border areas and to enhance efficiency of spectrum usage;

p) that administrations may diverge from the technical parameters, propagation models and procedures described in this Recommendation subject to bilateral / multilateral agreements;

q) that in the case of operator arrangements approved by national administrations it is possible to deviate from this Recommendation;

r) that in many CEPT member countries there are multiple operators for the GSM and /UMTS/LTE/WiMAX systems;

s) that a frequency coordination procedure is necessary both between countries operating the GSM and /UMTS/LTE/WiMAX systems and between those countries and countries operating other systems in accordance with the Radio Regulations;

t) that existing bi-/multilateral agreements for GSM systems have to be updated in order to include UMTS/LTE/WiMAX systems;

u) that this Recommendation does not consider TDD systems;

v) that frequency co-ordination in border areas should be based on the concept of equal spectrum access probability by systems on each side of a border;

w) that base stations which have already been coordinated for GSM based on ECC Recommendation (05)08 can continue to operate and also be optimised according to the same trigger values.

recommends

in general:

1. that, if the levels in Annex 1 are exceeded, coordination is required and the procedure detailed in Annex 4 should be used;
2. that interference field strength predictions should be made using the appropriate propagation models defined in Annex 2 for UMTS/LTE/WiMAX systems and in ECC/REC/(05)08 for GSM systems;
3. that administrations should encourage and facilitate the establishment of arrangements between operators of different countries with the aim to enhance the efficient use of the spectrum and the coverage in the border areas;
4. that frequency coordination between UMTS/LTE/WiMAX systems and other systems in neighbouring countries should be based on bilateral / multilateral agreements;
5. that coordination in coastal areas is based on prediction of field strength levels at the coastline of the neighbouring country. Other principles for co-ordination in coastal areas may be agreed between the administrations concerned;
6. that this Recommendation should be reviewed within 2 years of its adoption in the light of practical experience of its application and of the operation of UMTS/LTE/WiMAX systems;

between GSM systems at the border:

7. that frequency co-ordination between GSM systems should be based on ECC/REC/(05)08;

between GSM and UMTS/LTE/WiMAX (FDD) systems or between UMTS/LTE/WiMAX systems at the border :

8. that new bi/multi-lateral agreements are established for frequency coordination between GSM systems and UMTS/LTE/WiMAX systems. The trigger values for GSM systems can be based either on ECC/REC/(05)08 or on the principles provided in Annex 1 section 3 of this Recommendation. The choice of trigger values for GSM is to be agreed between the concerned administrations. The trigger values for UMTS/LTE/WiMAX are based on the principles provided in Annex 1;
9. that new bi/multi-lateral agreements are established for frequency coordination between UMTS, LTE/WiMAX systems based on the principles provided in Annex 1;
10. that bi/multi-lateral agreements between administrations may define common frequency blocks to facilitate the introduction of the UMTS/LTE/WiMAX systems;
11. that frequency co-ordination between GSM and UMTS/LTE/WiMAX systems or between UMTS/LTE/WiMAX systems, in neighbouring countries may also use preferential frequencies based on bi/multi-lateral agreements;
12. that coordination between neighbouring UMTS systems in border areas should be based on the code groups provided in Annex 3;
13. that coordination between neighbouring LTE systems in border areas should be based on the PCI's provided in Annex 5 when channel centre frequencies are aligned;
14. that other radio parameters for LTE may need to be co-ordinated on a bi/multi-lateral basis based on the guidance provided in Annex 6.

Note:
Please check the Office documentation database http://www.ecodocdb.dk for the up to date position on the implementation of this and other ECC Recommendations

Annex 1

PRINCIPLES AND COORDINATION FIELD STRENGTH LEVELS FOR THE BORDER COORDINATION IN THE FREQUENCY BANDS 880-915 MHz /925-960 MHz and 1710-1785 MHz /1805-1880 MHz

1. Between GSM systems deployed on both sides of the borderline

GSM systems can continue their operations according to ECC Recommendation (05)08 and the existing agreements.

