ECC Report 229

Guidance for improving coexistence between GSM-R and MFCN in the 900 MHz band

Approved May 2015

0 EXECUTIVE SUMMARY

This Report provides guidance to administrations as well as GSM-R (GSM for Railway) and MFCN (Mobile/Fixed Communications Networks) licensees at 900 MHz to enable a better coexistence between GSM-R and MFCN. To this regard, it proposes a systematic approach based on a coordination/cooperation process and guidelines for the dialogue amongst administrations as well as GSM-R and MFCN licensees.

In any case, railway interoperability, i.e. ability for trains and staff to run uninterruptedly across railway networks, must be ensured. Requirements and conditions for the provision of harmonised functionality along the railway lines are defined in EIRENE FRS (Functional Requirements Specification) and SRS (System Requirements Specification). Those related to interoperability are legally binding in Europe, since they are part of the Interoperability for Control Command and Signalling Technical Specification (CCS TSI), which is published through the European Decision [16] and its amendments.

Both GSM-R and MFCN licensees use their assigned radio spectrum in compliance with the relevant European and national regulations.

Measurement campaigns performed during 2013-2014 concluded that current GSM-R receivers are affected by intermodulation products generated from a wideband signal such as UMTS/LTE, two narrowband signals such as GSM, or a combination of wideband and narrowband signals. Wideband signals can impact the whole GSM-R downlink frequency range. UMTS, LTE/5MHz and LTE/10MHz have similar interference potential.

In order to sustainably mitigate interferences due to blocking and intermodulation, the standard for GSM-R radios has been improved with respect to the receiver characteristics and published in June 2014 as ETSI TS 102 933-1 v1.3.1 [10]. GSM-R radios compliant with this new specification are robust against MFCN emissions in the E-GSM band.

Field tests carried out in the UK clearly showed the improvements achieved by the radio module vendors. They result from the use of a built-in filter function which prevents the creation of IM3 products inside the GSM-R RF-frontend and the improvement of the linearity of the receiver chain.

As a certain period of time is needed to implement GSM-R radios with improved performance in all trains within Europe, a transition period should be defined in which additional mitigation measures are required to avoid GSM-R interferences, such as coordination/cooperation between MFCN and GSM-R operators.

Before and during the transition period, the coordination/cooperation process is intended to avoid/mitigate issues related to intermodulation or blocking. Nevertheless, improved receivers may still be impacted by MFCN out-of-band (OOB) emissions falling into the receiving band of the GSM-R radio. Thus the process is also intended to prevent interference from MFCN OOB emissions before, during and after the transition period. Visibility and exchange of information between the stakeholders shall remain after the transition period to prevent any further issues.

The process is described in section 7 and can be adapted to meet national needs; it remains a national decision, noting that there are existing processes in use in some CEPT countries. The process is to be used proactively for existing, new and modified sites as well as reactively for resolving actual interference cases.

Changes at the GSM-R radio equipment such as incorporation of a filter at trains (in front of cab radios or EDORs) or exchange of radio modules, as well as changes on the MFCN network side, are expensive and time consuming.

The coordination volume and effort should be kept as low as possible for all involved parties; otherwise the ability to rollout both MFCN and GSM-R could be jeopardised. Furthermore, the risk of interference should be evaluated from the occurrence probability and the severity of its consequences on railway operation. Therefore, a pre-filtering of critical zones is suggested to be conducted before detailed coordination is triggered.

This Report also includes in its section 5.1 a calculation method that gives the maximum MFCN OOB level below 924.9 MHz and anywhere at 4m above the rail tracks, which should trigger the proactive coordination process. It should take into account national GSM-R parameters.

To support the technical analysis, a single agreed technical tool could be developed. It would allow GSM-R and MFCN operators, as well as the spectrum regulator, to use the same tool, thus avoiding mutual misunderstandings. The report recommends the usage of a common tool, e.g. SEAMCAT, which is an interference assessment tool and not a network planning tool.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
2G	2nd MFCN generation
3G	3rd MFCN generation
4G	4th MFCN generation
3GPP	3rd Generation Partnership Project
ARFCN	Absolute Radio-Frequency Channel Number
BCCH	Broadcast Control Channel
BNetzA	Bundesnetzagentur (Federal Network Agency, Germany)
BSIC	Base Station Identification Code
BS	Base Station
C/I	Carrier to Interference ratio
CCS	Control-Command and Signalling
Cell ID	Cell Identifier
CEPT	European Conference of Postal and Telecommunications Administrations
CER	Community of European Railway
CG	Correspondence Group
CPICH	Common Pilot Channel
CSD	Circuit Switched Data
DTT	Digital Terrestrial Television
EC	European Commission
ECC	Electronic Communications Committee
EDGE	Enhanced Data rates for Global Evolution
EDOR	ETCS Data Only Radio
E-GSM	Extended GSM (880-915 MHz / 925-960 MHz) as defined by ETSI
EIRENE	European Integrated Railway Radio Enhanced Network
e.i.r.p.	equivalent isotropically radiated power
ERA	European Railway Agency
ER-GSM	Extended R-GSM (873-915MHz / 918-960MHz) as defined by ETSI
ERM	Electromagnetic compatibility and Radio spectrum Matters
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
ETSI	European Telecommunications Standards Institute
E-UTRA	Evolved Universal Terrestrial Radio Access
FRS	Functional Requirements Specification
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
GSMA	GSM Association
GSM-R	GSM for Railway
HCM	Harmonised Calculation Method
IC	Interoperability Constituent

