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The co-ordination of GSM-R systems and radio planning at borders

Coordination des systèmes GSM-R et de la planification radio aux frontières
Die Koodinierung der GSM-R-Systeme und der Funkplanung an den Grenzen

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Contents

Summary

The purpose of this leaflet is to give the background of the radio frequency aspects and to enable railways to co-ordinate the introduction and operation of GSM-R networks in the most efficient manner. The leaflet describes:

-	the frequencies allocated to GSM-R and Direct Mode,

-	the method to be used in co-ordinating these frequencies at borders,

-	the use of network colour codes,

-	the implementation of new features and software upgrades,

-	the use of algorithms,

-	the use of network names,

-	the management of network parameters.

1 - General

The signatories to the *EIRENE Memorandum of Understanding* (see Bibliography - page 18 and List of abbreviations - page 16) agreed that in the development and introduction of new radio communications systems for railway operations in Europe and throughout the world, it is important that a common standard is adopted and that in their individual implementations they would ensure that full interoperability as defined by the mandatory requirements of the EIRENE specification is contained within the systems of their individual railways.

To enable this goal to be achieved, the signatories of the MoU agreed the following:

1. To adopt those aspects of the ETSI GSM (see List of abbreviations - page 16) standard adapted for railway operations essential to interoperability as the basis for their new train radio systems from 2005 at the latest.

2. To implement the mandatory requirements of the EIRENE specification when it is - overall - economically advantageous on a particular route to do so to enable interoperability of rolling stock across international boundaries.

3. To co-operate with neighbouring railways on the introduction of new systems to enable as rapid an introduction as possible.

4. To co-ordinate with neighbouring railways or other radio spectrum licence holders where applicable, on the allocation of frequencies from *CEPT/ERC Recommendation TR 25-09* (see Bibliography - page 18), using the procedure laid down in point 4 - page 6.

5. To exchange information on the practical experience gained in the implementation of systems.

The purpose of this leaflet is to enable railways to co-ordinate the introduction and operation of their GSM-R networks (see List of abbreviations - page 16) in the most efficient manner. In the following sections this leaflet describes

- the frequencies allocated to GSM-R and Direct Mode (see List of abbreviations - page 16),

- the method to be used in co-ordinating these frequencies at borders,

- the use of network colour codes,

- the implementation of new features and software upgrades,

- the use of algorithms,

- the use of network names,

- the management of network parameters.

2 - Frequencies for GSM-R

The frequencies for GSM-R as designated in the EIRENE Specification were negotiated with the European Communications Committee (formerly the CEPT) (see List of abbreviations - page 16) to ensure that interoperability was achievable between countries.

These are set out in the *ECC Decision ECC (02) 05 of 5 July 2002*. This superseded *ERC Recommendation T/R 25-09 E* (see Bibliography - page 18).

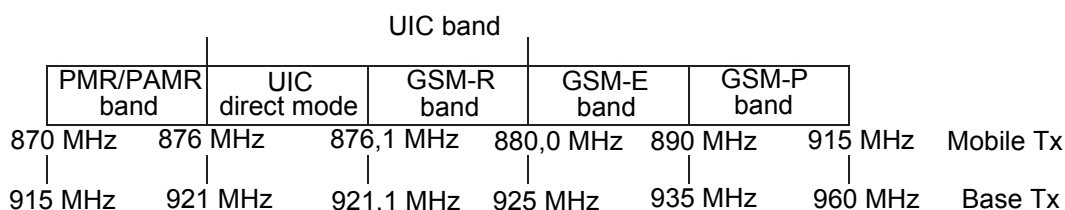|	UIC band				
PMR/PAMR band	UIC direct mode	GSM-R band	GSM-E band	GSM-P band	
870 MHz 876 MHz	876,1 MHz	880,0 MHz 890 MHz	915 MHz	Mobile Tx	
915 MHz 921 MHz	921,1 MHz	925 MHz 935 MHz	960 MHz	Base Tx	

Fig. 1 - The 900 MHz Band

Fig. 1 shows the UIC band in relation to the adjacent allocations to other services in Europe. Each GSM-R channel (like those allocated to GSM) is 200 kHz wide. The ECC recommends guard bands to protect adjacent services, which can be found in the appropriate ECC reports. In the case of GSM-R a 400 to 600 kHz guard band is recommended to PMR/PAMR services below the UIC GSM-R allocation of which 100 kHz is taken from the UIC band (and is now reserved for UIC Direct mode). The recommended guard band between the GSM-R band and the GSM-E band is one channel if services are co-ordinated and two channels if they are uncoordinated. One channel of the GSM-R allocation is allocated to this guard band leaving 19 channels for GSM-R use out of the twenty possible channels (see List of abbreviations - page 16).