2. Between UMTS systems deployed on both sides of the borderline using non preferential codes and with centre frequencies aligned

Frequencies in the bands of 925-960 MHz and 1805-1880 MHz for systems using **non preferential codes** and **with centre frequencies aligned** may be used without coordination in a neighbouring country if the mean field strength of each carrier produced by the base station does not exceed a value of:

- UMTS900 => 35 dBμV/m/5MHz at a height of 3 m above ground at the border line between two countries in the frequency band 925-960 MHz.
- UMTS1800 => 41 dBμV/m/5MHz at a height of 3 m above ground at the border line between two countries in the frequency band 1805-1880 MHz.

Administrations may agree in bilateral or multilateral agreements on preferential frequency blocks of 5 MHz for UMTS. In this case, the trigger values for the coordination between UMTS systems at 900 MHz and 1800 MHz are increased by 10 dB for administrations which are using the preferential frequency blocks. UMTS systems operating at non-preferential frequencies in the border area must accept interference from services in the neighbouring country using preferential frequencies.

Note: If UMTS centre frequencies are not aligned or code groups are distributed into preferential groups according to Annex 3 then the limits in 3 can be used.

3. All other cases[1]

For all other cases the following limits apply:

Frequencies in the bands 925-960 MHz and 1805-1880 MHz may be used without coordination with a neighbouring country if the mean field strength of each carrier produced by the base station does not exceed a value of:

- 900 MHz (FDD) => 59 dBμV/m/5MHz at a height of 3 m above ground at the borderline between two countries and a value of 35 dBμV/m/5MHz at a height of 3 m above ground at a distance of 9 km inside the neighbouring country, in the frequency band 925-960 MHz.

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[1]All other cases refers to:

- UMTS vs. UMTS when using preferential codes
- UMTS vs. UMTS when center frequencies are not aligned
- LTE vs. LTE
- WiMAX vs. WiMAX
- LTE vs. GSM (and GSM vs LTE)
- LTE vs. WiMAX (and WiMAX vs LTE)
- LTE vs. UMTS (and UMTS vs. LTE)
- UMTS vs. GSM (and GSM vs. UMTS)
- UMTS vs. WiMAX (and WiMAX vs UMTS)
- WiMAX vs. GSM (and GSM vs WiMAX).

- 1800 MHz (FDD) => 65 dBμV/m/5MHz at a height of 3 m above ground at the borderline between two countries and a value of 41 dBμV/m/5MHz at a height of 3 m above ground at a distance of 9 km inside the neighbouring country, in the frequency band 1805-1880 MHz.

Calculation explanations and examples:

- The “mean field strength of each carrier” refers up to a frequency block of 5 MHz.

- If the bandwidth of the signal is larger than 5 MHz (for LTE and WiMAX) , 10 x log(bandwidth/5MHz) should be added to the limit values. E.g. 59 dBμV/m/5MHz becomes 62 dBμV/m/10MHz for a 10 MHz carrier

- For calculation of the field strength in case of a GSM system, the power sum of all radiated 200 kHz channels inside the 5 MHz block has to be considered. If all single GSM channels radiate the same power, 10 x log(number of channels in the considered 5 MHz block) has to be subtracted from the above limit values to get the limit for a single GSM channel. For example if we consider the case where a single base station contributes to the field strength which has 4 GSM carriers at the same power operating within a 5 MHz band in a 900 MHz cell, the cumulative permitted field strength is 59 dBμV/m/5MHz at a height of 3 m above ground at the borderline between two countries, which is equivalent to 53 dBμV/m/200 kHz,