IM	Intermodulation
IM3	3rd order Intermodulation
LNA	Low Noise Amplifier
LoS	Line of Sight
LTE	Long Term Evolution
MFCN	Mobile/Fixed Communications Networks
MI	Mandatory for Interoperability
MNO	Mobile Network Operator
NPT	Norwegian Post and Telecommunications
NRA	National Regulatory Authority
NSA	National Safety Authority
OOB	Out-Of-Band
P-GSM	Primary GSM (890-915MHz / 935-960MHz) as defined by ETSI
RBC	Radio Block Centre
RED	Radio Equipment Directive
R-GSM	Railways GSM (876-915MHz / 921-960MHz) as defined by ETSI
RMS	Root Mean Square
RRU	Remote Radio Unit
RSSI	Received Signal Strength Indicator
RT	Railway Telecommunications
RxLev	Received signal Level
RxQual	Received signal Quality
SEAMCAT	Spectrum Engineering Advanced Monte Carlo Analysis Tool
SC	Scrambling Code
SRS	System Requirements Specification
TC	Technical Committee
TCH	Traffic Channel
TR	Technical Report
TS	Technical Specification
TSI	Technical Specification for Interoperability
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
UMTS	Universal Mobile Telecommunications System
UTRA	Universal Terrestrial Radio Access
WB	Wideband
WG FM	Working Group Frequency Management (part of the ECC)

1 INTRODUCTION

The aim of this report is to enable a better coexistence between GSM-R and MFCN and to give guidance to administrations as well as GSM-R and MFCN licensees at 900 MHz on how this goal could be reached. It defines options for a generic and open framework for the discussions between GSM-R and MFCN licensees.

This report provides a systematic approach based on a coordination/cooperation process and guidelines for the dialogue amongst administrations as well as GSM-R and MFCN licensees, taking into account existing coordination/cooperation processes. It does not list the possible technical solutions to achieve better coexistence, as these are already described in ECC Report 162 [1].

The proposed generic coordination/cooperation process described in this report can be adapted by the involved stakeholders to meet national needs, such as existing national GSM-R and MFCN operating conditions. In several countries coordination/cooperation processes are already in use.

Results of different measurement campaigns performed in 2013 and 2014 [2] have been used to understand the behaviour of GSM-R cab radios and EDORs in the presence of GSM, UMTS and LTE signals in the adjacent spectrum above 925 MHz.

Annex 3 includes information collected via a questionnaire to CEPT administrations on interference into GSM-R caused by MFCN in 2013 [3].

2 DEFINITIONS

2.1 BLOCKING

Blocking is a phenomenon that can be caused by either insufficient selectivity (filter discrimination), saturation of the front-end (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 harmonised European standards (including those for GSM/GSM-R) 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.

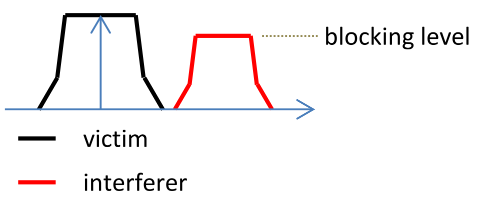

Figure 1: Illustration of the blocking level

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 **3rd order intermodulation products**.

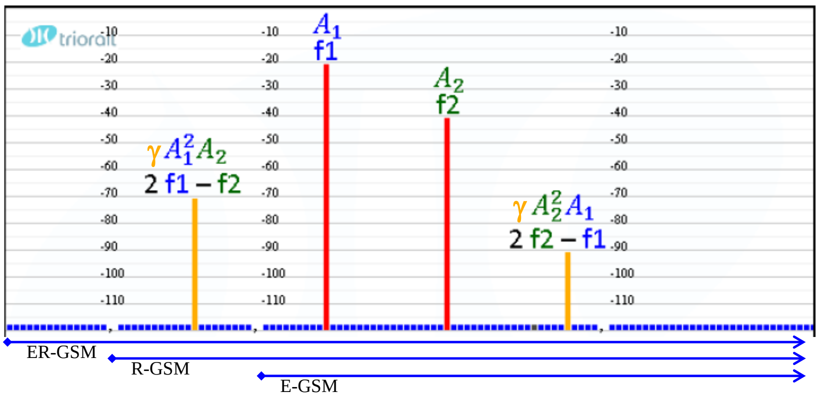

Figure 2: Generation of intermodulation products

Where γ is the 3rd order gain of the amplifier.

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

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

For narrowband (GSM) signals, it has been shown that the bandwidth of the IM3 products is 600 kHz.

For wideband (UMTS, LTE) signals, it has been shown that a GSM receiver perceives the wideband signal as multiple 200 kHz signals. Therefore each single IM3 product has a 600 kHz bandwidth. In that case, multiple IM3 products may fall within the GSM-R band.

2.3 MORE INFORMATION CAN BE FOUND IN THE OFCOM REPORT, “UMTS900 - GSM-R INTERFERENCE MEASUREMENTS” PREPARED BY RED-M. [22]. OUT-OF-BAND EMISSIONS

ETSI TS 137 104 [11] 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.”

In this report, it is assumed that unwanted emissions in general do not exceed the out-of-band emissions from MFCN BS as defined in ETSI TS 137 104 [11], section 6.6.

See also provisions Nos. 1.144, 1.146 and 1.146A of the ITU Radio Regulations.

2.4 STANDARD AND REALISTIC SIGNALS OF MFCN BASE STATIONS

Standard signal designates a signal compliant with the spectrum emission mask defined in ETSI standards/specifications.