ECC decision (02)05 specifies the frequencies for GSM-R as shown in Table 1 - page 4.

Table 1 : GSM-R Channels

Centre frequency Mobile TX (MHz)	Centre frequency Base TX (MHz)
876,2000	921,2000
876,4000	921,4000
876,6000	921,6000
876,8000	921,8000
877,0000	922,0000
877,2000	922,2000
877,4000	922,4000
877,6000	922,6000
877,8000	922,8000
878,0000	923,0000
878,2000	923,2000
878,4000	923,4000
878,6000	923,6000
878,8000	923,8000
879,0000	924,0000
879,2000	924,2000
879,4000	924,4000
879,6000	924,6000
879,8000	924,8000
880,0000 [a]	925,0000 [a]

a. The frequency 880,0000 MHz paired with 925,0000 MHz may be considered as guard channel to other services in adjacent bands.

It is a condition of the ECC Decision that the original recommendation on frequencies in the 450-470 MHz band (*Recommendation CEPT/ERC T/R 22-01* - see Bibliography - page 18) will be withdrawn.

The GSM-R frequencies are also designated in the *modified Annex A of 29 April 2004 of the European Community Decision 2002/731/EC of 30 May 2002* (see Bibliography - page 18) establishing the main characteristics of Class A system (ERTMS - see List of abbreviations - page 16) of the control-command and signalling subsystem relating to the trans-European conventional rail system (notified under document number C(2004) 1559) .

GSM Channel numbers for the GSM-R frequencies are designated in the *ETSI specification EN 300 910* (see Bibliography - page 18), available from the ETSI website, http://www.etsi.org.

3 - Frequencies for Direct Mode

3.1 - Definition

Direct Mode operation is specified in the EIRENE FRS as an optional feature to allow users to communicate when in close proximity under GSM-R network failure conditions.

R ## 3.2 - Frequency issues

The frequencies for Direct Mode operation are specified in the EIRENE specification and *ECC Decision ECC (02)05* and are located in the Mobile transmit leg only of the allocation between 876,0 and 876,1 MHz.

As the Direct Mode frequencies are situated in the GSM-R guard band to the PMR/PAMR allocation below the first GSM-R channel (see point 2 - page 3) they should not be used at the same time as the first three GSM-R channels as they will cause interference to the GSM-R service. This aspect is detailed in *ECC Report 86* (see Bibliography - page 18).

o 4 - Frequency co-ordination at borders

The signatories of the *EIRENE Memorandum of Understanding* agreed in their individual implementations that they will co-operate to ensure that optimum use of the frequencies in the GSM-R band is achieved.

Within the CEPT administrations this is handled by bi- and multilateral frequency co-ordination MoUs and agreements such as the *Berlin Agreement* and *CEPT/ECC Recommendation T/R 25-08* (see Bibliography - page 18), in which channelling, pairing and agreed propagation curves to be used in frequency co-ordination within the range 29,7-960 MHz are set out. The *Berlin Agreement* can be found at the website: http://ba.bmwa.bund.de.

Frequency administrations often set up preferential frequency agreements as part of their co-ordination process. These are tables where the individual radio channels are preferentially allocated to different countries. A non-preferential frequency is subject to co-ordination at the national border whilst a preferential frequency is co-ordinated at the agreed point outside the national border.

To enable this goal to be achieved the GSM-R network operators should:

- Manage their use of the radio frequencies in the most spectrum efficient manner, reusing frequencies as often as possible and keeping transmitter powers and heights to the lowest possible levels;

- Co-ordinate frequency assignments with their national frequency administration. The co-ordination procedures laid down in the main text and annexes of the current version of the *Berlin Agreement* shall be applied. All bi- or multilateral agreements of Administrations concerning the co-ordination in the frequency bands 876-880 MHz and 921-925 MHz overrule the *Berlin Agreement* (i.e. preferential frequency agreements and co-ordination distance);

- If a co-ordination request to the Administration of a neighbour country is required, a binding agreement between the neighbouring railways using the procedure defined below is essential.