4. Summary of field strength levels for the coordination between systems at 900 MHz and 1800 MHz

	Field strength level at 3 m height	
	900 MHz	1800 MHz
GSM vs. GSM	GSM systems can continue operating according to ECC Recommendation (05)08 and the existing agreements.	
UMTS vs. UMTS using non preferential codes and with centre frequencies aligned	35 dBμV/m/5MHz @0 km	41 dBμV/m/5MHz @0 km
All other cases*	59 dBμV/m/5MHz @0 km & 35 dBμV/m/5MHz @9 km	65 dBμV/m/5MHz @ 0km & 41 dBμV/m/5MHz @ 9km

Table 1: Summary of field strength levels for the coordination between systems at 900 MHz and 1800 MHz

*Note: For the case of GSM vs UMTS/LTE/WiMAX, the trigger values to be used for GSM can also be based on ECC/REC/(05)08 if the concerned administrations wish to do so in order not to change the existing GSM networks (see Recommends 8).

Annex 2

PROPAGATION MODEL

The following methods are proposed for assessment of anticipated interference inside neighbouring country based on established trigger values. Due to complexity of radiowave propagation nature different methods are proposed to be considered by administrations and are included here for guidance purposes only.

It should be noted that following methods provide theoretical predictions based on available terrain knowledge. It is practically impossible to recreate these methods with measurement procedures in the field. Therefore only some approximation of measurements could be used to check compliance with those methods based on practical measurement procedures. The details of such approximation are not included in this recommendation and should be negotiated between countries based on their radio monitoring practices.

Path specific model

Where appropriate detailed terrain data is available, the propagation model for interference field strength prediction is the latest version of ITU-R Rec. P.452. For the relevant transmitting terminal, predictions of path loss would be made at x km steps along radials of y km at z degree intervals. The values for those receiver locations within the neighbouring country would be used to construct a histogram of path loss – and if 10% of predicted values exceed the threshold the station shall be required to be coordinated.

Values for x, y and z to be agreed between the administrations concerned.

Site General model

If it is not desirable to utilise detailed terrain height data for the propagation modelling in the border area, the basic model to be used to trigger co-ordination between administrations and to decide, if co-ordination is necessary, is ITU-R Rec. P.1546, “Method for point to area predictions for terrestrial services in the frequency range 30 to 3000 MHz”. This model is to be employed for 50% locations, 10% time and using a receiver height of 3m.

For specific reception areas where terrain roughness adjustments for improved accuracy of field strength prediction are needed, administrations may use correction factors according to terrain irregularity and/or an averaged value of the TCA parameter in order to describe the roughness of the area on and around the coordination line.

Administrations and/or operators concerned may agree to deviate from the aforementioned model by mutual consent[2].

Area calculations

In the case where greater accuracy is required, administrations and operators may use the area calculation below.

For calculations, all the pixels of a given geographical area to be agreed between the Administrations concerned in a neighbouring country are taken into consideration.

For the relevant base station, predictions of path loss should be made for all the pixels of a given geographical area from a base station and at a receiver antenna height of 3m above ground.

For evaluation,

- only 10 percent of the number of geographical area between the borderline (including also the borderline) and the 6 km line itself inside the neighbouring country may be interfered by higher

[2]e.g. as used by members of the HCM-Agreement

field strength than the trigger field strength value given for the borderline in Annex 1 at a height of 3 m above ground.

- only 10 percent of the number of geographical area between the 6 km (including also 6km line) and 12 km line inside the neighbouring country may be interfered by higher field strength than the trigger field strength value given for the 6 km line in Annex 1 at a height of 3 m above ground.

It is recommended that during area calculations not only detailed terrain data but also clutter data be taken into account. Use of correction factors for clutter is crucial in particular where the border area is ‘open’ or ‘quasi-open’ from the point of view of clutter or where the interfering base station is just a few kilometres from a borderline.

If the distance between a base station and a terrain point of a borderline is closer than or equal to 1 km, free space propagation model needs to be applied. Furthermore, if there is no terrain obstacle within the 1st Fresnel zone,” also the free space propagation model should be applied.

If clutter data is not available, it is proposed to extend the usage of free space propagation model to a few kilometres, depending on the clutter situation in border areas.