Realistic signal designates a signal whose spectrum emission mask is derived from real base stations currently in use, and where the unwanted emission suppression was measured.

2.5 STANDARD AND IMPROVED GSM-R RECEIVERS

Standard GSM-R receiver designates a GSM-R cab radio or EDOR that represents those currently in use on-board trains (fixed installed) for voice and data communication. They are compliant with ETSI EN 301 515 [7].

An **improved GSM-R receiver** can be either an improved radio module or an existing one combined with an external filter installed between the train rooftop antenna and the antenna connector of the radio equipment. In both cases such an improved GSM-R receiver shall provide at least the performance specified in ETSI TS 102 933-1 v1.3.1 [10].

3 RAILWAY GENERAL PRINCIPLES

EIRENE specifies the requirements for a digital radio standard for the European railways, although it is also applicable worldwide. It consists of FRS (Functional Requirements Specification) and SRS (System Requirements Specification). EIRENE has a direct link with the relevant ETSI specifications, which cover the technical details of the GSM radio technology used.

One of the main objectives of the EIRENE FRS and SRS is to ensure interoperability for trains and staff crossing national borders or other borders between systems. It defines the requirements and conditions for the provision of harmonised functionality along the railway lines.

Some of the requirements in the EIRENE 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 the European Decision [16] and its amendments.

It is mandatory that each railway subsystem (train, infrastructure) in the European Union meets these requirements on lines under the scope of the Railway Interoperability Directive [14], 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 ones.

The word interoperability is used in different sectors with a sense that may not always be the same. In the railway environment, the focus is placed on the fact that trains should be able to run uninterruptedly across railway networks and without the need to modify their configuration, so no technical barrier is found by them when travelling between two locations.

The following definitions are extracted from the Railway Interoperability Directive 2008/57/EC [14] and the associated European Decision [16] and its amendments, as well as EIRENE System Requirements Specification [6].

3.1 DEFINITION OF RAILWAY INTEROPERABILITY

Today, the competitiveness of the railways is curbed by the differences between Member States in terms of rolling stock, technology, signalling systems, safety regulations, braking systems, traction currents and speed limits. This state of affairs forces international trains crossing several States to stop at "frontiers".

Historically, these technical differences met the need to protect the Member States' own interests or those of their rail industry. At the same time, the road transport industry took advantage of its freedom from technical barriers to reinforce its position on the market.

In the Directive 2008/57/EC [14] on the interoperability of the railway system within the Community, 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 for these lines. This ability depends on all the regulatory, technical and operational conditions which must be met in order to satisfy the essential requirements;

The technical details required for railway interoperability are included in the Technical Specifications for Interoperability. The definition, also in Article 2 of the Directive, explains its content:

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

The so called “essential requirements” are listed in the TSI:

> ‘essential requirements’ means all the conditions set out in Annex III of the directive which must be met by the rail system, the subsystems, and the interoperability constituents, including interfaces;

Together with the “basic parameters”:

> ‘basic parameters’ means any regulatory, technical or operational condition which is critical to interoperability and is specified in the relevant TSIs;

As a concrete example, let us consider the requirements set up for the radio communication system to be used by railways. In the Control-Command and Signalling (CCS) TSI (Decision 2012/88/EU [16]), there are two subsystems described: the trackside subsystem and the on-board subsystem. Both of them have elements related to radio communication.

The features of the subsystems, contained in the TSI, are:

- the functions that are essential for the safe control of railway traffic, and that are essential for its operation, including those required for degraded modes;
- the interfaces;
- the level of performance required to meet the essential requirements.

The CCS TSI specifies only those requirements which are necessary to assure the interoperability of the trans-European rail system and compliance with the essential requirements.

The radiocommunication system to be used is GSM-R. This is stated in the basic parameters included in the CCS TSI, section 4. The air interface is also characterised and it is specifically mentioned that the interfaces shall operate in the R-GSM band as specified in EIRENE SRS, version 15.4.0, section 3.5 (see table 3-A in 3.5.1) of the EIRENE SRS [6].

Extracts from EIRENE SRS, version 15.4.0, section 3.5 [6]:

“3.5.1 For applications of EIRENE Systems which are relevant to interoperability of the rail system within the European Community, in particular according to the Directive 2008/57/EC, the network shall operate in a sub-band, or combination of sub-bands, of the R-GSM band as defined in EN 301 515 according to the table 3-A below: (I)

	Sub-bands	***Frequencies (MHz)***	
R-GSM band	*UIC frequency band*	*876-880 / 921-925*	*(MI)*
	Extended GSM (E-GSM) band	*880-915 / 925-960*	*(M)*
	Primary GSM (P-GSM) band	*890-915 / 935-960*	*(M)*

Table 3-A

3.5.2 The UIC frequency band for GSM-R is defined in CEPT T/R 25-09[1], 1999/569/EC [17][17] *and ECC/DEC/(02)05: (I)* [18]

- *876 – 880 MHz (mobile station transmit); paired with*
- *921 – 925 MHz (base station transmit).”*

The requirements in EIRENE FRS and SRS that are classified as (MI) are mandated by the CCS TSI.

[1] ERC Recommendation T/R 25-09 has been withdrawn and replaced by ECC/DEC/(02)05 [18]

Some GSM-R operators have signed national roaming agreements with MFCN operators. GSM-R radio modules compliant with ETSI TS 102 932-1 [21] have also the capability to use public mobile 900 MHz frequencies. Currently, only the frequency band 876-880 MHz / 921-925 MHz is Mandatory for Interoperability (MI).