Details of contact names addresses, etc., for the CEPT frequency administrations can be found on the ERO website, http://www.ero.dk, under the heading CEPT administrations.

Procedure for binding arrangements between railways on frequencies in the frequency bands 876-880 MHz and 921-925 MHz

R 4.1 - Allocation of preferred frequencies

When obtaining frequency assignments from frequency administrations, it is usual that preferred frequencies will be identified. There are a number of alternative schemes that can be applied, however it is recommended that the allocation be made on the basis of radio channels alternating individually or in blocks on either side of the borderline between two or more networks as shown in the Table 2. More examples can be found in the *Berlin agreement*.

Table 2 : Examples of preferred frequency agreement

GSM Channel Number	Uplink frequency	Downlink frequency	Country/ Network Scheme 1	Country/ Network Scheme 2
955	876,2	921,2	Common	Common
956	876,4	921,4	A	A
957	876,6	921,6	B	A
958	876,8	921,8	A	A
959	877,0	922,0	B	A
960	877,2	922,2	A	B
961	877,4	922,4	A	B
962	877,6	922,6	B	B
963	877,8	922,8	B	B
964	878,0	923,0	A	B
965	878,2	923,2	A	A
966	878,4	923,4	B	A
967	878,6	923,6	B	A
968	878,8	923,8	A	A
969	879,0	924,0	B	A
970	879,2	924,2	B	B
971	879,4	924,4	A	B
972	879,6	924,6	A	B
973	879,8	924,8	B	B
974	880,0	925,0	Common	Common

o 4.2 - Identification of interference potential

The railway (GSM-R Network Operator) wishing to use a frequency (hereafter known as the originator) shall calculate the field strength on the borderline and in case of a preferential frequency on a line 15 km inside the border of the neighbouring country, (or at some other locations if so required by the frequency administrations based on the GSM-R operational rules which have been defined bilaterally). The Harmonized Calculation Method (HCM) according to Annex 5 of the *Berlin Agreement* shall be used. Fig. 2 describes the procedure to be followed for identification of need for co-ordination. The permissible field strength to be used is 19 dBµV/m at 3 m above ground.

o 4.3 - Advice to neighbouring railways

If the proposed use of the frequency is found to exceed the limits identified in point 4.2, the neighbour(s) railway(s) shall be advised of the details of the proposal for their consideration. For exchange of technical information, the data format according to *Annex 2A of the Berlin Agreement* shall be used.
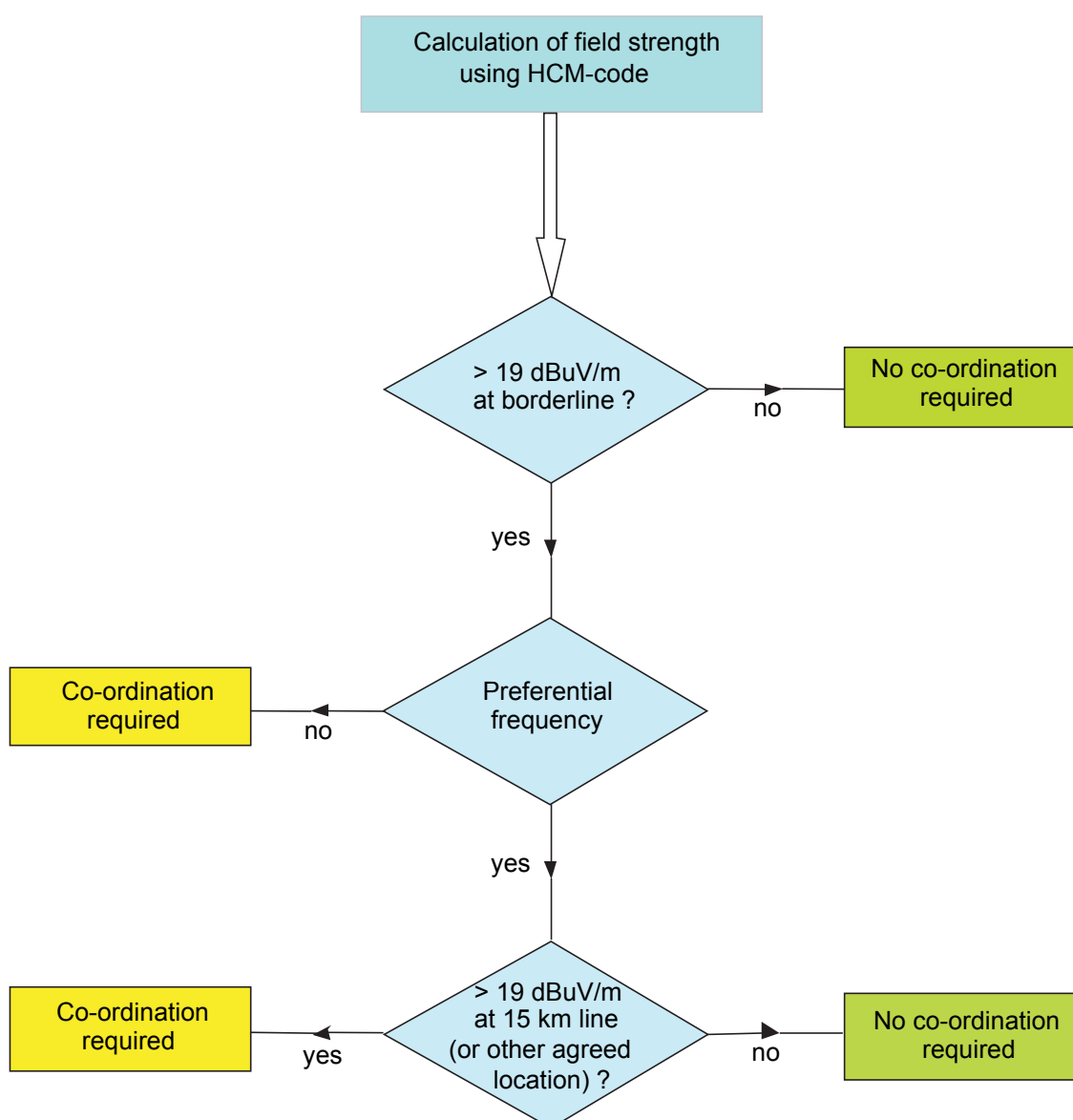
Fig. 2 - Procedure for identification of need for co-ordination

