CEPT ECC
Electronic Communications Committee

ECC Report 374

Guidance for an efficient national implementation of ECC Decision (20)02 and facilitating coexistence between RMR and MFCN

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0 EXECUTIVE SUMMARY

This Report provides guidance to administrations as well as to RMR (Railway Mobile Radio) and MFCN (Mobile/Fixed Communications Networks) licensees to facilitate coexistence between RMR and MFCN. It describes a toolbox for an efficient national implementation of ECC Decision (20)02. The purpose of this Report is not to revise ECC Decision (20)02 [2], but to outline possible measures and procedures that minimise the implementation burden for all involved parties for cooperation between administrations, RMR operators and MFCN operators. The toolbox describes principles of coordination, possible mitigation measures and a generic coordination and cooperation process for implementation of a new radio site or modification of an existing radio site.

The generic principles of the toolbox include early information sharing between RMR and MFCN operators, reasonable efforts by operators to plan new radio sites so as to avoid interference with the other network and minimising the need for direct coordination. A pragmatic approach during the Future Railway Mobile Communications System (FRMCS) or MFCN planning stage is to identify critical radio sites before triggering any detailed coordination. A critical radio site is a radio site with potential risk of interference from adjacent frequency band. This Report does not prescribe a coordination zone between FRMCS and MFCN sites. Coordination zones could be defined on a national level and should be specific per frequency band and per MFCN operator (due to variation in frequency separation between MFCN and RMR channels resulting from MFCN spectrum assignment within a frequency band).

When potential coexistence issues arise, the different parties (RMR and MFCN operators) should be encouraged to work together to find a mutually agreed solution. In this process, national administrations could act as a neutral mediator, working with both parties to find solutions and proportional mitigation options. Important mitigation options are site location, antenna height and main beam direction, radio-planning measures (while meeting railway planning and quality criteria for safety and interoperability) and hardware-related measures including enhanced receiver selectivity for MFCN base stations as considered in ECC Decision (20)02 [2] and ECC Decision (06)01 [14].

The strategy and the migration timeline of GSM-R to FRMCS will be decided at national level. Railway infrastructure managers will make their decisions for the relevant migration scenario from their current GSM-R network to a new FRMCS network, based, amongst others, on interoperability and specific national requirements. During the migration period, train on-board equipment will need to be upgraded to support FRMCS. Even if no specific FRMCS deployment plans have been communicated by RMR operators to MFCN operators, all existing GSM-R sites should be assumed to be future FRMCS radio sites.

Railway interoperability throughout Europe must be ensured, even during the migration period from GSM-R to FRMCS. Requirements and conditions for the provision of harmonised functionality along the railway lines are defined today for GSM-R in EIRENE FRS (Functional Requirements Specification) and SRS (System Requirements Specification). Those specifications related to interoperability are legally binding in Europe, since they are part of the Control Command and Signalling Technical Specification for Interoperability (CCS TSI), which is published through a European Commission Regulation and its amendments. A similar framework will also be used for FRMCS once standardisation has been completed. Section 3 describes the ECC regulatory framework for RMR and MFCN and the additional requirements in ETSI technical specifications (ETSI TS 103 807 [10] and ETSI TS 103 793 [11]) reflecting EC/CEPT spectrum regulatory framework.

The toolbox for facilitating coexistence between RMR and MFCN is described in section 5 and can be adapted to meet specific needs at national level. Co-located sites are usually managed by contracting parties. This Report may also be used to facilitate coexistence on co-located sites.

Annex 1 provides an overview of the existing processes of cooperation and coordination implemented for GSM-R interference resolutions in national railway environments throughout Europe. These processes are essentially based on ECC Report 229 [7] and can be adapted to the needs of an efficient national implementation of ECC Decision (20)02 [2].

Annex 2 describes recommended data that should be exchanged between operators for the purpose of evaluating possible interference. The list can be amended by national agreements.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
2G	2nd generation of 3GPP mobile network technology
3G	3rd generation of 3GPP mobile network technology
4G	4th generation of 3GPP mobile network technology
5G	5th generation of 3GPP mobile network technology
3GPP	3rd Generation Partnership Project
ACLR	Adjacent Channel Leakage power Ratio
AGL	Above Ground Level
ARFCN	Absolute Radio Frequency Channel Number
ASL	Above Sea Level
BEM	Block Edge Mask
BS	Base Station
CCS	Control Command and Signalling
CEPT	European Conference of Postal and Telecommunications Administrations
EC	European Commission
ECC	Electronic Communications Committee
EDOR	ETCS Data Only Radios
E-GSM	Extended GSM band
EIRENE	European Integrated Railway Radio Enhanced Network
e.i.r.p.	Equivalent Isotropically Radiated Power
ER-GSM	Extended R-GSM (873-915MHz / 918-960MHz) as defined by ETSI
ETCS	European Train Control System
ETSI	European Telecommunications Standards Institute
EU	European Union
FRMCS	Future Railway Mobile Communication System
GSM	Global System for Mobile Communications
GSM-R	GSM for Railway
LNA	Low Noise Amplifier
LTE	Long Term Evolution

Abbreviation	Explanation
LRTC	Least Restrictive Technical Conditions
MCL	Minimum Coupling Loss
MFCN	Mobile/Fixed Communications Networks
MNO	Mobile Network Operator
MORANE 2	MObile radio for RAilway Networks in Europe 2
NDA	Non-Disclosure Agreement
NR	New Radio
NRA	National Regulatory Authority
OOB	Out-Of-Band
P-GSM	Primary GSM band
RF	Radio Frequency
RMR	Railway Mobile Radio
RU	Railway Undertaking
RX	Receiver
SRS	System Requirements Specification
TR	Technical Report
TS	Technical Specification
TSI	Technical Specification for Interoperability
UE	User Equipment
UMTS	Universal Mobile Telecommunications System

1 INTRODUCTION

CEPT has developed the regulatory framework for the introduction of Future Railway Mobile Communication System (FRMCS) in the paired frequency band 874.4-880 MHz / 919.4-925 MHz and in the unpaired frequency band 1900-1910 MHz and has developed respective ECC Decision (20)02 [2]. RMR encompasses GSM-R and its successor(s) including FRMCS.

The aim of this Report is to provide guidance to administrations as well as to RMR and MFCN licensees to enable an efficient national implementation of ECC Decision (20)02.

Based on the experience of cooperation between different stakeholders in the national railway environment as per ECC Report 162 [9] and ECC Report 229 [7], this Report proposes a systematic approach for those cases where a coordination and cooperation process is needed to facilitate dialogue amongst administrations, RMR and MFCN licensees. The Report addresses the 900 MHz (n100) and 1900 MHz (n101) RMR bands, 900 MHz (B8/n8: 880-915 MHz and 925-960 MHz) and 2100 MHz (B1/n1: 1920-1980 MHz and 2110-2170 MHz) MFCN bands[1]. This Report can also be used on a national basis to solve some specific issues that may be identified between RMR and MFCN band n3/B3 (1710-1785 MHz and 1805-1880 MHz).

The methodology described in this Report can be adapted by the involved stakeholders to meet national needs such as specific national RMR and MFCN operating conditions. In several countries, similar coordination and cooperation processes are already in place for GSM-R.

[1] n1, n3, n8, n100 and n101 use the 3GPP 5G band designation terminology, B1, B3 and B8 use the 3GPP 4G band terminology

2 DEFINITIONS

2.1 BLOCKING

Blocking is a phenomenon that can be caused by insufficient selectivity (filter discrimination), saturation of the front-end (Low Noise Amplifier (LNA) and/or mixer) or reciprocal mixing (with local oscillator phase noise).

Blocking capabilities of a receiver (sometimes also called desensitisation of a receiver) is defined in most European standards (including those for RMR) as a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequencies other than those of the spurious responses in adjacent channels or bands. The relevant standards define a measurement test suite for the blocking capability measurements of a receiver together with the relevant definition of the unwanted signal(s) and precise frequencies at which measurements should be conducted.

For a given received power from the wanted signal, the blocking level is defined as the maximum emission level that can be accepted by the receiver from an off-channel unwanted signal without preventing the processing of this wanted signal.

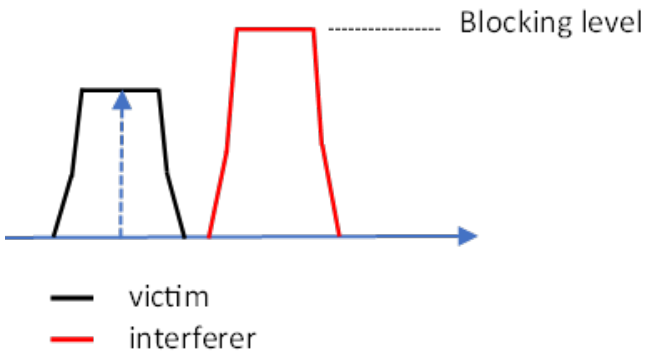


Figure 1: Illustration of the blocking level

2.2 RECEIVER INTERMODULATION

The unwanted intermodulation phenomenon comes from the non-linearity of the amplifier in the receiving chain and is generated when two (or more) signals are present in a non-linear circuit. Two signals of frequencies $2f_1 - f_2$ and $2f_2 - f_1$ may appear in the receiver: these are third order intermodulation products.