3.2 LEGAL FRAMEWORK

Before a vehicle can run on a railway infrastructure, there are a number of steps that have to be completed, which include the verification of the technical characteristics required in the different legal texts, in the standards and a number of processes that have to be followed in order to ensure the safe integration of the elements in the vehicle and of the vehicle with the infrastructure it will run in.

These processes for placing on the market and placing in service of the vehicles are regulated in the corresponding Directives. The time and resources required to fulfil these processes, together with the logistic restrictions of modifying the fleets that are already in service, cannot be neglected, as they impose some restrictions to the rhythm of the adoption of modifications in the vehicles.

3.2.1 Train authorisation framework

The Interoperability Directive (2008/57/EC [14]) describes the steps required in order to get the authorisation for placing in service of the railway subsystems.

In the Control-Command and Signalling TSI (Decision 2012/88/EU [16] and its amendments), there are two subsystems described: the trackside subsystem and the on-board subsystem. Both of them have elements related to radio communication.

Each Member State shall authorise the placing in service of the subsystems to operate in its territory.

In order to grant the above mentioned authorisation, the National Safety Authority (NSA) considers the EC declaration of verification (based on a certificate issued by a Notified Body) that is included in the application for the authorisation; the documents in this application ensures the compliancy to the corresponding TSIs, the integration with the infrastructure and the compliancy to additional national rules (if applicable).

When a train (on-board subsystem) has been authorised and it is modified, the Member State shall receive a description of the modifications performed (Article 20). The Member State shall examine this file, and, taking account of the implementation strategy indicated in the applicable TSI, shall decide whether the extent of the works means that a new authorisation for placing in service is needed.

Such new authorisation for placing in service shall be required whenever the overall safety level of the subsystem concerned may be adversely affected by the works described. If a new authorisation is needed, the Member State shall decide to what extent the TSIs need to be applied to the project.

This decision has to be taken no later than 4 months after the submission of the complete file to the NSA.

When a modification to a subsystem is performed, the Notified Body that has issued an EC certificate of verification for the subsystem has to be also contacted, and an assessment has to be done by it in order to either reissue a certificate containing the modification or to issue a new certificate if the changes are considered as significant.

A similar exercise is required for the defined Interoperability Constituents (IC) (for the on-board subsystem: cab radio, EDOR). When an IC is going to be placed on the market, it requires a prior “conformity or suitability for use”. The Member States shall consider that an IC meets the essential requirements laid in a TSI based on the corresponding certificate, issued by a Notified Body or the entity indicated in the corresponding TSI. When the IC is also subject to other regulation (such as the Radio Equipment Directive), the certificate issued shall contain the compliancy to the requirements set in other regulations or Directives.

When an IC already placed on the market is modified, this modification has to be communicated to the assessment body (Notified Body or the entity indicated in the TSI), who will consider if the change is significant and if there is a need to issue a new certificate or to reissue the existing one, containing the modification.

These processes (certification, authorisation) are laid down in the Interoperability Directive [14], but there is no indication on the length of some of them. For the authorisation of placing in service of vehicles, the times are described in Art 23.7 of the Interoperability Directive which states:

“All applications for an authorisation to place in service submitted in accordance with this Article shall be the subject of a decision by the national safety authority, to be taken as soon as possible and not later than:

- *a.* ***two months*** *after submission of the file referred to in paragraph 3;*
- *b. where applicable,* ***one month*** *after provision of any additional information requested by the national safety authority;*
- *c. where applicable,* ***one month*** *after provision of the results of any tests requested by the national safety authority.”*

As a consequence, changes in the railway and GSM-R environments must follow a stringent process which can take time.

3.2.2 Radio Equipment Directive (RED or RE Directive)

GSM-R equipment falls under the scope of the Radio Equipment Directive (RE Directive) 2014/53/EU [15]. Under the RE Directive, providers/manufacturers of radio equipment have also to provide a declaration of conformity that includes the information about the intended use and usage restrictions in relation to the radio equipment. The RE Directive applies according to the considering (10) below:

(10) “In order to ensure that radio equipment uses the radio spectrum effectively and supports the efficient use of radio spectrum, radio equipment should be constructed so that: in the case of a transmitter, when the transmitter is properly installed, maintained and used for its intended purpose it generates radio waves emissions that do not create harmful interference, while unwanted radio waves emissions generated by the transmitter (e.g. in adjacent channels) with a potential negative impact on the goals of radio spectrum policy should be limited to such a level that, according to the state of the art, harmful interference is avoided; and, in the case of a receiver, it has a level of performance that allows it to operate as intended and protects it against the risk of harmful interference, in particular from shared or adjacent channels, and, in so doing, supports improvements in the efficient use of shared or adjacent channels.”

From 13 June 2016 on, based on the RE Directive, the harmonised standards will also have to define receiver parameters.

Passive elements however, which could be placed separately on the market such as passive antennas or filters are *a priori* not considered as ‘radio equipment’ falling under the scope of the RE Directive. These elements can make a declaration of conformity invalid when they would lead to the creation of harmful interference or have a negative impact (not sufficient protection against harmful interference) on the spectrum usage.

In case of the addition of a passive filter (i.e. a filter containing exclusively passive components) in the GSM-R receiving chain, this has no impact on the conformity declaration under the RE Directive [15].

These elements are also subject to the train authorisation framework, as described in section 3.2.1.