For area type interference calculations, propagation models with path specific terrain correction factors are recommended (e.g. Recommendation ITU–R P.1546 with the terrain clearance angle correction factor TCA, HCM method with the terrain clearance angle correction factor or Recommendation ITU–R P.1812).

As to correction factors for clutters ‘open area’ and ‘quasi-open area’, 20 dB and 15 dB should be used respectively. Recommendation ITU–R P.1406 should be used if a finer selection of clutter is required. It must be noted that terrain irregularity factor Δh is not recommended to be used in area calculations. Administrations and/or operators concerned may agree to deviate from the aforementioned models by mutual consent.

Annex 3

PREFERENTIAL CODES FOR UMTS (UTRA FDD)

The code groups defined for the FDD modes have no particular correlation properties and no particular organisation of the repartition is required.

Administrations should agree on a repartition of these code groups on an equitable basis.

In any case, apart from in the border areas, each country could use all code groups.
In border areas, the codes will be divided into 6 "code sets" containing each one sixth of the available code groups. Each country is allocated three code sets (half of the codes) in a bilateral case, and two code sets (one third of the codes) in a trilateral case.

Four types of countries are defined in a way such that no country will use the same code set as any one of its neighbours. The following lists describe the distribution of European countries:

Type country 1: BEL, CVA, CYP, CZE, DNK, E, FIN, GRC, IRL, ISL, LTU, MCO, SMR, SUI, SVN, UKR, AZE, SRB.

Type country 2: AND, BIH, BLR, BUL, D, EST, G, HNG, I, MDA, RUS (Exclave), GEO
Type country 3: ALB, AUT, F, HOL, HRV, POL, POR, ROU, RUS, S, MLT
Type country 4: LIE, LUX, LVA, MKD, MNE, NOR, SVK, TUR.

For each type of country, the following tables and figure describe the sharing of the codes with its neighbouring countries, with the following conventions of writing:

■	Preferential code
	non-preferential code

For the FDD mode; 3GPP TS 25.213 defines 64 « scrambling code groups » in §5.2.3, numbered {0…63}, hereafter called « code groups ».

	Set A	Set B	Set C	Set D	Set E	Set F
Country 1	0..10	11..20	21-31	32..42	43..52	53..63
Border 1-2	■	■				■
Zone 1-2-3	■	■				
Border 1-3	■	■	■			
Zone 1-2-4	■					■
Border 1-4	■		■			■
Zone 1-3-4	■		■			

	Set A	Set B	Set C	Set D	Set E	Set F
Country 2	0..10	11..20	21..31	32..42	43..52	53..63
Border 2-1			■	■	■	
Zone 2-3-1			■	■		
Border 2-3		■	■	■		
Zone 2-1-4			■	■		
Border 2-4			■	■		■
Zone 2-3-4			■	■		

	Set A	Set B	Set C	Set D	Set E	Set F
Country 3	0..10	11..20	21..31	32..42	43..52	53..63
Border 3-2	■				■	■
Zone 3-1-2					■	■
Border 3-1				■	■	■
Zone 3-1-					■	■

	Set A	Set B	Set C	Set D	Set E	Set F
Country 4	0..10	11..20	21..31	32..42	43..52	53..63
Border 4-1		■		■	■	
Zone 4-1-2		■			■	
Border 4-2	■	■			■	
Zone 4-2-3	■	■				