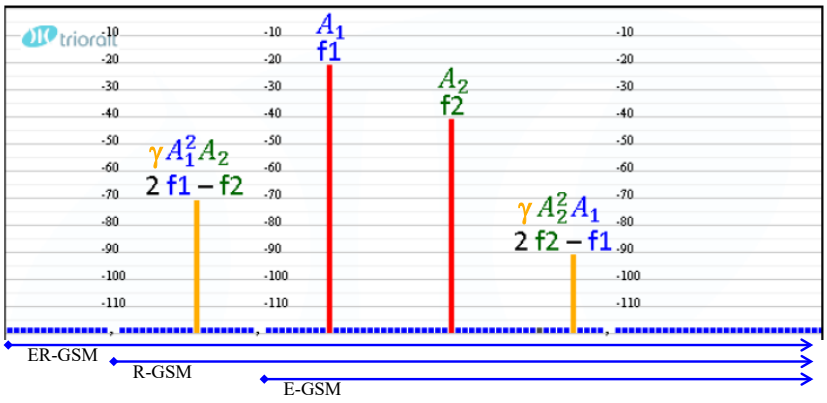


Figure 2: Example of generation of third order intermodulation products

The receiver, listening to a channel whose frequency is f_0, is interfered by intermodulation products when the following conditions are met:

- $f_0 = 2f_1 - f_2$ or $f_0 = 2f_2 - f_1$;
- the strength of the signals f_1 and f_2 is above a given threshold.

The intermodulation described above is third order intermodulation (IM3); it is usually accompanied by a combination of different intermodulation orders, such as fifth, seventh, etc.

It has to be noted that, for modulated signals, the bandwidth of the intermodulation products is multiplied by a factor equal to the intermodulation product order.

2.3 OUT-OF-BAND EMISSIONS

ETSI TS 137 104 [13] defines out-of-band emissions as:

"Out-of-band emissions are unwanted emissions immediately outside the channel bandwidth resulting from the modulation process and non-linearity in the transmitter but excluding spurious emissions.

The out-of-band emissions requirement for the BS transmitter is specified in terms of an Operating band unwanted emissions requirement that defines limits for emissions in each supported downlink operating band plus the frequency ranges 10 MHz above and 10 MHz below each band. Emissions outside of this frequency range are limited by a spurious emissions requirement."

2.4 INTERFERENCE SCENARIOS STUDIED IN PREVIOUS ECC REPORTS

This section presents interference scenarios that were studied in ECC Report 313 [8], ECC Report 314 [5] and ECC Report 318 [6].

2.4.1 Frequency allocation in CEPT countries for RMR and MFCN

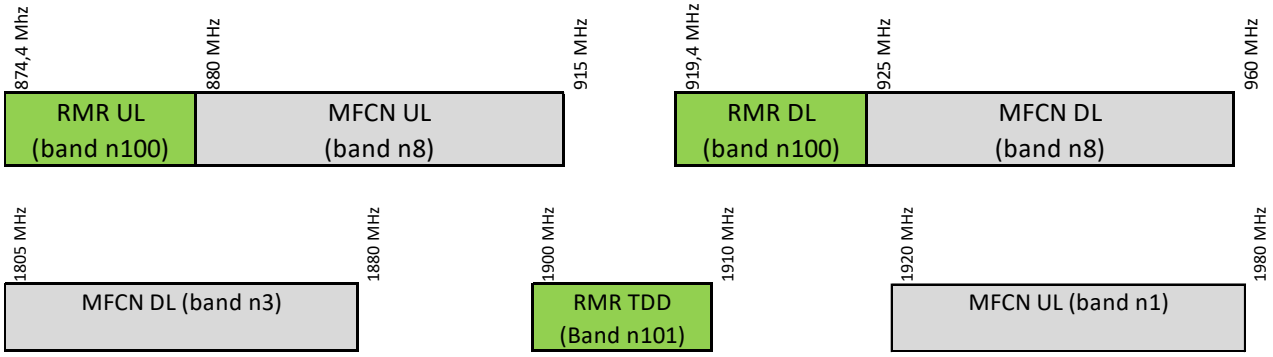


Figure 3: Frequency allocation in CEPT countries for RMR and MFCN (in 900/1900 MHz frequency ranges)

2.4.2 MFCN to FRMCS interference scenarios

In the 900 MHz frequency range, Figure 4 presents the different MFCN to FRMCS interference scenarios addressed in ECC Report 313 [8]:

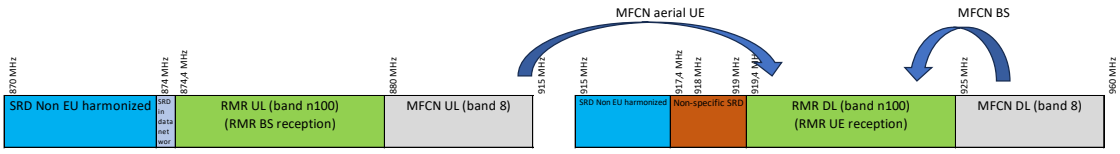


Figure 4: MFCN to FRMCS Interference scenario in 900 MHz band

Note that the impact study of adjacent systems on FRMCS was limited to the downlink in ECC Report 313 [8]. Indeed, experience has shown since the introduction of GSM-R in the 900 MHz band that interferences occur at the on-board equipment rather than at the base stations.

In the 1900 MHz frequency range, Figure 5 presents the different MFCN to FRMCS interference scenarios addressed in ECC Report 314 [5]:

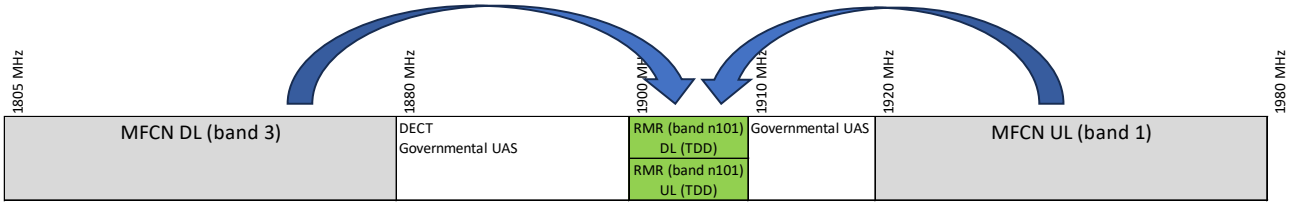


Figure 5: MFCN to FRMCS interference scenario in 1900 MHz

2.4.3 FRMCS to MFCN interference scenarios

Figure 6 and Figure 7 present the different FRMCS to MFCN interference scenarios addressed in ECC Report 318 [6]:

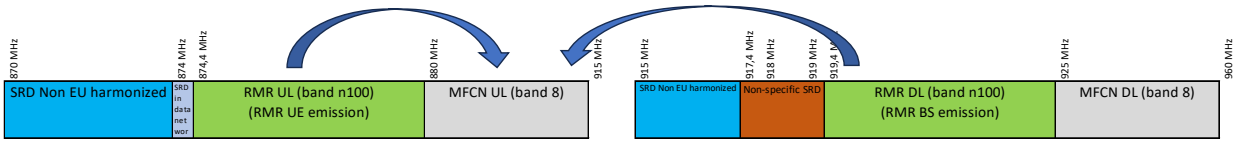


Figure 6: FRMCS to MFCN Interference scenario in 900 MHz band

Note that the impact of possible interference from FRMCS BS and the high-power cab-radio on the MFCN UE operating in the 900 MHz band has not been analysed in this Report. Indeed, FRMCS BS behaves as a regular BS for MFCN UE and high-power cab-radio were addressed in ECC Decision (20)02 [2] by an Adjacent Channel Leakage power Ratio (ACLR) requirement of 37 dB minimum.