3.3 EIRENE RADIO REQUIREMENTS

The minimum GSM-R coverage levels are defined in the EIRENE SRS 15.4.0 [6] section 3.2 as follows:

> "*3.2.1 For network planning, the coverage level is defined as the field strength at the antenna on the roof of a train (nominally a height of 4m above the track). An isotropic antenna with a gain of 0dBi is assumed. This criterion will be met with a certain probability in the coverage area. (The target coverage power level is dependent on the statistical fluctuations caused by the actual propagation conditions.) (I)*
>
> *3.2.1i The values concerning coverage and speed-limitations listed in § 3.2.2 to §3.2.3 are applicable for ER-GSM band frequencies. For other frequencies listed in §4.2.1i, the equivalent power budget taking into account attenuation conditions and power classes as defined in 4.2.4 is to be considered. (I)*
>
> *3.2.2 The following minimum values shall apply: (MI)*
>
> - *coverage probability of 95%[2] based on a coverage level of 38.5 dBµV/m (-98 dBm) for voice and non-safety critical data;*
> - *coverage probability of 95% based on a coverage level of 41.5 dBµV/m (-95 dBm) on lines with ETCS levels 2/3 for speeds lower than or equal to 220km/h.*
>
> *3.2.3 The following minimum values shall apply: (MI)*
>
> - *coverage probability of 95% based on a coverage level of 44.5 dBµV/m (-92 dBm) on lines with ETCS levels 2/3 for speeds above 280km/h;*
> - *coverage probability of 95% based on a coverage level between 41.5 dBµV/m and 44.5 dBµV/m (-95 dBm and - 92 dBm) on lines with ETCS levels 2/3 for speeds above 220km/h and lower than or equal to 280km/h.*
>
> *3.2.4 The EIRENE mobile installation shall be designed to operate in a network meeting the criteria in 3.2.2 and 3.2.3. (MI)*
>
> *3.2.5 The specified coverage probability means that with a probability value of at least 95% in each location interval (length: 100m) the measured coverage level shall be greater than or equal to the figures stated above. The coverage levels specified above consider a maximum total loss of 6 dB between antenna and receiver inputs (including a margin of e.g. 3 dB for ageing). This value is defined in order to ensure that the level at the input of the receiver will never be lower than the reference sensitivity level of the receiver. The relevant clauses according to the appropriate frequency band defined in EN 301 515 should apply. It is always possible to compensate losses higher than 3 dB between antenna and receiver inputs by using an antenna with the corresponding gain above the assumed value of 0 dBi (I).*
>
> *3.2.6 The values for ETCS levels 2/3 concerning coverage and speed-limitations are to be validated and, if necessary, reviewed after the first operational implementation of ETCS. (I)"*

3.4 CRITICAL ZONES FOR GSM-R

Interruption of radio communication can have an impact on railway operation and/or safety. A continuous availability of and accessibility to the GSM-R network is required in order to transmit and receive a Railway Emergency Call everywhere along the rail tracks. Furthermore, based on the railway operational needs, critical zones can be identified on a national basis such as:

[2] The 95% minimum coverage probability requirement may be related to a 50% value by use of a correction factor. However that correction factor depends on the actual propagation, fading and terrain aspects; it typically varies between ca 10 and 13dB.

- locations where trains will start their trip or continue it after a stop, for example:
  - stations,
  - signals,
  - shunting yards;
- locations where trains can encounter a dangerous situation, for example:
  - junctions,
  - rail/road crossings,
  - tunnels, bridges;
- areas with ETCS Level 2/3 where continuous data communication is required:
  - ETCS Level 2/3 entry zones,
  - specific or complete stretch of ETCS Level 2/3 lines (including stations, tunnels, bridges, entrance to shunting yard, etc.), Note that special attention has to be paid to the possible stopping points in the lines signalled with ETCS L2/3, including Radio Block Centre (RBC) handover areas.

Preventing interferences in these critical zones should have the highest priority in the coordination process.

4 GSM-R VERSUS MFCN TEST RESULTS

4.1 LAB TESTS IN MUNICH

Several test campaigns were performed in the laboratories of the Monitoring Station Munich of the Federal Network Agency, Germany (BNetzA): the first one between 19 and 23 August 2013 and additional measurements in 2013 and 2014. Both the UIC and the GSMA (GSM Association) participated. The measurement report is provided in document FM(13)134r2 [2].

The interfering effects from MFCN transmitters (unwanted emissions inside the GSM-R band) as well as from GSM-R receivers (blocking and receiver intermodulation) were measured separately. It is very difficult to separate blocking from intermodulation, often it is a combination of both. The results allow determination of the transition between transmitter and receiver effects to a certain extent which may help to develop solutions in order to improve the situation, especially when UMTS and LTE are introduced in the band above 925 MHz.

To assess the possible improvements enabled by internal filtering, a GSM-R receiver with a built-in filter, called hereafter *receiver Rx1*[3], was measured in addition to a receiver currently used by the railway operators, called hereafter *receiver Rx2*[4], which fulfils the requirements of ETSI EN 301 515 [7]. The two receivers were from two different vendors.

These two GSM-R receivers were tested in front of GSM, UMTS and LTE signals, both standard and realistic. Standard signals are based on 3GPP/ETSI spectrum emission masks; realistic signals are based on spectrum emission masks from products currently rolled out. The latter has lower unwanted emissions than the former.

