CEPT ECC
Electronic Communications Committee

ECC Recommendation (11)05

Cross-border Coordination for Mobile/Fixed Communications Networks (MFCN) in the frequency band 2500-2690 MHz

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INTRODUCTION

This Recommendation contains provisions for cross-border coordination between Mobile/Fixed Communications Networks (MFCN) in border areas in the frequency band 2500-2690 MHz.

ECC RECOMMENDATION (11)05 OF 26 MAY 2011 ON CROSS-BORDER COORDINATION FOR MOBILE/FIXED COMMUNICATIONS NETWORKS (MFCN) IN THE FREQUENCY BAND 2500-2690 MHz, AMENDED 3 FEBRUARY 2017, UPDATED 18 NOVEMBER 2022, CORRECTED 8 MARCH 2024

"The European Conference of Postal and Telecommunications Administrations,

considering

a) that the Radio Regulations [1] identify the frequency band 2500-2690 MHz for terrestrial IMT (RR 5.384A);

b) that "mobile/fixed communications networks" for the purpose of this Recommendation includes IMT and other communications networks in the mobile and fixed services;

c) that ECC Decision (05)05 [2] designates the band 2500-2690 MHz for terrestrial IMT and harmonises spectrum usage for IMT;

d) that EC Decision of 13 June 2008 [3] on the harmonisation of the 2500-2690 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community (2008/477/EC) is mandatory for EU and EFTA countries;

e) that in many CEPT member countries there may be multiple operators for MFCN systems;

f) that different administrations may wish to adopt different approaches to cross border co-ordination;

g) that CEPT Report 19 [4] proposes one set of trigger values for cross-border coordination of MFCN systems at 2500-2690 MHz;

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

i) that coordination is necessary between countries operating different technologies and different channel bandwidths in the same frequency band;

j) that ECC Decision(05)05 is based on a block size of 5 MHz at 2500-2690 MHz;

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

l) that other radio parameters may need to be coordinated for LTE systems on a bi/multi-lateral basis.

recommends

1. that cross-border coordination between MFCN systems in border areas should be based on bilateral or multilateral agreements between administrations;

2. that cross-border coordination between MFCN systems and other services in neighbouring countries should be based on bilateral / multilateral agreements;

3. that bilateral / multilateral agreements should define coordination methods which encompass all MFCN radio interfaces present on each side of the border;

4. that cross-border co-ordination between FDD MFCN systems should be based on the principles and the field strength limits provided in Annex 1;

5. that cross-border co-ordination between TDD MFCN systems or between TDD MFCN and FDD MFCN should use the principles and the field strength limits provided in Annex 2;

6. that if the levels in Annex 1 and / or Annex 2 are exceeded coordination is required and the procedure detailed in Annex 4 should be used;

7. that the coordination of LTE systems in border areas should be based on the PCI's provided in Annex 5 when channel centre frequencies are aligned;

8. that other radio parameters for LTE may need to be coordinated on a bi/multi-lateral basis based on the guidance provided in Annex 6;

9. that interference field strength predictions should be made by using one of the propagation models defined in Annex 3;

10. that administrations should encourage and facilitate the establishment of arrangements between operators of neighbouring countries with the aim to enhance the efficient use of the spectrum and the coverage in the border areas;

11. 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;

12. that administrations may diverge from the technical parameters and procedures described in this Recommendation subject to bilateral / multilateral agreements;

13. that this Recommendation should be reviewed within 4 years of its adoption in the light of practical experience of its application and of the operation of MFCN systems."

Note:

Please check the Office documentation database https://docdb.cept.org/ for the up to date position on the implementation of this and other ECC Recommendations.

ANNEX 1: FIELD STRENGTH LEVELS FOR THE CROSS BORDER OPERATION BETWEEN FDD MFCN SYSTEMS IN THE FREQUENCY BAND 2500-2690 MHz

1. Stations of FDD systems with centre frequencies not aligned on both sides of the borderline or with centre frequencies aligned using preferential PCI codes given in Annex 5 may be used without coordination with a neighbouring country if the mean field strength produced by the cell (all transmitters within the sector) does not exceed the value of 65 dBμV/m/5 MHz at a height of 3 m above ground at the borderline between countries and does not exceed a value of 49 dBμV/m/5 MHz at a height of 3 m above ground at a distance of 6 km inside the neighbouring country.