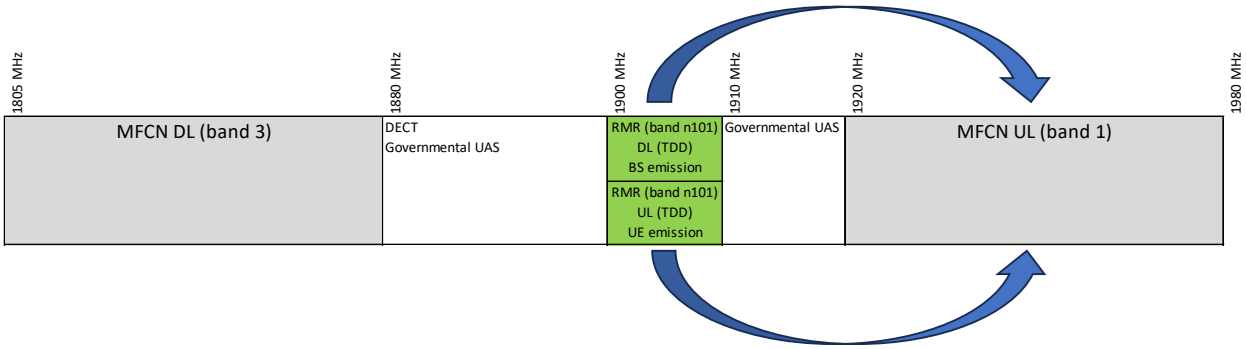


Figure 7: FRMCS to MFCN Interference scenario in 1900 MHz band

3 BACKGROUND AND REGULATORY FRAMEWORK

3.1 RAIL SPECIFICITIES

Railway transport occupies a core position in Europe's overall transport sector, and the interoperability of the rail system within the European Union is the cornerstone of the establishment of a single European railway area. The concept of one single signalling system at EU level to enhance interoperability dates back from 1989, when the European Commission launched an analysis of signalling issues across the EU Member States. The first legislative acts serving that objective were issued in 1996 with the so-called Interoperability Directive related to trans-European high-speed trains and in 2001 with another Interoperability Directive, this time related to trans-European conventional rail system. The Interoperability Directive currently in force dates from 2016 [19].

The interoperability of the European railway system is ensured by the Railway Interoperability Directive and the Control Command and Signalling Technical Specifications for Interoperability (CCS TSI) [4] which provide the regulatory framework.

In the Directive 2016/797/EU [19] on the interoperability of the railway system within the European Union, the definition of railway interoperability can be found in its Article 2:

- 'interoperability' means the ability of a rail system to allow the safe and uninterrupted movement of trains which accomplish the required levels of performance.

The technical details required for railway interoperability are included in the CCS TSI. The definition, also in Article 2 of the Interoperability Directive 2016/797/EU, explains its content:

- 'technical specification for interoperability' (TSI) means a specification adopted in accordance with this Directive by which each subsystem or part of a subsystem is covered in order to meet the essential requirements and ensure the interoperability of the Union rail system.

Interoperability-related requirements in the EIRENE (European Integrated Railway Radio Enhanced Network) specifications and in the FRMCS specifications, are legally binding in the European Union since they are part of the CCS TSI and its amendments, which is currently published in the Commission Implementing Regulation (EU) 2023/1695 of 10 August 2023 [4].

It is mandatory that each railway subsystem (train and infrastructure) in the European Union meets these requirements under the scope of the Railway Interoperability Directive to ensure technical compatibility between Member States and safe integration between train and track. Radio related requirements on spectrum, coverage and signal strength are amongst these requirements. Hence, railway interoperability must be considered when discussing RMR spectrum issues.

In the context of this Report, the effect of the CCS TSI and ECC Decision (20)02 [2] is that both national trains and visiting international trains must comply with the same radio characteristics in order to achieve the railway interoperability. As a result of this, the coordination and cooperation process described in this Report applies to the trackside RMR infrastructure manager.

3.2 ECC REGULATORY FRAMEWORK ON RMR AND MFCN

The harmonised use of the paired frequency band 874.4-880.0 MHz / 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz has been established by ECC Decision (20)02 [2] and the Commission Implementing Decision (EU) 2021/1730 [1]. Member States are required to use these frequencies and the harmonised conditions for the deployment of FRMCS[2].

The CCS TSI, published in the Commission Implementing Regulation (EU) 2023/1695, is referring to the Commission Implementing Decision (EU) 2021/1730 [1], thus placing this EU Decision in the context of the railway regulations.

[2] (EU) 2021/1730 - Whereas: "(12) As long as a Member State does not have railway lines in operation, it should be allowed to postpone the implementation of RMR spectrum harmonisation measures until such operation is planned".

The harmonised use of the paired frequency bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805 - 1880 MHz for MFCN have been established by ECC Decision (06)13 [15] and the Commission Implementing Decision (EU) 2022/173 [18].

The harmonised use of the paired frequency band 1920-1980 MHz / 2110-2170 MHz for MFCN has been established by ECC Decision (06)01 [14] and the Commission Implementing Decision 2012/688/EU [20] as amended.

3.3 ADDITIONAL ETSI TECHNICAL SPECIFICATIONS ARISING FROM EC/ECC SPECTRUM REGULATORY FRAMEWORK

The technical conditions defined in ECC Decision (20)02 [2] result in new ETSI technical specification.

ETSI TS 103 793 [11] specifies the radio frequency (RF) technical characteristics and methods of measurements required by ECC Decision (20)02 for base stations, cab-radio user equipment and terminals other than cab-radio intended to be used for FRMCS. An updated version is planned to be published after the completion of the FRMCS field tests (e.g. MORANE 2).

With respect to MFCN, ECC Decision (06)01 [14] states in its *considering k)* that “the least restrictive technical conditions (LRTC) for wideband RMR in 1900-1910 MHz contained in ECC Decision (20)02 [2] assume that MFCN BS receiving above 1920 MHz have an enhanced selectivity as per ETSI TS 103 807 [10], which would facilitate coexistence with RMR BS transmitting up to 65 dBm *e.i.r.p.*, and that current MFCN BS located near an RMR radio site may need to be adapted so that they do not suffer interference”.

3.4 TIMELINE OF DEPLOYMENTS

The strategy and the timeline for migration from GSM-R to FRMCS will be decided at national level. Railway infrastructure managers will make their decisions for the relevant migration scenario from their current GSM- - - R network to a new FRMCS network, based, amongst others, on interoperability requirements and national needs. During the migration period, train on-board equipment will need to be upgraded to support FRMCS.

Some requirements in the FRMCS system requirement specifications, related to interoperability, are legally binding in Europe, since they are part of the Control Command and Signalling Technical Specification for Interoperability which is published through Commission Implementing Regulation (EU) 2023/1695 and possible future amendments.

To enable a country and/or line specific switch-off of the GSM-R network, an infrastructure manager will have to issue a notification to the Railway Undertakings (RU) prior to the planned switch-off date, as per the conditions laid down in the 2023 CCS TSI. Until that switch-off date the RU’s vehicles may, for example, be able to use a mix of GSM-R and FRMCS for their operational tasks. Considering the relevant transition regime after entry into force of any CCS TSI amendment, a timeline of five years after the notification date from the national infrastructure manager can be derived. The implication of this is that GSM-R may be in parallel operation with FRMCS for this duration.

The 2023 CCS TSI refers to the first version of the FRMCS specifications, called FRMCS V1. FRMCS V2 has since been published and serves as input to the MORANE 2 project, which will carry out field testing of compliant products and contribute to the validation of the specifications. Further standardisation work on FRMCS is ongoing within ETSI and 3GPP. A fully specified, standardised and tested FRMCS ecosystem is expected to be available only with FRMCS V3. The current roadmap is shown below in Figure 8.

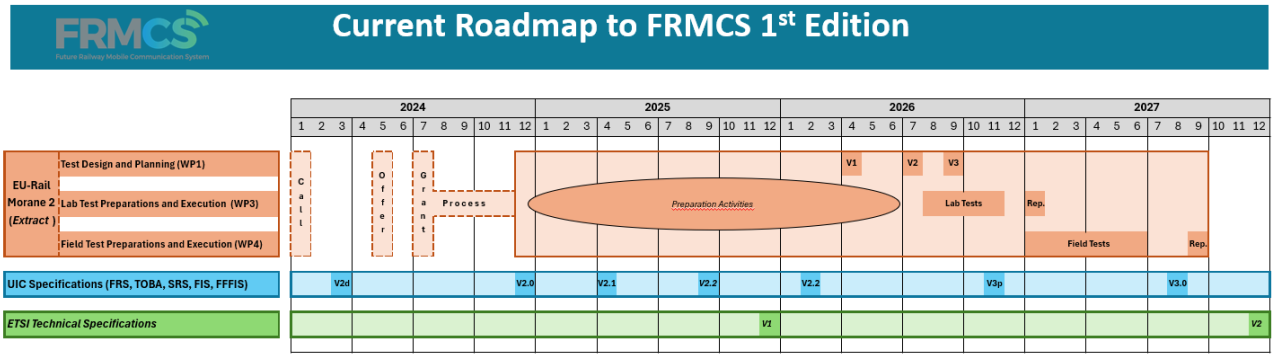


Figure 8: Current FRMCS roadmap

4 EVALUATIONS

4.1 EXISTING STUDIES AND REPORTS

4.1.1 Overview of conclusions from existing reports

The technical conditions to ensure coexistence between RMR and systems operating in the frequency domain vicinity (including MFCN) were defined in ECC Decision (20)02 [2]:

Table 1: MFCN <-> RMR coexistence as per ECC Decision (20)02

Scenarios covered (between MFCN and RMR)	Requirements on RMR equipment (according to ECC Decision (20)02)		Remarks
	RMR BS	RMR UE	
Coexistence between MFCN ➔ RMR (in band 900 MHz)	See ECC Decision (20)02, annex 2.4, table 7	See ECC Decision (20)02, annex 2.4, table 8	For more details, please refer to ECC Report 313
Coexistence between MFCN ➔ RMR (in band 1900 MHz)	See ECC Decision (20)02, annex 3.4, table 11	See ECC Decision (20)02, annex 3.4, table 12	For more details, please refer to ECC Report 314
Coexistence between RMR (in band 900 MHz) ➔ MFCN	See ECC Decision (20)02, annex 2.1, table 2 to table 6	See ECC Decision (20)02, annex 2.2 and annex 2.3	For more details, please refer to ECC Report 318
Coexistence between RMR (in band 1900 MHz) ➔ MFCN	See ECC Decision (20)02, annex 3.1, table 9 and table 10	See ECC Decision (20)02, annex 3.2 and annex 3.3	

Notes:

- Under these conditions and assuming that an MFCN BS receiving in 1920-1980 MHz near an RMR BS has an enhanced selectivity compared to the current Harmonised European Standards, no additional coordination and/or mitigation measures are expected for general cases;
- If operational conditions exceed these conditions and in some specific conditions, additional mitigation measures may be required according to section 5.