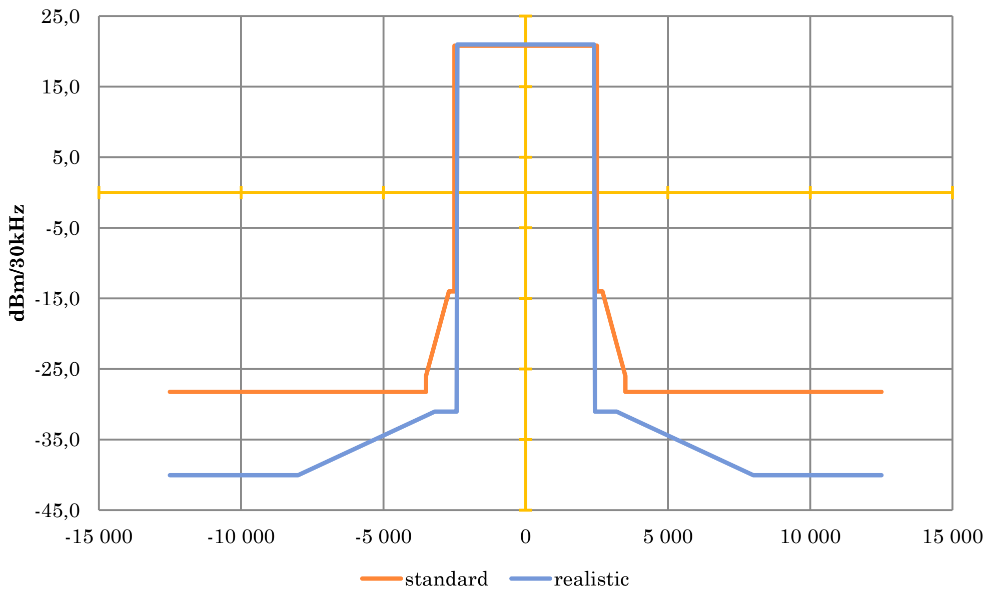

Figure 3: UMTS/LTE emission masks, at antenna connector

To ensure comparable results, the failure criterion used for all measurements was an RxQual value of 4.

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[3] Rx1 defines an improved GSM-R radio module compared to Rx2, but not yet fully compliant with ETSI TS 102 933-1 v1.3.1 [10]

[4] Rx2 reflects the most commonly used GSM-R receivers, fully compliant with ETSI EN 301 515 [7]

The main results of these measurement campaigns can be summarised as follows:

- the GSM-R receiver Rx2 generates intermodulation products, it is UMTS/LTE intra-signal intermodulation and also inter-signal intermodulation with GSM;
- when interfered, it is likely that the whole GSM-R downlink frequency range is affected;
- UMTS, LTE/5MHz and LTE/10MHz have similar interference potential;
- the GSM-R receiver Rx1 is mainly affected by unwanted emissions;
- both receivers show a co-channel C/I of 6 dB.

4.1.1 Results for the receiver Rx2

The receiver Rx2 is affected by intermodulation when MFCN emissions in the E-GSM band are above the following thresholds.

Table 1[5]: Intermodulation generated in presence of a single UMTS/LTE 5 MHz carrier

Carrier frequency separation	Intermodulation threshold for the receiver Rx2 and a GSM-R signal level of -98 dBm
2.8 MHz	-40 dBm/5MHz
6.4 MHz and further	-33 dBm/5MHz and then increase of 1 dB/2.5MHz of additional carrier frequency separation

Table 2[6]: Intermodulation generated in presence of several UMTS/LTE carriers or of a combination of UMTS/LTE and GSM carriers

Carrier frequency separation	Intermodulation threshold for the receiver Rx2 and a GSM-R signal level of -98 dBm
≥ 6.2 MHz Note 1	-33 dBm/channel Note 2
Note 1: no measurement has been performed for lower carrier frequency separation Note 2: for UMTS, channel bandwidth is typically 5 MHz; for GSM, channel bandwidth is 200 kHz	

The measurements in Munich show that at lower GSM-R coverage levels some other effects come into force. Since the effect of IM3 is a linear one, the curves can be extrapolated to -39 dBm/200 kHz instead of -41 dBm/200 kHz to reflect the expected IM3 behaviour.

For the specific case of intermodulation generated in presence of 2 GSM carriers, the threshold is -39 dBm/200 kHz[7]. The intermodulation threshold increases by 1 dB when the wanted GSM-R signal level increases by 3 dB (typical of IM3). Effect of unwanted emissions cannot be seen since intermodulation is the dominant phenomenon.

As shown in section 2.2, the main contributor to the intermodulation product is the signal with the lower frequency.

4.1.2 Results for the receiver Rx1

The receiver Rx1 (with built-in filter) is more robust to adjacent wanted emissions but still may be affected by a UMTS/LTE signal located in the first 5 MHz of the E-GSM band:

[5] Annexes 4 and 6 of FM(13)134r2
[6] Annex 5 of FM(13)134r2
[7] Annex 5 of FM(13)134r2

Table 3: Effect on the receiver Rx1 facing a realistic UMTS/LTE signal

WB frequency block	GSM-R signal level	Effect on the receiver Rx1
1st 5 MHz block (925-930 MHz) see Figure 5	C_{GSM-R} < -83 dBm [Note 1]	Unwanted emissions: C/I =6dB Protection ratio of -59 dB
	C_{GSM-R} ≥ -83 dBm [Note 1]	Intermodulation: $P_{UMTS/LTE}$ ≥ -24 dBm [Note 2] Protection ratio ≥ -59 dB
2nd 5 MHz block and beyond	Any	Unwanted emissions: C/I = 6 dB Protection ratio of -66 dB

Note 1: The transition point where the dominant phenomenon becomes intermodulation instead of unwanted emissions is around -52 dBm when facing a standard UMTS/LTE signal. This is in line with the standard spectrum emission mask that shows higher out-of-band emissions than the realistic one.