2. Stations of MFCN FDD systems with centre frequencies aligned on both sides of the borderline using non-preferential PCI codes given in Annex 5 may be used without coordination with a neighbouring country if the mean field strength produced by the cell (all transmitters within the sector) does not exceed the value of 49 dBμV/m/5 MHz at a height of 3 m above ground at the borderline between countries.

3. It is usually not considered necessary to define preferential frequencies. If administrations wish to agree on frequency coordination based on preferential frequencies, while ensuring a fair treatment of different operators then they can do so based on mutual agreements. In this case field strength levels in *paragraph 1* above may be applicable.

The following table gives overview of the trigger values of the field strength and the relevant sections of this Annex.

Table 1: Trigger values at a height of 3 m above ground for MFCN FDD systems

Non-Preferential frequency usage			Preferential frequency usage
Centre frequencies aligned		**Centre frequencies not aligned**	Based on bi-or multilateral agreements/ arrangement (paragraph 3)
Using preferential PCI codes	Using non-preferential PCI codes	Using all PCI codes	
65 dBμV/m/5 MHz@0 km and 49 dBμV/m/5 MHz@6 km (paragraph 1)	49 dBμV/m/5 MHz@0 km (paragraph 2)	65 dBμV/m/5 MHz@0 km and 49 dBμV/m/5 MHz@6 km (paragraph 1)	
@ stands for "at a distance inside the neighbouring country"			

For field strength predictions the calculations should be made according to Annex 3. In cases of channel bandwidth other than 5 MHz, a factor of 10 x Log_{10} (channel bandwidth[1] /5 MHz) should be added to the field strength values.

[1] not occupied bandwidth

ANNEX 2: FIELD STRENGTH LEVELS FOR THE CROSS BORDER OPERATION BETWEEN TDD MFCN AND BETWEEN TDD AND FDD MFCN SYSTEMS IN THE FREQUENCY BAND 2500-2690 MHz

1. In general, stations of MFCN systems may be operated without coordination if the mean field strength produced by the cell (all transmitters within the sector) does not exceed the value of 30 dBµV/m/5 MHz at at 3 metres above ground level at the borderline.

2. If administrations wish to agree on frequency coordination based on preferential frequencies, or MFCN TDD systems are in operation across both sides of a border and are synchronised across the border, or MFCN TDD systems are deployed as downlink only on both sides of the border, then field strength levels such as those in Annex 1 may be applicable. If those values are not acceptable, field strength levels should be agreed on a bi- or multilateral basis.

3. TDD operation within the bands 2500-2570 MHz and 2620-2690 MHz has not been studied with FDD operation. TDD operation within these bands will only occur if countries do not adopt the channelling arrangement in ECC Decision (05)05 [2]. In this case the field strength levels should be agreed on a bi- or multilateral basis.

The following table gives overview of the trigger values of the field strength and the relevant sections of this Annex.

Table 2: Trigger values at a height of 3 m above ground between TDD systems

<table>
<tr><th colspan="5">Non-Preferential frequency usage</th><th>Preferential frequency usage</th></tr>
<tr><td colspan="3">Centre frequencies aligned</td><td colspan="2">Centre frequencies not aligned</td><td rowspan="4">Based on bi-or multilateral agreements (Annex 1 paragraph 3)</td></tr>
<tr><td colspan="2">Synchronised TDD, or DL only</td><td>Unsynchronised TDD</td><td>Synchronised TDD, or DL only</td><td>Unsynchronised TDD</td></tr>
<tr><td>Preferential PCI codes</td><td>Non-preferential PCI codes</td><td>All PCI codes</td><td colspan="2">All PCI codes</td></tr>
<tr><td>65 dBµV/m/5 MHz@0 km
and
49 dBµV/m/5 MHz@6 km
(paragraph 2)</td><td>49 dBµV/m/5 MHz@0 km
(paragraph 2)</td><td>30 dBµV/m/5 MHz@0 km
(paragraph 1)</td><td>65 dBµV/m/5 MHz@0 km
and
49 dBµV/m/5 MHz@6 km
(paragraph 2)</td><td>30 dBµV/m/5 MHz@0 km
(paragraph 1)</td></tr>
<tr><td colspan="6">@ stands for “at a distance inside the neighbouring country”</td></tr>
</table>

For field strength predictions the calculations should be made according to Annex 3. In the case of other channel bandwidth other than 5 MHz, a factor of 10 x Log$_{10}$ (channel bandwidth[2] /5 MHz) should be added to the field strength values.