4						
Border 3-4						
Zone 3-2-4						

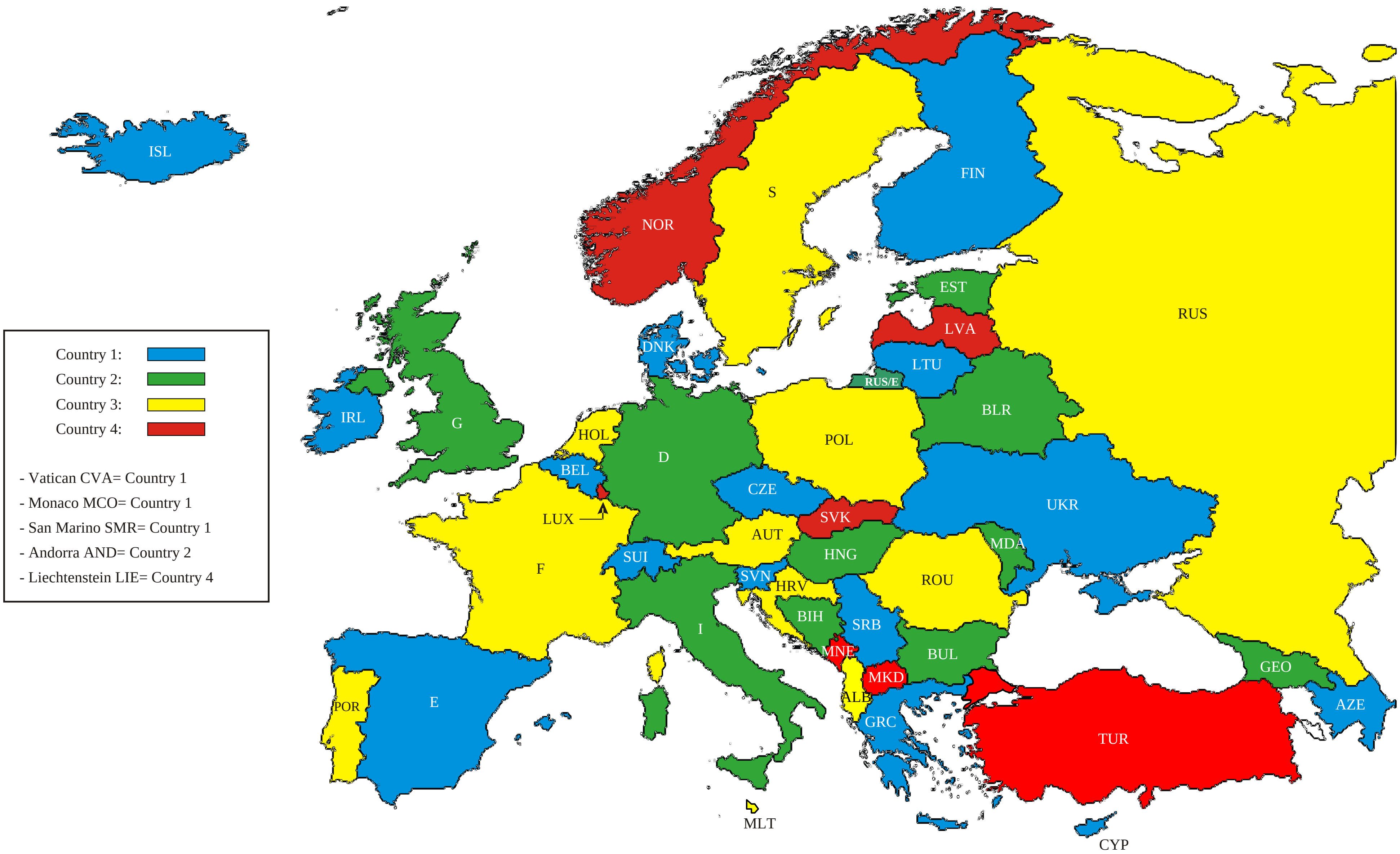
Border 4-3						
Zone 4-3-1						

Notes

1. All codes are available in areas away from the border where the field strengths into the neighbouring country are below the relevant trigger levels.

2. A two countries code sharing should be applied or used by base stations that exceed the relevant trigger level (Annex 1) of only one neighbouring country. A three countries code sharing should be applied or used by base stations that exceed the relevant trigger level (Annex 1) of two neighbouring countries.

3. In certain specific cases (e.g. AUT/HRV) where the distance between two countries of the same Type number is very small (< few 10s km), it may be necessary to address the situation in bi/multilateral coordination agreements as necessary, and may include further subdivision of the allocated codes in certain areas.