o 4.4 - Neighbouring railways' response

The neighbour(s) shall consider the proposed use of the frequency and provide, as quickly as possible, a binding agreement to its use or co-operate so that an alternative proposal can be agreed.

o 4.5 - Formal approval

The originator will submit the proposal (as agreed with its neighbours following the procedure in points 4.2 - page 8 to 4.4) through its frequency administration for co-ordination with the neighbour's administration. On receipt of the proposal the neighbour(s) railway(s) shall indicate their willingness to approve the proposal to their Administrations without undue delay.

R 5 - Use of Network Colour Codes (NCC)

Within the *GSM Specification GSM 03.03 - A.2: "Guidance for planning"*, the following is stated: "*If there exist places where MSs can receive two cells, whether in the same PLMN or in different ones, that use the same BCCH frequency, it is highly preferable that these two cells have different BSICs*" (see Bibliography - page 18).

Where the radio coverage areas of two PLMNs (see List of abbreviations - page 16) overlap, the rule above is respected if:

1. The PLMNs use different sets of BCCH (see List of abbreviations - page 16) frequencies. This is in particular the case if no frequency is common to the two PLMNs. This usually holds for PLMNs in the same country.

2. The PLMNs use different sets of NCCs (see List of abbreviations - page 16).

3. BSIC and BCCH frequency planning is co-ordinated.

As GSM-R systems use the same frequencies, solution 1 cannot be applied to distinguish between networks, although solution 3 applies as recommended in point 4 - page 6. Generally it is advantageous to use different NCCs in adjacent networks as identified by solution 2.

The following list is based on those values already being used by railways (GSM-R network operators) and on *GSM 03.03 A.3 "Example of PLMN Colour Codes (NCCs) for the European region"* (see Bibliography - page 18). It is recommended that railways use the NCCs listed here.

Table 3 : List of recommended NCCs

Country	Recommended NCC
Albania	4
Austria	0
Belgium	0
Belarus	1
Bosnia and Herzegovina	1
Bulgaria	1
Croatia	3
Czech Republic	1
Denmark	1
Estonia	2
Euro Tunnel	3
Finland	4
France	4
Germany	7
Greece	0
Hungary	4

Table 3 : List of recommended NCCs

Country	Recommended NCC
Ireland (Republic of)	3
Italy	2
Latvia	2
Lithuania	2
Luxembourg	2
The Former Yugoslav Republic of Macedonia	2
Moldova	4
Netherlands	1
Norway	3
Poland	4
Portugal	3
Romania	2
Russia	0
Serbia and Montenegro	3
Slovakia	2
Slovenia	1
Spain	1
Sweden	7
Switzerland	1
Turkey	2
UK	2
Ukraine	3

This allows for each country a second operator by allocating the colour codes n (in Table 3) and n ± 4. More than two colour codes per country may be used provided that in border areas only the values n and/or n ± 4 are used.