[2] not occupied bandwidth

ANNEX 3: 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.

A3.1 PATH SPECIFIC MODEL

Where appropriate detailed terrain data is available, the propagation model for interference field strength prediction is the latest version of Recommendation ITU-R P.452 [1], 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 more than 10% of predicted values exceed the threshold the station should be required to be coordinated.

Values for x, y, z and path specific field strength levels are to be agreed between the administrations concerned.

A3.2 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 coordination between administrations and to decide, if co-ordination is necessary, is Recommendation ITU-R P.1546 [2]. This model is to be employed for 50% locations, 10% time and using a receiver height of 3 m.

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[3].

A3.3 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 3 m above ground.

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

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 field strength than the trigger field strength value given for the borderline in Annex 1 and Annex 2 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 and Annex 2 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 [2] with the terrain clearance angle correction factor TCA, HCM method with the terrain clearance angle correction factor or Recommendation ITU–R P.1812 [3]).

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 [4] 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 4: EXCHANGE OF INFORMATION

When requesting coordination the relevant characteristics of the base station and the PCI numbers should be forwarded to the administration affected. All of the following characteristics should be included:

a) centre frequency (MHz);

b) channel bandwidth (MHz);

c) name of transmitter station;

d) country of location of transmitter station;

e) geographical coordinates (W/E, N; WGS84);

f) effective antenna height (m);

g) antenna polarisation;

h) antenna azimuth (deg);

i) directivity in antenna systems or antenna gain (dBi);

j) effective radiated power (dBW);

k) expected coverage zone;

l) date of entry into service (month, year);

m) PCI numbers used (only for LTE);

n) antenna tilt (deg / Electric and mechanic tilt);

o) antenna pattern or envelop.

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

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 should be deemed to have given its consent and the PCI coordination 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 IMT-2000/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 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.

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, BUL, D, EST, G, HNG, I, MDA, GEO.

Type country 3: ALB, AUT, F, HOL, HRV, POL, POR, ROU, 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 PCI’s with its neighbouring countries, with the following conventions of writing:

(black)	Preferential PCI
	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:

Table 3: PCI sub-sets for use in border areas when the carrier frequencies are aligned

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..33	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		■		■		

Note: 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.