4.1.2 Coexistence between RMR and MFCN when deploying RMR in the 1900-1910 MHz band

Current MFCN base stations receiving in 1920-1980 MHz and located near an RMR radio site may experience interference from RMR transmissions. In such cases, additional mitigation measures may be required, such as the use of new MFCN BS radio units compliant with ETSI TS 103 807 [10], or the deployment of external filters for existing radio units operating with passive antenna systems. The coordination and cooperation procedures, together with a list of possible mitigation techniques, are provided in section 5.

4.2 OOB EMISSION

ECC Report 313 [8] concluded that, in close vicinity to railway tracks, MFCN BS out-of-band emissions may cause interference to a FRMCS cab-radio, in particular when MFCN and FRMCS operate in channels adjacent to each other. In practice, to solve these cases, coordination and/or other mitigation techniques may be required. ECC Report 313, section 4.1.3 gives the results for worst-case situations, where the MFCN BS operates in close vicinity to the railway tracks and the main beam of the MFCN BS is hitting directly onto the railway tracks. In this scenario, the victim FRMCS cab-radio is situated inside the MFCN main beam lobe in the azimuth plane. The interference situation will be less severe in cases where the victim is in a side-lobe region of the interferer.

5 TOOLBOX

5.1 PRINCIPLES OF COORDINATION

5.1.1 Principles for a coordination and cooperation process

5.1.1.1 Radio systems under the coordination and cooperation process

This section describes a generic process, that can be adapted to each national situation, to enable an efficient national implementation of ECC Decision (20)02 [2], related to coexistence between RMR in 900 MHz, 1900 MHz bands and MFCN in 900 MHz and 2100 MHz bands. This process can also be used on a national basis to solve some specific issues identified between RMR and MFCN 1800 MHz band.

In this Report, a *radio system* operates a specific radio access technology in a specific frequency band.

Only radio systems which are located within a nationally defined coordination zone are subject to coordination. This coordination zone should be defined per RMR frequency band and per MFCN operator (due to variation in frequency separation between MFCN and RMR channels resulting from MFCN spectrum assignment within a frequency band) to minimise the number of sites that need to be coordinated. Special cases like small cells and leaky feeders in tunnels or in railway stations may require additional measures on a national basis.

The measures proposed in this toolbox can be adapted by national or bilateral coordination procedures. Co-located sites and specific cases as tunnels are usually managed by contracting parties[3]. This Report may also be used to facilitate coexistence on co-located sites.

ECC Decision (20)02 [2] defines the LRTC applicable to FRMCS BS in the form of a block edge mask (BEM). The BEM is developed on the basis that detailed coordination and cooperation agreements would not be required for the majority of cases to be in place prior to network deployment, under the assumption of MFCN enhanced receiver selectivity according to ETSI TS 103 807 [10]. For the remaining cases, ECC Report 229 [7] proposes a systematic approach based on a coordination and cooperation process, and guidelines for the dialogue between RMR and MFCN licensees as well as with the NRA. Additionally, CEPT Report 74 [3] gives an example of a coexistence criterion as part of a national coordination procedure. The principles of coordination described in this toolbox are derived from these Reports.

In some countries national agreements between GSM-R and MFCN operators are in place. These may need to be updated for RMR at 900 MHz and 1900 MHz, reflecting this Report.

5.1.1.2 Identification of the different cases or situations

In the context of national railway environments, the following cases shall be considered during the rollout or modification of MFCN or RMR radio systems, where they operate within the nationally defined coordination zone:

a) New physical site:
   i) New physical RMR site with FRMCS 900 or 1900 MHz frequency layer;
   ii) New physical MFCN site with 900 or 2100 MHz frequency layer, and 1800 MHz if applicable.

b) New relevant frequency layer on existing physical site:
   i) New FRMCS 900 or 1900 MHz frequency layer on existing RMR site;
   ii) New 900 or 2100 MHz frequency layer on existing MFCN site, and 1800 MHz if applicable.

c) Changes to a radio system should be considered if they would increase the interference potential to the victim, for example:

[3] No additional measures may be needed when RMR and MFCN are co-located due to the typically very high isolation between the base station antennas on the same mast.

i) Increase of the radiated transmission power in the direction of the coordinated site, such as increase of output power, change of antenna configuration;
ii) Reduction of the path loss (e.g. changes of antenna position, antenna height) to the coordinated site;
iii) Change of technology (e.g. GSM-R to FRMCS for Railway or GSM to LTE or NR for MFCN);
iv) Change of MFCN channel allocation within the same frequency band.

d) Changes that do not increase the potential interference to the victim are not considered as relevant changes, hence no new coordination process is triggered. Such changes include:
i) Decrease of the radiated transmission power in the direction to the coordinated site, such as decrease of output power, change antenna configuration;
ii) Increase of the path loss to the coordinated site (e.g. changes of antenna position, antenna height);
iii) MFCN operators frequently adapt their network parameters for optimisation purposes (e.g. transmission power, electric tilt, beamforming). The initial coordination process will be performed with worst case parameter values. Any changes to these parameters not exceeding the worst-case values will not trigger a new coordination process.

5.1.1.3 Generic principles

a) Information sharing as early as possible:
i) Subject to national safety regulations for the critical infrastructure, RMR operators should consider sharing relevant data on existing GSM-R sites and planned FRMCS sites, railway track data and indicative timelines of FRMCS deployment to MFCN operators as early as possible to promote collaboration and ensure the efficient coexistence of both systems;
ii) MFCN operators should share relevant data on existing radio sites and planned sites and indicative timelines of new or modified relevant MFCN frequency layers or sites to RMR operators as early as possible to promote collaboration and ensure the efficient coexistence of both systems. An indication of implementation of ETSI TS 103 807 [10] (or other adaptations leading to equivalent improvement) by MFCN BS would facilitate the planning of an RMR 1900 MHz radio site and reduce the amount of direct coordination efforts for both parties. The use of the manufacturer's data on base station receiver performance can also be used for evaluation of coexistence. MFCN operators may use RF parameter ranges for information exchange to enable frequent radio network optimisation. Worst case values of parameters ranges may be used to trigger the process of a more detailed coordination.

b) Generic principles to introduce a new radio site or system:

If operators in adjacent bands want to introduce a new radio system, they shall make reasonable efforts to plan their sites as to avoid causing interference to the existing radio systems on existing sites. If this is not possible, a detailed coordination process as per section 5.2 will be necessary.

When potential coexistence issues arise, the RMR and MFCN operators should be encouraged to work together to find solutions that they can both agree on. In this process, administrations can act as a neutral mediator, working with both parties to find solutions and proportional mitigation options.

There will be cases where adaptations will be needed. The RMR operator may have to do adaptations to the original FRMCS radio plan, or the MFCN operator may need to take measures due to FRMCS deployment, in some cases even on existing sites. In difficult cases when both parties have taken the first level of reasonable efforts, it is recommended they apply the following overall measures.

New FRMCS vs existing MFCN:
i) RX improvement of MFCN BS as described in ECC Decision (20)02 [2] (or other adaptations leading to equivalent improvement);
ii) Adaptations of RMR site (while meeting railway planning and quality criteria for safety and interoperability);
iii) Adaptation of MFCN site.

New FRMCS vs new MFCN or existing FRMCS vs new MFCN:

i) RX improvement of MFCN BS as described in ECC Decision (20)02 [2] (or other adaptations leading to equivalent improvement);

ii) Adaptations of MFCN site;

iii) Adaptations of RMR site (while meeting railway planning and quality criteria for safety and interoperability).

Existing MFCN radio systems operate in various frequency bands to facilitate continuity of coverage for public networks and license obligations. These radio systems near railway lines may serve as infrastructure for fulfilling regulatory coverage requirements, and upgrades (e.g. additional frequency layers) may be necessary to meet evolving demands.