Note 2: To be compared with -35 dBm for the receiver Rx2. Generally the tolerable wideband signal level for the receiver Rx1 is at least 10 dB higher than for the receiver Rx2.

The intermodulation threshold increases by 1 dB when the wanted GSM-R signal level increases by 3 dB (typical of IM3).

Figure 4 shows Rx1 receiver's filtering capability by comparing Rx1 selectivity with Rx2.

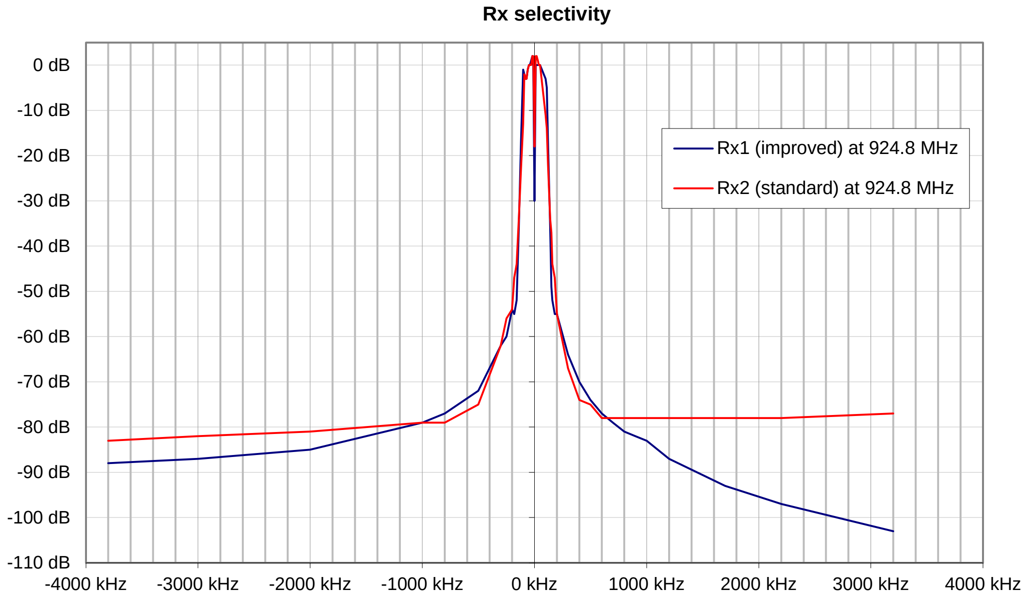


Figure 4: Rx1 receiver's filtering capability of the public 900 MHz band

By plotting the variation of the protection ratio between GSM-R and MFCN signals with the increase of the GSM-R wanted signal, Figure 5 shows where intermodulation starts to become the dominant effect in the GSM-R Rx1 receiver, instead of MFCN OOB emissions.

GSM-R at 924,8 MHz – UMTS and LTE at 927,6 MHz

Figure 5: Rx1 receiver behaviour, comparison between UMTS and LTE realistic signals

4.2 FIELD TESTS IN THE UNITED KINGDOM

The UIC Frequency Management Group executed in July 2013 a field test, together with three GSM-R mobile radio suppliers and hosted by Network Rail UK. The field test was conducted at five different locations in the greater London area. The London area was chosen because Network Rail is facing an increasing number of interferences since the Olympics in 2012 when the mobile operators switched to UMTS900. All visited sites were identified by Network Rail due to failure reports provided by train drivers and can be seen as severe interference environment where MFCN networks were transmitting in close vicinity to the railway tracks.

The aim of these field tests was to identify the capabilities of radio modules to resist to external interferences and the improvements that can be achieved on the GSM-R terminal side. During the activities no external filter or filtering function was tested.

The results clearly showed the improvements achieved by the radio module vendors. These results could be achieved by the use of a built-in filter function which prevents the creation of IM3 products inside the GSM-R RF-frontend and the improvement of the linearity of the receiver chain.

Detailed information can be found in UIC Report O-8740 [5].

5 MFCN UNWANTED EMISSIONS

5.1 MFCN OOB EMISSIONS

Where issues due to blocking and intermodulation have been solved by the introduction of improved GSM-R receivers, still interferences due to out-of-band (OOB) emissions from MFCN transmissions may exist when the GSM-R signal level is low. Note that this is the case with any improved receiver solution. Therefore it is important to address OOB emissions and identify means to avoid interferences due to them.

Table 4 provides a calculation method that gives the maximum MFCN OOB level below 924.9 MHz anywhere at 4m above the rail tracks, which should trigger the coordination process (see section 7).

Table 4 also considers that some GSM-R operators define a minimum C/I and a target C/I which is higher in order to enhance the quality of their network. For those networks, the maximum MFCN OOB level should be calculated based on the target C/I, and only for worst case situations on the minimum C/I on a case by case basis.

This table is applicable to any GSM-R service: Voice, ETCS over CSD, ETCS over GPRS, at high speed or not. Cells highlighted in blue are those where national values should apply, based on operational inputs.