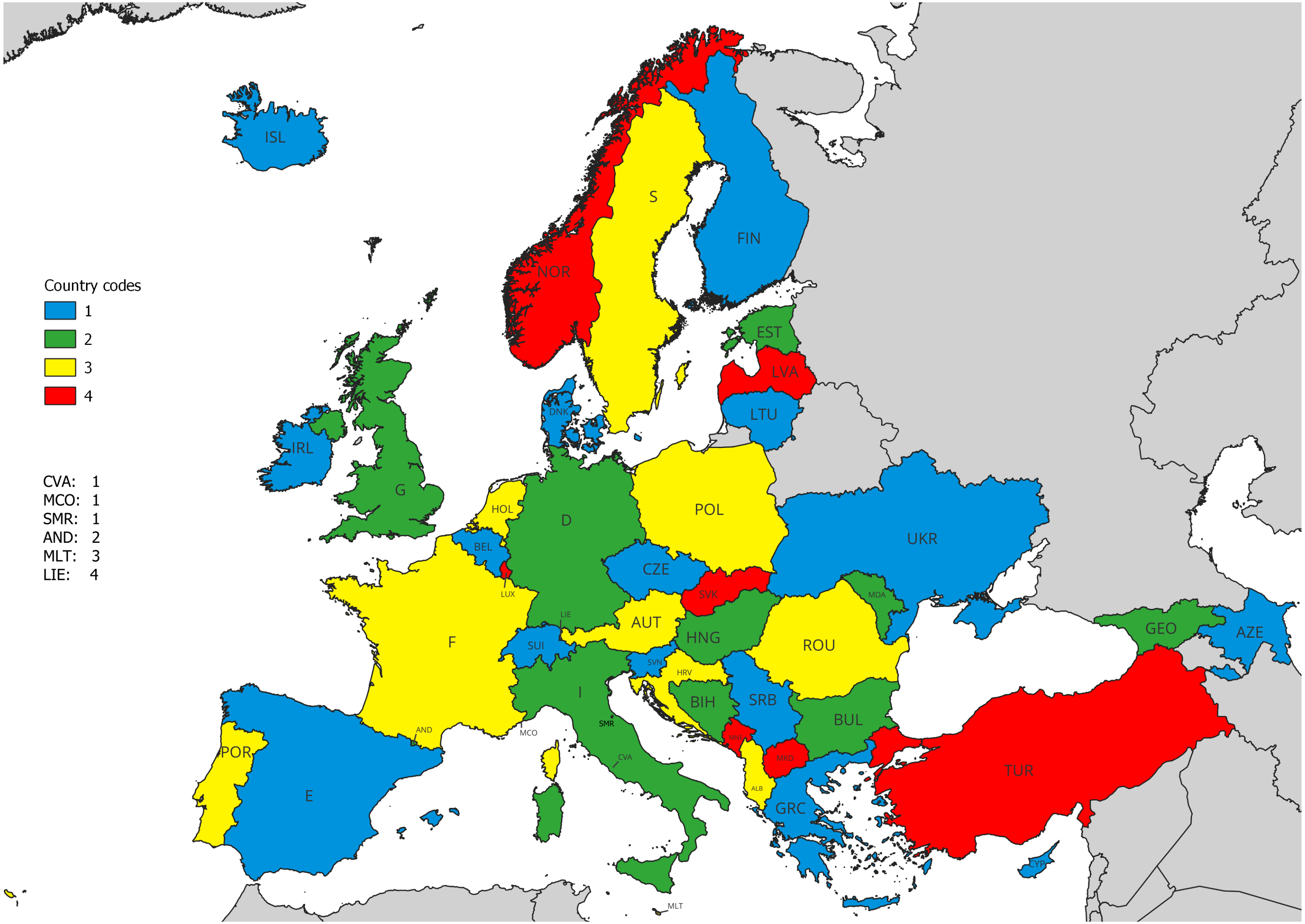

Figure 1: Recommended PCI distribution map

ANNEX 6: GUIDANCE ON THE CONSIDERATION OF LTE RADIO PARAMETERS FOR USE IN BILATERAL 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 coordinate 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 optimised during LTE radio network planning of an operator's network. The idea of optimisation 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 optimisation 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.

A6.1 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 synchronisation. 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 utilised. 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 Annex 5.

A6.2 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 synchronised 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 coordinate 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:

Table 4: Interdependency of PRACH root sequences with cell range

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 repartition 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 this Recommendation but could be deduced in a similar manner to the PCI repartition shown in Annex 5.

ANNEX 7: LIST OF REFERENCES

[1] ITU Radio Regulations, Edition of 2020

[2] ECC Decision (05)05: “ECC Decision of 18 March 2005 on harmonised utilisation of spectrum for Mobile/Fixed Communications Networks (MFCN) operating within the band 2500-2690 MHz”, latest corrected 4 March 2022

[3] EC Decision 2008/477/EC: “Commission Decision of 13 June 2008 on the harmonisation of the 2500-2690 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community”

[4] CEPT Report 19: “Report from CEPT to the European Commission in response to EC Mandate to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS”, approved October 2008

[5] Recommendation ITU-R P.452: “Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz”

[6] Recommendation ITU–R P.1546: “Method for point to area predictions for terrestrial services in the frequency range 30 to 3000 MHz”

[7] Recommendation ITU–R P.1812: “A path-specific propagation prediction method for point-to-area terrestrial services in the frequency range 30 MHz to 6 000 MHz”

[8] Recommendation ITU–R P.1406: “Propagation effects relating to terrestrial land mobile and broadcasting services in the VHF and UHF bands”