Existing RMR radio systems and sites ensure the railway coverage obligations (EIRENE for GSM-R and future obligations for FRMCS):

- They provide validated GSM-R railway line coverage certified under EIRENE SRS requirements, ensuring interoperability and safety for rail operations according to Commission Implementing Regulation (EU) 2023/1695. Similar formal validation is anticipated for FRMCS deployments to meet future operational needs.
- They are essential for supporting FRMCS in bands n100 (900 MHz) and n101 (1900 MHz). Co-location of FRMCS base stations depends on the frequency band:
  - n100 (for efficient infrastructure reuse and GSM-R coexistence) requires adherence to GSM-R technical constraints, including equivalent FRMCS *e.i.r.p.* levels, to maintain coverage integrity.
  - n101 (to facilitate FRMCS introduction and/or enhanced capacity) will be constrained by GSM-R site limitations, particularly antenna azimuths, to avoid operational conflicts.
- They face stringent spatial, power, and security constraints due to railway lineside regulations, limiting opportunities for physical or RF parameter modifications during the GSM-R/FRMCS coexistence period.
- They risk triggering costly re-certification processes for railway lines if radio parameters (e.g. transmit power, antenna configuration) are significantly altered, underscoring the need for long-term stability at these sites.

Both MFCN and GSM-R/FRMCS radio sites are subject to practical limitations on new site acquisition and upgrades. Coordination processes should consider the balance of MFCN obligations to meet public coverage demands with GSM-R/FRMCS requirements to safeguard rail safety, interoperability and operational continuity.

c) Minimising direct coordination efforts:

i) As far as practically feasible, radio site parameters would benefit from using standardised data format on common basic parameters on a per frequency basis: site geographic location, site height ASL, antenna height AGL, main beam direction, antenna tilt, maximum antenna gain, antenna type.

ii) Where possible, additional characteristics may be made available to facilitate finer estimation of the coexistence scenarios, and standardised data format would facilitate the adoption of common tools reducing the burden on achieving an initial estimate of the situation, for FRMCS and MFCN operators alike (e.g. in France https://www.cartoradio.fr/).

5.1.1.4 Definition of the national coordination zones

Input for determining the national coordination zones could be the following criteria:

a) Minimum Coupling Loss (MCL) values defined in the ECC Report 313 [8], ECC Report 314 [5] and ECC Report 318 [6], which have been derived from impact studies on adjacent systems;

b) Methodology as per ECC Report 229 [7] or existing national coordination procedures based on that Report;

c) Results of national lab and/or field tests of RMR-MFCN compatibility measurements based on real equipment behaviour.

5.1.2 Site planning

In some countries the coordination process will be performed bilaterally between operators. In this case information is exchanged directly between operators. In some countries this information exchange must be performed via the NRA or other authorities.

Information will be exchanged when FRMCS and MFCN operators plan to bring into service new or modified radio systems to which this process is applicable (see section 5.2.1.1) and located within the coordination zone defined by the administrations or by operator agreements. This applies to new radio sites, installation or commissioning of new bands on existing radio sites and relevant changes to existing sites. The definition of the coordination zone for each FRMCS railway line / section of lines should be done individually per MFCN licensee and spectrum band reflecting the individual national situation.

Wherever possible, the operators will also exchange information on future planned sites and planned relevant changes to radio systems. It shall contain all relevant information to evaluate interference, e.g. the geographic coordinates of the planned site, the frequency band (spectrum related measures), transmission power, antenna characteristics, antenna height and main beam direction. Furthermore, the notification should also contain information about already realised interference mitigation techniques (e.g. enhanced selectivity).

Colocation between MFCN and RMR antennas on the same physical towers, masts or poles in railway environment should be encouraged whenever possible. As the railway tracks are either surrounded by densely built-up or in very rural areas with limited access, it could be very difficult to build a radio site in a new location in those environments.

Furthermore, colocation between MFCN and RMR antennas can ensure tailored radio coverage for railway tracks with optimal radio coverage. Further positive effects are reduced civil engineering cost, minimised environmental footprint, faster deployment times and shared operational costs.

The required isolation between MFCN and RMR antennas in most cases could be achieved by a vertical separation. The vertical separation depends mostly on the individual antenna characteristics. The use of additional RF filters on both systems can further increase the mutual isolation. The separation distance between the antenna systems has to be derived from RF parameters and technical specifications, e.g. ETSI TS 138 104 [12], ETSI TS 103 793 [11] and ETSI TS 103 807 [10].

Figure 9 shows a typical scenario for the colocation between MFCN and RMR antennas on the same mast.

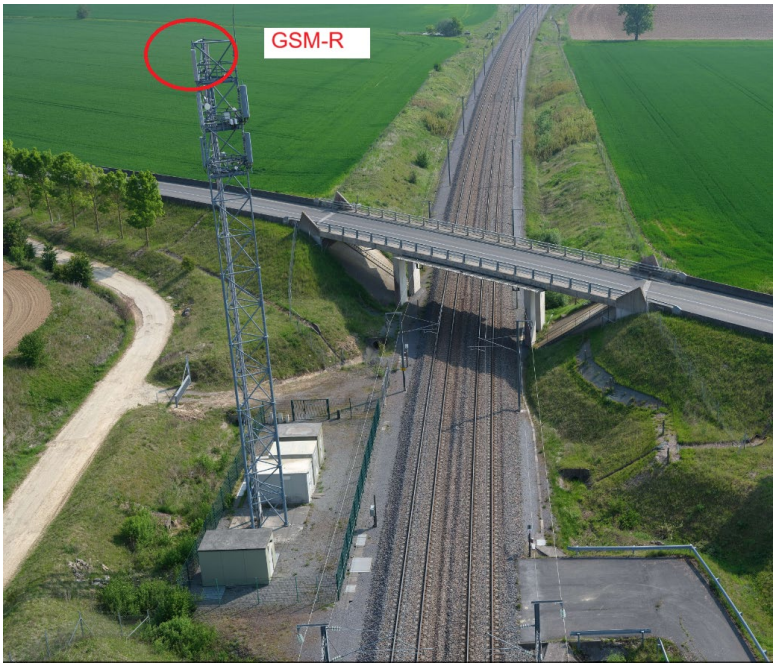


Figure 9: Typical MFCN/RMR colocation scenario in the railway environment

The notification shall be provided in a timely manner, so that potential required changes in planning are still possible.

Even if no specific FRMCS deployment plans have been communicated by the RMR operator to MFCN operators, all existing GSM-R sites should be considered as future FRMCS radio site using both n100 and n101sites.

Both RMR and MFCN can request the other operator to enter the national coordination and cooperation process to study and mitigate interference. To prevent unnecessary efforts in site coordination, there shall be a possible exemption from entering the coordination and cooperation process, if the new radio site does not increase the received interference to the victim as listed in section 5.1.1.2 d) or if both operators agree that this is not required in the specific case.

5.1.3 Site coordination

Both operators shall work together in good faith to enable all radio systems on radio sites within the coordination zone to work without undue technical restrictions and undue degradation in radio performance. To this end, operators shall exchange at least:

- all relevant information on the sites located within the coordination zone;
- all relevant assumptions used in the analysis process;
- evaluations of coupling losses;
- proposals for interference mitigation.

Annex 2 describes recommended data that should be exchanged between operators for the purpose of evaluating possible interference.

A neutral mediator can be requested by both parties to mediate the coordination process, if no agreement can be reached in bilateral coordination (see 5.1.1.3 b)).

5.1.4 Interference resolution

If an operator of an existing radio system detects a new continuous or recurring interference from the other network, it shall notify the NRA and the other operator of this interference case. Both operators shall work together to resolve interference, adhering to the principles of the generic cooperation/coordination process in this Report, national operator agreements and applicable national regulation. Interference cases on existing radio systems shall be addressed with priority over cases of potential interference on planned ones.

It is recommended to set up joint working groups (at national level) between RMR and MFCN operators to solve such interference cases.

5.2 COORDINATION PROCESS AND MITIGATION MEASURES

5.2.1 Coordination process flow

Standardised early exchange of radio site specific data may allow the "introducing party" to consider existing radio systems as part of its RF planning. The operators provide information on their radio sites if any of the cases listed in 5.1.1.2 points a) to c) apply.

5.2.1.1 Pragmatic approach to the coordination at FRMCS radio planning stage

a) Definition of the coordination zone for RMR railway lines / section of lines per MFCN operator and band;
b) Agreement on data format for information exchange;
c) Request for data on MFCN radio sites within coordination zone from the MFCN operators;
d) Determination of FRMCS radio sites for potential coordination, identifying the existing GSM-R radio sites separately from the new radio sites;

e) Identification of MFCN radio sites in close geographical proximity of these FRMCS radio sites and which could be a victim of FRMCS;

f) Joint assessment of these “critical radio sites” by the involved radio network operators per railway line section to determine the realistic interference potential;

g) By using feasible mitigation techniques described in section 5.2.2, an evaluation of which specific pragmatic mitigation would have a significant positive impact on existing MFCN radio systems. In the case where a planned FRMCS site could be interfered by existing MFCN radio sites, an evaluation of which specific pragmatic mitigation technique would have a significant positive impact on the FRMCS radio system. Due consideration shall be given to protect the site against harmful interference, e.g. RF filters;

h) Cross-check of planned MFCN upgrades and MFCN evolutions;

i) Resolution of the remaining “critical radio sites” on a case-by-case basis;

j) An agreed upon mediator can be called upon by both parties to find a compromise in terms of mitigation solution, if no agreement can be reached in the bilateral coordination. Note: in this case, the radio sites could start in operation with a provisional commissioning permit with the risk of entering the interference resolution process (depending on the overall national regulation).