Country 1:
Country 2:
Country 3:
Country 4:
- Vatican CVA= Country 1
- Monaco MCO= Country 1
- San Marino SMR= Country 1
- Andorra AND= Country 2
- Liechtenstein LIE= Country 4
ISL
NOR
S
FIN
RUS
EST
LVA
LTU
RUS/E
BLR
DNK
IRL
G
HOL
BEL
LUX
D
POL
CZE
SVK
UKR
AUT
HNG
MDA
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Annex 4

EXCHANGE OF INFORMATION

When requesting coordination the relevant characteristics of the base station, the code group number and the PCI numbers should be forwarded to the Administration affected. All of the following characteristics should be included:

a) carrier frequency (MHz)
b) name of transmitter station
c) country of location of transmitter station
d) geographical coordinates (W/E, N; WGS84)
e) effective antenna height (m)
f) antenna polarisation
g) antenna azimuth (deg)
h) directivity in antenna systems or antenna gain (dBi)
i) effective radiated power (dBW)
j) expected coverage zone
k) date of entry into service (month, year).
l) code group number used only for UMTS
m) PCI numbers used (only for LTE)
n) antenna tilt (deg / Electric and mechanic tilt)
o) antenna pattern or envelop.

The Administration affected shall evaluate the request for coordination and shall within 30 days notify the result of the evaluation to the Administration requesting coordination.

If in the course of the coordination procedure an Administration may request additional information.

If no reply is received by the Administration requesting coordination within 30 days it may send a reminder to the Administration affected. An Administration not having responded within 30 days following communication of the reminder shall be deemed to have given its consent and the code co-ordination may be put into use with the characteristics given in the request for coordination.

The periods mentioned above may be extended by common consent.

Annex 5

PREFERENTIAL PHYSICAL-LAYER CELL IDENTITIES (PCI) FOR LTE

PCI co-ordination is only needed when channel centre frequencies are aligned independent of the channel bandwidth.

3GPP TS 36.211 defines 168 “unique physical-layer cell-identity groups” in §6.11, numbered 0…167, hereafter called “PCI groups”. Within each PCI group there are three separate PCIs giving 504 PCIs in total.

Administrations should agree on a repartition of these 504 PCI’s on an equitable basis when channel centre frequencies are aligned as shown in the Table below. It has to be noted that dividing the PCI groups or PCI’s is equivalent. Each country should only use their own preferential PCI’s close to the border. Each country can use all PCI groups away from the border areas.

Administrations may wish to define different field strength levels (than those in Annex 1) for non-preferential PCI’s.

As shown in the table below, the PCI’s should be divided into 6 sub-sets containing each one sixth of the available PCI’s. Each country is allocated three sets (half of the PCI’s) in a bilateral case, and two sets (one third of the PCI’s) in a trilateral case.

Four types of countries are defined in a way such that no country will use the same code set as any one of its neighbours. The following lists describe the distribution of European countries:

Type country 1: BEL, CVA, CYP, CZE, DNK, E, FIN, GRC, IRL, ISL, LTU, MCO, SMR, SUI, SVN, UKR, AZE, SRB.

Type country 2: AND, BIH, BLR, BUL, D, EST, G, HNG, I, MDA, RUS (Exclave), GEO.
Type country 3: ALB, AUT, F, HOL, HRV, POL, POR, ROU, RUS, S, MLT.
Type country 4: LIE, LUX, LVA, MKD, MNE, NOR, SVK, TUR.

(Note: Country type map can be found in Annex 3).