6 - Implementation of new features and software upgrades

When implementing new features and software upgrades where radio coverage may be affected, GSM-R network operators and train operators need to co-ordinate their implementation, not only nationally but also internationally.

It is preferred that all changes support full backward compatibility for mobiles operating within the home network and those roaming from adjacent networks **(R)**. Where this is not possible bi-lateral or multi-lateral agreements as appropriate shall be set up to ensure the change is fully co-ordinated **(O)**.

Other new features and software upgrades should be implemented in a harmonised way to guarantee interoperability.

R 7 - Algorithms

The GSM encryption algorithm specifically supplies signalling protection, so that sensitive information such as telephone numbers is protected over the radio path, and user data protection, to protect voice calls and other user generated data passing over the radio path.

The recommended encryption algorithm for GSM-R networks is A5. The latest available version is A5/3, which is described in *EN 301 515 (references 47-50)* (see Bibliography - page 18) and is available under license from ETSI with the approval of EPRT (see List of abbreviations - page 16).

A fee is chargeable to railways wishing to implement and/or use the A5/3 and GEA3 algorithm specifications.

The authentication algorithm is freely available and is described in *ETSI specification EN 301 515 (reference 46)*.

R 8 - Network names

To give a clear indication of the available networks to GSM-R users on international trains, the recommended format for GSM-R network names is as follows GSM-R XXXXX, where XXXXX describes the railway or network operator e.g. GSM-R OEBB for the OEBB.

R 9 - The management of network parameters

Within a GSM-R network there are parameters such as timers and warning tones that are set by the network operator. Typical examples are the "no activity timer" for clearing group calls and railway emergency calls, and the warning tone associated with the termination of a group call.

Railways should share information on these aspects to avoid unexpected effects for users when roaming to neighbouring networks.

List of abbreviations

BCCH   GSM-R base station broadcast control channel

BSIC   Base Station Identification Code – The code transmitted by each GSM-R base station that enables a mobile station to identify that base station and its associated network.

CEPT   European Committee for Post & Telecommunications – The European body with representatives from national governments and their agencies which co-ordinates post and telecommunications matters across Europe.

Direct Mode   Direct Mode is a method of radio communication where communication takes place directly between mobiles (one of which may be in a fixed location) without use of radio infrastructure or a network.

ECC   Electronics Communication Committee – The committee responsible as part of the CEPT for the management of radio frequencies in Europe.

EIRENE   European Integrated Railways Radio Enhanced Network – The UIC specifications which define the requirements for GSM-R implementation and operation to ensure international interoperability.

EPRT   ETSI Project Rail Team

ERC   European Radio Communications Committee – The predecessor to the ECC

ERTMS   European Rail Traffic Management System

ETSI   European Telecommunications Standards Institute – The European organisation responsible for Telecommunications standards

GSM   Global System for Mobile Communications – The abbreviation used to identify the world-wide public mobile communications system developed by and defined in ETSI specifications.

GSM-E band   The extended frequency band for public GSM below the GSM-P band (880-890 MHz paired with 925-935 MHz)

GSM-P band   The primary band for public GSM (890-915 MHz paired with 935-960 MHz)

GSM-R   GSM for Railways – The GSM system that has been defined in the EIRENE specifications and is based on enhanced GSM specifications.

GSM-R band   The preferred frequency band for GSM -R below the GSM-E band (876-880 MHz paired with 921-925 MHz).

GSM-R Network Operator A railway or associated organisation responsible for the operation and maintenance of a GSM-R network.

MS Mobile Station – any mobile radio operating on a GSM or GSM-R network

NCC Network Colour Code – A code transmitted by each GSM-R base station as part of its BSIC

PAMR Public Access Mobile Radio – A public mobile network designed and operated to provide communication for business organisations

PLMN Public Land Mobile Network – The definition used in ETSI for an individual GSM or GSM-R network

PMR Private Mobile Radio – Mobile radio generally operated by an organisation for its own use and benefit

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