5.2.1.2 Pragmatic approach to the coordination at MFCN radio planning stage

a) Definition of a search area around the new or upgraded MFCN radio site per MFCN band;

b) Agreement on data format for information exchange;

c) Request for data on RMR radio sites within search area from the RMR operator;

d) Determination of MFCN radio sites for potential coordination;

e) Identification of RMR radio sites in close geographical proximity of these MFCN radio sites and which could be a victim of MFCN;

f) Joint assessment of these “critical radio sites” by the involved radio network operators per railway line section to determine the realistic interference potential;

g) By using feasible mitigation techniques described in section 5.2.2, an evaluation of which specific pragmatic mitigation would have a significant positive impact on existing RMR radio systems. In case where a planned MFCN site could be interfered by existing RMR radio sites, an evaluation of which specific pragmatic mitigation technique would have a significant positive impact on the MFCN radio system. Due consideration shall be given to protect the site against harmful interference, e.g. RF filters or receivers with enhanced selectivity according to ETSI TS 103 807 [10];

h) Cross-check of planned RMR upgrades;

i) Resolution of the remaining “critical radio sites” on a case-by-case basis;

j) An agreed upon mediator can be called upon by both parties to find a compromise in terms of mitigation solution, if no agreement can be reached in the bilateral coordination. Note: in this case, the radio sites could start in operation with a provisional commissioning permit with the risk of entering the interference resolution process (depending on the overall national regulation).

5.2.2 Possible mitigation measures

Interference mitigation shall enable all radio systems on coordinated sites to work without undue technical restrictions and undue degradation in radio performance to the extent possible. Interference mitigation shall aim to find a least restrictive solution for both operators, with priority on measures that cause least restrictions on the operator of an existing site.

The measures in this section are not exhaustive.

5.2.2.1 Site location, antenna height and main beam direction

Site distance can be used to mitigate interference. RMR site locations are usually limited in one dimension along the track and inter-site distance along the track. MFCN site locations are possible in two dimensions, but may be limited by site availability, especially in case of rooftop sites. Since existing sites shall not be moved, they take priority in the coordination process.

Antenna height can be used for decoupling in case of RMR-MFCN co-location. Adequate consideration shall be given to vertical separation in the planning of antenna masts.

Main beam direction of the antenna can be used for horizontal antenna decoupling. It is acknowledged that RMR sites are usually constrained by the specific need for coverage along railway tracks.

5.2.2.2 Radio planning and optimisation related measures

Antenna gain in the main beam direction, side lobe direction and magnitude can be used to mitigate interference. Antennas with different gains and radiation pattern shall be considered, if this can effectively mitigate interference and does not jeopardize coverage and performance targets of sites.

Adaptation of MFCN and/or RMR RF transmit power can be used to mitigate interference on a case-by-case basis.

5.2.2.3 Hardware related measures

RF filters can be considered to mitigate interference or strengthen the resilience against interference. Depending on the nature of interference, the insertion location of RF filters may vary. Due consideration to civil construction (e.g. static load and wind load) and/or other practical constraints shall be given.

MFCN operators can introduce receivers with enhanced selectivity in coordinated sites where this effectively mitigates interference and provided such receivers are deployable in practice and compatible with other BS equipment on the site. This is in line with ECC Decision (20)02 [2] *considering k)* “that the least restrictive technical conditions (LRTC) for wideband RMR in 1900-1910 MHz assume that MFCN base stations (BS) receiving above 1920 MHz have an enhanced selectivity compared to the current Harmonised European Standards, which would facilitate coexistence with RMR BS transmitting up to 65 dBm *e.i.r.p.*, and that current MFCN BS located near an RMR radio site may need to be adapted so that they do not suffer interference”.

5.2.3 New physical site with relevant frequency layer

Based on the principles for a coordination and cooperation process as per section 5.1, the findings in the following subsections for the planning of new physical sites with relevant frequency layers can be highlighted.

Longer deployment times compared to MFCN can be expected for RMR. An extensive site evaluation for new physical radio sites with relevant frequency layer is to be considered because of rail specific project management processes, safety requirements and energy provisions with backups.

5.2.3.1 New physical site with FRMCS 900 layer

When a new FRMCS 900 layer on a new site is planned, the RMR operator will have more flexibility compared to the upgrade of an existing site. However, the RMR operator is somewhat limited in its ability to change the overall RF characteristics of the site as this will also have implications for the co-located GSM-R layer (for GSM-R/FRMCS 900-layer coexistence issue).

Dependent on coverage and performance requirements, degrees of flexibility could be:

- GSM-R/FRMCS 900 power adjustment;
- consideration of a more directional antenna;
- adjustment of geometry (antenna height, azimuth, tilt);
- RF filters to protect the systems against interference;
- depending on the nature of the interference, there may be an opportunity to consider alternative mitigation techniques.

5.2.3.2 New physical site with FRMCS 1900 layer

When a new FRMCS 1900 layer on a new site is planned, the RMR operator will have more flexibility compared to the upgrade of an existing GSM-R site. However, the RMR operator will probably be constrained on the azimuth of the antenna (driven by geometry of the railway line) but may be able to adapt its RF design in other aspects depending on situations.

The RMR operator should try to use more directional antennas assuming this is compatible with its operational needs and coverage requirements. In some cases, it is possible that a less directional antenna could be a mitigating factor, but it may have side effects on other MFCN sites.

5.2.3.3 New physical site with MFCN 900 or MFCN 2100 layers and MFCN 1800 MHz if applicable

When a new MFCN site is planned to be introduced, the MFCN operator may be constrained by availability of site location but may be able to adapt its RF design.

5.2.4 New relevant frequency layer on existing physical site

Based on the principles for a coordination and cooperation process as per section 5.1, the findings in the following subsections for the planning of a new relevant frequency layer on existing physical sites can be highlighted.

For RMR larger deployment times compare to MFCN can be expected. An extensive RMR site evaluation for a new relevant frequency layer on existing physical site is to be considered because of rail specific project management processes, safety requirements and energy provisions with backups.

5.2.4.1 New FRMCS 900 layer on existing physical site

When a new FRMCS 900 layer on an existing GSM-R site is planned, the RMR operator will have very limited ability to change the overall RF characteristics of the site due to parallel GSM-R operation.

Dependent on coverage and performance requirements, the degrees of (limited) flexibility could be:

- if GSM-R antennas and FRMCS 900 antennas are independent, there may be an opportunity to consider a more directional antenna;
- depending on the nature of the interference, there may be an opportunity to consider alternative mitigation techniques;
- RF filters to protect the systems against interference.

5.2.4.2 New FRMCS 1900 layer on existing site

When a new FRMCS 1900 layer on an existing GSM-R site is planned, the RMR operator will probably be constrained on the azimuth of the antenna (driven by geometry of the railway line or by the azimuth of the GSM-R antenna, especially in case of common antenna housing for GSM-R and FRMCS layers) but may be able to adapt its RF design in other aspects depending on situations.

The RMR operator should try to use more directional antennas assuming this is compatible with its operational needs and coverage requirements. In some corner cases, it is possible that a less directional antenna could be a mitigating factor, but it may have side effects on other MFCN sites.

When introducing a FRMCS1900 layer on an existing GSM-R site, assuming a given choice of antenna directivity and *e.i.r.p.*, three cases can be categorised in the perspective of the generic coordination process:

- No issue foreseen with nearby MFCN sites;
- No issue foreseen with nearby MFCN sites under the assumption of ETSI TS 103 807 [10];
- Issue foreseen with nearby MFCN sites under the assumption of ETSI TS 103 807.

In the last case, cooperation and coordination on case-by-case basis is required to find an acceptable solution for both parties. Mitigation measures on FRMCS side are essentially adoption of a more directional antenna (if compatible with operational railway needs) and consideration of RF filters. The coordination efforts need to be considered on a per railway line (section) basis as coverage of a railway line is not "coverage area" driven but "line section" driven.

5.2.4.3 New MFCN 900 or MFCN 2100 layers on existing site and MFCN 1800 MHz if applicable

When a new MFCN frequency layer or a new MFCN site is planned to be introduced, the MFCN operator may be able to adapt its RF design.

5.2.5 Change to relevant parameters

If an operator wants to make relevant changes to a coordinated site (see section 5.1.1.2 points a), b) and c)), they shall notify other operators of coordinated sites. In case the changes could lead to more severe interference, a coordination process shall be entered.