For each type of country, the following tables and figure describe the sharing of the PCI’s with its neighbouring countries, with the following conventions of writing:

(black)	Preferential PCI
(white)	non-preferential PCI

The 504 physical-layer cell-identities should be divided into the following 6 sub-sets when the carrier frequencies are aligned in border areas:

PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 1	0..83	84..167	168..251	252..335	336..419	420..503
Border 1-2	■	■				■
Zone 1-2-3	■	■				
Border 1-3	■	■	■			
Zone 1-2-4	■					■
Border 1-4	■		■			■
Zone 1-3-4	■		■			

PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 2	0..83	84..167	168..251	252..335	336..419	420..503
Border 2-1			■	■	■	
Zone 2-3-1			■	■		
Border 2-3		■	■	■		
Zone 2-1-4			■	■		
Border 2-4			■	■		■
Zone 2-3-4			■	■		

PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 3	0..83	84..167	168..251	252..335	336..419	420..503
Border 3-2	■				■	■
Zone 3-1-2					■	■
Border 3-1				■	■	■
Zone 3-1-4					■	■
Border 3-4			■		■	■
Zone 3-2-4					■	■

PCI	Set A	Set B	Set C	Set D	Set E	Set F
Country 4	0..83	84..167	168..251	252..335	336..419	420..503
Border 4-1		■		■	■	
Zone 4-1-2		■			■	
Border 4-2	■	■			■	
Zone 4-2-3	■	■				
Border 4-3	■	■		■		
Zone 4-3-1		■		■		

Notes

1) All PCI's are available in areas away from the border.

2) In certain specific cases (e.g. AUT/HRV) where the distance between two countries of the same type number is very small (< few 10s km), it may be necessary to address the situation in bi/multilateral coordination agreements as necessary, and may include further subdivision of the allocated codes in certain areas.

3) Country type map can be found in Annex 3.

Annex 6

GUIDANCE ON THE CONSIDERATION OF LTE RADIO PARAMETERS FOR USE IN BI-LATERAL AND MULTI LATERAL AGREEMENTS

This Annex is provided for guidance purposes for use in bi-lateral and multilateral discussions. For LTE, it may be beneficial to co-ordinate other radio parameters besides PCI (which is covered by the previous Annex) in order to minimise deteriorating effects of uplink interference.

The parameters described in this Annex are usually optimized during LTE radio network planning of an operator's network. The idea of optimization is to plan the parameters taking into account specific correlation properties of the uplink control signals which enable more stable and predictable operation of the network. In the cross-border scenario the optimization of parameters among neighbouring operators could provide better control of uplink interference. However because of the difference between intra-network and inter-network interference and due to limited experience in the LTE cross-border deployment it is difficult to assess the benefits of such optimisation. The following guidance provides the basis for operators to consider in border areas in case of high levels of uplink interference.

1. Demodulation Reference Signal (DM RS) coordination

Demodulation reference signals (DM RS) are transmitted in the uplink and used for channel estimation. There is a risk of intercell interference between neighbouring cells even in case of no frame synchronization. That is why special measures for DM RS allocation between networks in neighbouring countries occupying the same channel may need to be applied.

The case of partial channel overlap has not been studied but due to DM RS occupying resource blocks of separate users there is a risk of DM RS collisions between neighbouring networks when the subcarriers positions coincide (the frequency offset between central carriers of neighbouring networks is multiple of 300 kHz). Some minor benefits from DM RS coordination in these particular cases could be expected.

There are a number of possible approaches to the coordination of DM RS:

- In basic planning procedure only 30 DM RS sequence groups with favourable correlation characteristics are available, numbered {0…29}. In this case each cell could be assigned one of the 30 DM RS sequence groups providing cluster size of 30.
- It is possible to extend each DM RS sequence group to generate up to 12 time shifted sequence groups by applying the cyclic shift parameter stated in 3GPP TS 36.211. For example each tri-sector site could be assigned one DM RS sequence group with each co-sited cell having its own cyclic shift of 2π/3 which provides cluster size 30 only with 10 DM RS sequence groups. The latter case corresponds well to the case of DM RS sequence groups repartition between neighbouring countries when only limited number of groups is available for network planning. The drawback of DM RS sequence group cyclic shift is a loss of orthogonally of DM RS due to fading channels which has been found only recently during first trials of LTE and caused throughput loss as well as time alignment problems.
- Another approach for DM RS coordination is to implement dynamic DM RS sequence group allocation also called pseudo-random group hopping. In this method nearby cells are grouped into clusters up to 30 cells and within each cell cluster the same hopping-pattern is used. At the border of two clusters inter-cell interference is averaged since two different hopping patterns are utilized. There are 17 defined hopping patterns, numbered {0…16}, which leads to some minor unfairness in case of apportioning these patterns between neighbouring countries. Even in a trilateral case each operator will have at least 5 hopping patterns available near the border which should be enough for planning purposes. It should be noted the pseudo-random group hopping option could be absent in the first generations of LTE equipment.

The decision of which of these methods to use in cross-border coordination should be agreed by the interested parties. Specific DM RS sequence groups or hopping patterns repartition is not provided in the text of this Recommendation but could be deduced in a similar manner to the PCI repartition shown in the previous Annex.

2. Physical Random Access Channel (PRACH) coordination

Another radio network parameter which is considered during radio network planning is PRACH configuration which is needed to distinguish random access requests addressed to different cells. PRACH resources are allocated by specifying the PRACH Resource Blocks time positions within the uplink frame, their frequency position within the LTE channel bandwidth and by apportioning cell-specific root sequences. During radio network planning these parameters are usually used in the following way:

- time positions for PRACH resource allocations are usually used to create time collision of PRACH resources of co-sited/frame synchronized cells because PRACH-to-PRACH interference is usually less severe than PUSCH-to-PRACH interference;
- frequency positions within the LTE channel bandwidth is usually the same for all cells, again because PRACH-to-PRACH interference case is more favourable one.
- cell-specific root sequences are used to distinguish between PRACH requests addressed to different cells.

For cross-border coordination it is proposed to use frequency position offsets to exclude the possibility of so-called “ghost” PRACH requests caused by neighbouring networks. The PRACH is configured in LTE to use only 6 Resource Blocks or 1.08 MHz of the LTE channel bandwidth except in regions used by PUCCH. In case of overlapping or partially overlapping channel bandwidths of neighbouring networks it is enough to establish non-overlapping PRACH frequency blocks to perform coordination. Because it is difficult to establish an implementation dependent procedure for such allocation it will be the responsibility of operators to manage such frequency separation during coordination discussions.

In early implementation it is possible that very limited number of frequency positions will be supported by LTE equipment which will not be enough to co-ordinate in the trilateral case. In such cases root-sequence repartition could be used. There are 838 root sequences in total to be distributed between cells, numbered {0..837}. There are two numbering schemes for PRACH root sequences (physical and logical) and that only logical root sequences numbering needs be used for coordination. Unfortunately the process of root sequences planning doesn’t involve direct mapping of root sequences between cells because the number of root sequences needed for one cell is dependent on the cell range. The table showing such interdependency is presented below:

PRACH Configuration	Number of root seq. per cell	Cell Range (km)
1	1	0.7
2	2	1
3	2	1.4
4	2	2
5	2	2.5
6	3	3.4
7	3	4.3
8	4	5.4
9	5	7.3
10	6	9.7
11	8	12.1
12	10	15.8
13	13	22.7
14	22	38.7
15	32	58.7
0	64	118.8

Thus in the case of root sequence reparation it will be the responsibility of radio network planners to assign the correct number of root sequences in order to not to overlap with the root sequence ranges of other operators. It also should be noted that different root sequences have different cubic metrics and correlation properties which affect PRACH coverage performance and planning of so-called high-speed cells. For simplicity of cross-border coordination it is proposed to ignore these properties.

In summary it should be stipulated that frequency separation of PRACH resources should be used as the main coordination method. PRACH root sequences repartition should be avoided and used only in exceptional cases. Specific PRACH root sequences repartition is not provided in the text of Recommendation but could be deduced in a similar manner to the PCI repartition shown in the previous Annex.