During the initial coordination of the concerned radio systems, MFCN operators may use worst case parameter values. Making changes to these parameters while not exceeding the worst-case values does not trigger a new coordination process (see section 5.1.1.2 point d)).

ANNEX 1: NATIONAL IMPLEMENTATIONS EXAMPLES

This annex provides an overview of the established processes of cooperation and coordination in the national railway environment throughout Europe. These processes are essentially based on ECC Report 229 [7].

A1.1 NATIONAL COOPERATION BETWEEN INFRABEL AND MFCN IN BELGIUM

In Belgium, as in many other European countries, a relatively older RF receiver technology used in the train-installed RMR radios (cab-radios or EDOR – ETCS Data Only Radios) combined with the progressive implementation of wideband systems (3G) in the 900 MHz band by the MFCN, produced several cases of disturbances of the train communications in certain areas of the railway network. In total, 124 radio disturbance cases were identified and logged in the period from February 2012 to August 2017.

On 30 June 2015, the Belgian Institute for Postal Services and Telecommunications (BIPT) issued a national decision, motivated by the release of ECC Report 229 [7] (Guidance for improving coexistence between GSM - R and MFCN in the 900 MHz band), to ensure the good coexistence of both RMR and MFCN. This document set the starting point to a formal coordination process but also to a direct constructive cooperation between Infrabel and the mobile network operators to tackle the issues. The main stages of the coordination and cooperation were:

- Provide an accurate information on the RF equipment used by both Infrabel and MFCN to the BIPT;
- Identification the disturbance area and provide a proper documentation of the various radio bearers present on the air interface (using high-end RF scanning and acquisition equipment);
- Perform in-lab tests: replay of the acquired radio conditions and expose a reference cab-radio device to this environment in order to confirm the issue;
- Take corrective actions (on RMR and/or MFCN side) after an agreement was reached to drastically improve or solve the issue in the disturbance areas;
- Organize regular coordination meetings with the MFCN in order to define the proper course of action and limit the impact for the various stakeholders;
- Ensure a quick and specific attention is given to the most disruptive cases (e.g. large stations, ETCS high speed lines);
- Inform the BIPT along the coordination process.

The coordination process, although initially set to end by 31 July 2019 remained in place until 31 December 2020 following the feedback collected during a national public consultation. The decision was mostly motivated by longer than expected delays faced by various Railway Undertakings to complete the retrofit of the cab-radios and EDORs with improved performance RMR radio modules.

During the whole coordination and cooperation activities, more than 100 cases were completely solved. The remaining ones, which were the less impacting or critical ones, naturally disappeared with the introduction of the new improved RMR radio modules.

A1.2 NATIONAL COOPERATION BETWEEN SNCF RESEAU AND MFCN TO SOLVE GSM-R INTERFERENCES CASES IN FRANCE

In France, the first GSM-R interferences cases occurred in 2006. In 2013, Bundesnetzagentur (BNetzA) of Germany published a report with the results of different measures performed to compare the performance of different prototypes of improved GSM-R receivers (cab-radio). These results were used to finalise the first version of the ETSI TS 102 933 (GSM-R improved receiver parameters) in 2014 [20] and [21].

In the same period (2013-2014), the number of GSM-R interference cases increased in France making it necessary to establish a coordination process between SNCF Reseau (French railway infrastructure manager) and national MFCN.

In 2015, CEPT published the ECC Report 229 [7] (Guidance for improving coexistence between GSM-R and MFCN in the 900 MHz band), this document has been derived in the national context with the publication in 2016 of a national agreement between SNCF Reseau and the 4 MFCN operating in France.

Between 2016 and 2022, more than 50 cases have been solved in the corrective context (interferences cases detected on the field with major impact on the railway usage) and almost 500 reserves have been sent by SNCF Reseau to MFCN in the preventive context (identification of potential risk of GSM-R interferences identified before the construction of new MFCN sites or modification of MFCN sites closed to the rail tracks). For the identification of these potential cases, more than 29000 new MFCN sites or modifications of existing MFCN sites were analysed by SNCF Reseau on a weekly basis between 2016 and 2022. This analysis focused on a buffer of 500 m on each side of the rail tracks covered by with GSM-R.

The national procedure was successfully managed by the French national authority Agence nationale des fréquences (ANFR) with a good cooperation of the different parties involved in this process.

The coordination procedure (for corrective and preventive aspects) had been put in standby in 2022 after the completion of the retrofit of all GSM-R cab-radio (by improved GSM-R receivers) circulating on the national rail network. It should be noted that this procedure can be reactivated at any time in case of detection of new interference case.

A1.3 COORDINATION AND COOPERATION OF MFCN AND RMR IN GERMANY

In Germany, DB InfraGO AG is responsible for the planning and operation of RMR networks. After pooling the resources of the former DB Netz AG and DB Station&Service AG in a public service infrastructure company since 1 January 2024, DB InfraGO AG is the railway infrastructure manager of Deutsche Bahn AG and is responsible for the approximately 33.000 km rail network, including all operational necessary installations. An average of 50.000 trains is using the infrastructure per day. The main task is to make available a high–quality, high-availability, and non-discriminatory railway infrastructure to around 420 Railway Undertakings. Today´s GSM-R radio network is in operation since 2004. After the first years of GSM-R operation it became apparent that onboard GSM-R mobile stations were running in very limited areas nearby of some MFCN radio sites (in 900 MHz frequency band) in specific GSM-R interference situations. In order to solve these interference issues, it was necessary to complete special operator agreements until the complete introduction of improved GSM-R mobile stations.



Figure 10: Typical interference scenario for onboard GSM-R mobile stations in very close vicinity of some MFCN radio sites

As recommended in ECC Report 229 [7] (Guidance for improving coexistence between GSM-R and MFCN in the 900 MHz band), DB InfraGO AG in cooperation with MFCN and BNetzA has successfully established a national coordination and cooperation process between MFCN and GSM-R network operators. The whole

2x7 MHz GSM-R spectrum is covered by the national coordination and cooperation process. A soft coordination of all 900 MHz radio sites takes place in a buffered area of several hundred meters around operational railway lines, depended on technology (P-GSM, E-GSM or LTE) and the operational usage. Therefore, the number of MFCN interferences at legacy GSM-R mobile stations has been significantly reduced from around 300 to 10 since the establishment of first RMR MFCN operator agreement in 2017. This first operator agreement of 2017 was supplemented and expanded in the following years by bilateral and multilateral agreements for the introduction of LTE 900.

The key figures for the National Operator Agreements are:

- Several national operator agreements for GSM and LTE in the 900 MHz band agreed by the German radio network operators;
- Operational since 2017 with good cooperation between RMR and MFCN;
- Coordination and cooperation process in rail environment based on real RF equipment behaviour;
- Annually updated geodata on the actual RMR coverage and the relevant operational usage in a 100 m resolution;
- Fast interference evaluation by exchanging MFCN antenna data in the rail environment;
- Continuous cooperation between GSM-R RF Planning and MFCN experts and common monitoring of interferences issues;
- Common usage of a dedicated web portal which supports RMR and MFCN mobile network operators during all process steps of the operator agreement;
- GSM-R RF planning guideline for site sharing;
- Quick assessment of specific interference situations through continuously RF data exchange;
- Transparent decisions through agreed assessment procedures (e.g., always tried to apply frequency coordination before power reduction).

After the completion of the national retrofit program of all legacy onboard GSM-R mobile stations on the national rail network by improved GSM-R receivers by the end of 2024 only operational GSM-R handheld mobile stations in very close vicinity of some MFCN radio sites will be part of a dedicated multilateral operator agreement. The scope of this agreement are only handheld devices limited to level crossings and shunting areas. The coexistence conditions of the relevant GSM-R handheld scenarios were determined together with the representatives of MFCN and DB by lab measurements with real GSM-R equipment.



Figure 11 From 2025 onwards, only GSM-R handheld mobile stations in very close vicinity of some MFCN radio sites will be part of a multilateral operator agreement

A1.4 COORDINATION BETWEEN RAILWAYS AND MFCN IN SWITZERLAND REGARDING INTERFERENCE ISSUES

Coordination between Swiss Federal Railways (SBB) and MFCN regarding antenna sites is in general tight for two reasons:

1 According to Swiss telecommunication law all mobile operators including RMR operators are requested to share site infrastructure, where possible. So, there are quite a few GSM-R antennas on MFCN sites and MFCN antennas on GSM-R sites in Switzerland and thus structures with named single points of contacts for coordination issues at MNOs and SBB (representing all Swiss standard-gauge railways) in place;

2 Due to the popularity of railways in Switzerland, it is important for MNOs for their competitive position to provide good mobile radio coverage for railway passengers.

Given the rather small inter-site distances both for MFCN and RMR sites owing to topography and the strict electromagnetic field radiation limits in Switzerland, MFCN interference on GSM-R was so far not often an issue and there is still a significant share of rolling stock not being equipped with improved receivers as there is no technical pressure to do so for "domestic-only" rolling stock.

Nevertheless, there are some situations where interference cases can occur. For instance, because of the site sharing requirement and the numerous MFCN frequencies used on such sites, interference to GSM-R because of intermodulation products might result. Furthermore, sites using the 5 MHz band slot immediately adjacent to the GSM-R band (880-885 MHz / 925-930 MHz) for UMTS or LTE may cause interference. In the rare cases where harmful interference to GSM-R was experienced, it was analysed jointly between MFCN and railways what the most appropriate solution would be. In some cases, the MFCN accepted some power reduction, in one specific case the easiest solution was to build a low-power fill-in site for GSM-R to solve the issue.

A specific aspect is sharing in-tunnel radio communication equipment. Depending on the type of installation, special care has to be taken to avoid interference caused by intermodulation. This is taken care of by jointly planning these installations. Furthermore, regular meetings between SBB and the relevant MFCN represented in an "InTunnelCom" consortium take place to discuss issues and decide on measures during the operational phase.

In summary, there is close direct coordination between the railways and the MFCN on various topics related to interference mitigation. Given the electromagnetic field radiation laws and topography in Switzerland, interference cases are rare, but when they happen, owing to this coordination, the most appropriate measures on either side are jointly defined and implemented.

A1.5 NATIONAL COOPERATION BETWEEN NETWORK RAIL AND MFCN IN THE UK

In 2012, UK developed a coordination procedure for 3G UMTS deployments in the 900 MHz band and GSM-R deployments. This was later updated in 2013 to include requirements for 4G LTE deployment [16]. This procedure specified the coordination necessary to ensure the protection of existing GSM-R equipment from potential harmful interference from the deployment of 3G UMTS900 or 4G LTE900 equipment in the neighbouring spectrum bands (the E-GSM bands 880-890 MHz paired with 925-935 MHz). The procedure applies to the protection of GSM-R sites and GSM-R train mounted equipment in operation at the time a new 3G UMTS900 or 4G LTE900 site was deployed but not for any future GSM-R sites from 3G UMTS900 or 4G LTE900 sites that are already in operation at the time GSM-R sites are deployed.

For any new / upgraded 3G UMTS900 or 4G LTE900 sites that are likely to exceed the protection threshold, co-ordination must be undertaken before that site can be brought into operation. The 900 MHz MFCN and railway[4] operators in the UK also developed their own enhanced cooperative approach to coordination. The cooperative approach focuses around interference cases which are identified by railway operations. An initial analysis by Network Rail is carried out to ensure that the fault is not caused by an internal GSM-R network issue. A Network Rail engineer responsible for MFCN coordination will go to the identified location to carry out measurements with test handsets of the GSM-R signal and also the MFCN signals in the area with the aim to identify which MFCN site possibly caused the interference. Two outcomes are possible from this stage:

[4] Network Rail

1 If GSM-R coverage levels in the area are good and MFCN transmit power is more than agreed thresholds, Network Rail will work with the relevant MFCN operator to agree a solution e.g. power reduction, change of antenna tilt or orientation of the particular MFCN sector. This may be an iterative process with engineer re-visits to the affected area and further optimisation may be required.

2 If GSM-R coverage levels in the geographical area is low and the MFCN power is below the agreed thresholds, the Network Rail RF Planning and Optimisation team will investigate further and find a solution to enhance GSM-R coverage levels in the area.

In total between 2014 and 2022, 619 cases have been logged and 191 cases were valid MFCN interference cases.

Similar to other European countries, Network Rail along with Railway Undertakings undertook a national program from April 2020 to December 2022 to retrofit GSM-R cab-radios and EDORs with improved performance transceivers. The coordination procedures have not yet been updated to reflect this.

Additionally, a proactive process to prevent potential interference has been put in place. Radio parameters will be submitted to Network Rail for any new MFCN sites that will be modified or built within a certain distance from the railway corridor. A Telecom Clearance team within Network Rail process this data to identify whether any potential interference from the proposed MFCN site configuration could occur to GSM-R. If there is a potential for interference, some mitigation may need to be put in place on a case-by-case basis or a managed switch on process followed.

ANNEX 2: RECOMMENDED DATA FOR INFORMATION EXCHANGE BETWEEN RMR AND MFCN OPERATORS

The information exchange mentioned in this Annex may be subject to operator agreement, a non-disclosure agreement (NDA) or even stricter restrictions depending on national regulations.

As part of early information exchange, the relevant characteristics of the base stations / radio cells and additional information should be submitted to the neighbour operators in the coordination zone. All the following characteristics should be included:

a) type of site (macro, indoor, leaky feeder, etc.);
b) ARFCN (plus potential frequency offset);
c) channel bandwidth (MHz);
d) name/ID of transmitter station;
e) sector information;
f) location of the site / geographical coordinates (W/E, N; WGS84 decimal figures, altitude above sea level);
g) antenna height above the ground (m), AGL (centre of the antenna);
h) antenna azimuth (deg.);
i) equivalent isotropic radiated power *e.i.r.p.* (dBm);
j) date of entry into service (month, year);
k) electrical antenna tilt (deg.);
l) mechanical antenna tilt (deg.);
m) antenna type;
n) compliance of BS receiver selectivity to ETSI TS 103 807 [10] (Y/N);
o) external filter (Y/N);
p) additional information and/or remarks.

Further elements can be agreed among operators bilaterally, or as part of a nationally agreed coordination procedure.

ANNEX 3: LIST OF REFERENCES

[1] EC Decision (EU) 2021/1730: “Commission implementing Decision (EU) 2021/1730 of 28 September 2021 on the harmonised use of the paired frequency bands 874.4-880.0 MHz and 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz for Railway Mobile Radio”

[2] ECC Decision (20)02: “Harmonised use of the paired frequency bands 874.4-880.0 MHz and 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz for Railway Mobile Radio (RMR)”, approved November 2020, latest amended June 2024

[3] CEPT Report 074: "Report from CEPT to the European Commission in response to the Mandate on spectrum for the future railway mobile communications system. Report A: Spectrum needs and feasibility (tasks 1 to 4)”, approved July 2020

[4] Commission Implementing Regulation (EU) 2023/1695 of 10 August 2023 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919 : "

[5] ECC Report 314: "Co-existence between Future Railway Mobile Communication System (FRMCS) in the frequency range 1900-1920 MHz and other applications in adjacent bands”, approved May 2020

[6] ECC Report 318: "Compatibility between RMR and MFCN in the 900 MHz range, the 1900-1920 MHz band and the 2290-2300 MHz band”, approved July 2020

[7] ECC Report 229: “Guidance for improving coexistence between GSM-R and MFCN in the 900 MHz band”, approved May 2015

[8] ECC Report 313: “Technical study for co-existence between RMR in the 900 MHz range and other applications in adjacent bands”, approved May 2020, editorial update February 2024

[9] ECC Report 162: "Practical mechanism to improve the compatibility between GSM-R and public mobile networks and guidance on practical coordination", approved May 2011

[10] ETSI TS 103 807: "Mobile Standards Group (MSG); IMT Cellular Networks Base Stations (BS) Additional Regulatory Requirements", V1.1.1 (2021-10)

[11] ETSI TS 103 793 (V1.1.1. 2025-11): “Rail Telecommunications (RT); Future Railway Mobile Communication System (FRMCS); Radio Characteristics”

[12] ETSI TS 138 104: “5G; NR; Base Station (BS) radio transmission and reception”

[13] ETSI TS 137 104: “Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; 5G; NR, E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception”

[14] ECC Decision (06)01: “The harmonised utilisation of the bands 1920-1980 MHz and 2110-2170 MHz for mobile/fixed communications networks (MFCN) including terrestrial IMT systems”, approved March 2006, latest amended March 2025

[15] ECC Decision (06)13:”Harmonised technical conditions for mobile/fixed communications networks (MFCN) including terrestrial IMT systems, other than GSM and EC-GSM IoT, in the bands 880-915/925-960 MHz and 1710-1785/1805-1880 MHz approved December 2006, latest amended March 2022

[16] Ofcom: “Notice of Co-ordination Procedure required for 3G or 4G deployment under the Public Wireless Network Licences covering the 900 MHz band”, available here

[17] Decision (EU) 2022/173: “Commission Implementing Decision (EU) 2022/173 of 7 February 2022 on the harmonisation of the 900 MHz and 1800 MHz frequency bands for terrestrial systems capable of providing electronic communications services in the Union and repealing Decision 2009/766/EC”

[18] Directive (EU) 2016/797 of the European Parliament and of the Council of 11 May 2016 on the interoperability of the rail system within the European Union

[19] EC Decision 2012/688/EU: Commission Decision of 5 November 2012 on the harmonisation of the frequency bands 1920-1980 MHz and 2110-2170 MHz for terrestrial systems capable of providing electronic communications services in the Union

[20] ETSI TS 102 933-1 V1.3.1 (2014-06): “GSM-R improved receiver parameters; Part 1: Requirements for radio reception”

[21] ETSI TS 102 933-2 V1.3.1 (2014-08): “Railway Telecommunications (RT); GSM-R improved receiver parameters; Part 2: Radio conformance testing”