Table 4: Maximum MFCN OOB level

Assumption: 0 dBi antenna							
Allowable interference level							
Minimum coverage level at train antenna (service specific), 95% value	signal level	*A*	-95	dBm/200kHz			*Notes 1, 2*
Interference degradation margin	desensitization	*B*	3	dB			
Slow fading margin	planning margin	*C*	10	dB			*Note 3*
Hardware losses	losses	*D*	6	dB			
C/(N+I) (service specific)	C/(N+I)	*E*	12	dB			*Notes 2, 4, 5*
Total noise + interference acceptable at radio connector	N+I acceptable at connector	*F*	-100	dBm/200kHz	1E-10	Watt	*F = A + B + C - D - E* *Note 4*
Noise figure of receiver	noise figure	*G*	8	dB			
Receiver noise floor for 200 kHz bandwidth	noise floor	*H*	-113	dBm/200kHz	5,01187E-12	Watt	*H = -121 + G*
Total interference acceptable at radio connector	I_{total} acceptable at connector	*I*	-100	dBm/200kHz	9,49881E-11	Watt	$I = 10.\log_{10}(10^{F/10} - 10^{H/10})$ *Note 6*
Total interference acceptable at train antenna	I_{total} acceptable at antenna	*J*	-94	dBm/200kHz			*J = I + D* *Note 6*
OOB emissions							
GSM-R internal C/I (mainly due to emissions from co-channel and adjacent channel)	GSM-R internal C/I	*K*	20	dB			*Notes 6, 7*
GSM-R internal interference (mainly due to emissions from co-channel and adjacent channel)	GSM-R internal I	*L*	-111	dBm/200kHz	7,94328E-12	Watt	*L = A + C - D - K* *Note 6*
MFCN OOB level acceptable at radio connector, 50% value	MFCN external I at connector	*M*	-101	dBm/200kHz	8,70448E-11	Watt	$M = 10.\log_{10}(10^{I/10} - 10^{L/10})$ *Note 6*
MFCN OOB level acceptable at train antenna, 50% value	MFCN external I at antenna	*N*	-95	dBm/200kHz			*N = M + D* *Note 6*

Note 1: The minimum coverage level depends on the service considered. It is equal to or higher than the EIRENE requirement for that service. The minimum level specified in EIRENE is based on the assumption that there is no external interference source present. Therefore, locations where the minimum GSM-R signal level falls between -98 dBm and -95 dBm should be discussed carefully at national level. It is assumed that the number of occurrences is quite low and can be solved by applying the best engineering practice.

Note 2: Both the GSM-R coverage level C and the required target C/I increase by the same amount of dB depending on the service. Some GSM-R operators define a minimum C/I and a target C/I value which is higher, in order to enhance the quality of their network. For those networks, the maximum MFCN OOB level should be calculated based on the target C/I, and only for worst case situations on the minimum C/I on a case by case basis.

For ETCS over CSD at speeds ≤220km/h, a 3 dB additional margin must be applied. For ETCS over CSD at speeds >280km/h, an additional 3 dB Doppler shift margin must be applied. For ETCS over GPRS, it is for further specification.

Note 3: The slow fading margin is the one used by the GSM-R operator and dependent on the propagation model selected for its cell planning.

Note 4: The noise floor is included.

Note 5: For voice, it is expected that C/(N+I) falls between 9 and 12 dB.

Note 6: The noise floor is excluded.

Note 7: GSM-R networks generally have a measured C/I of 20 dB or better, which is an average value over the network. This value may be lower at cell edge.

The table below explains the parameters taken into account in that Excel based calculation.

Table 5: Parameters used to derive the maximum MFCN OOB level that triggers the coordination process

Parameter	Explanation and reference
Minimum coverage level at train antenna (service specific), 95% value	The minimum coverage level depends on the service considered. It is chosen by the GSM-R operator and is equal to or higher than EIRENE requirement for that service. The EIRENE minimum coverage level (for voice: -98 dBm) is defined at 4m above the rail tracks and shall be fulfilled with a probability of 95% over any track section of 100m. For ETCS over CSD at speeds ≤220km/h, a 3 dB additional margin must be applied. For ETCS over CSD at speeds >280km/h, an additional 3 dB Doppler shift margin must be applied. These levels are based on the situation where there is no external interference source such as OOB emissions. Locations where the minimum GSM-R signal level falls between -98 dBm and -95 dBm should be discussed carefully at national level. It is assumed that the number of occurrences is quite low and can be solved by applying the best engineering practice.
Interference degradation margin / Desensitisation	Interference should not desensitise the GSM-R receiver by more than 3 dB (generic rule for GSM and IMT terminals, as used in e.g. ECC Report 162 [1]).
Slow fading margin	The GSM-R slow fading margin is dependent on the propagation model used by each country. It is used to translate the minimum coverage level with a 95% probability to the planned coverage level with a 50% probability. It typically varies between circa 10 and 15 dB.
Hardware losses	EIRENE assumes 6 dB of hardware losses: 3 dB for cable loss and 3 dB for ageing.
C/(N+I) (service specific)	GSM TS 05.05 [8] defines a minimum C/(N+I) of 9 dB for voice. The value depends on the service considered and on the desired quality. Both the GSM-R coverage level C and the required C/(N+I) increase by the same amount of dB depending on the service. According to EIRENE, for ETCS over CSD at speeds ≤220km/h, a 3 dB additional margin must be applied. For ETCS over CSD at speeds >280km/h, an additional 3 dB Doppler shift margin must be applied. N = noise floor; I = sum of the internal interfering signals (co-channel, adjacent channels) and the external interfering signals (MFCN OOB emissions).
Total noise + interference acceptable at radio connector	This is the total noise + interference (N+I) power that can be accepted by the GSM-R receiver in order to achieve the desired C/(N+I).
Noise figure of receiver	The noise figure of a typical GSM-R radio equipment is 8 dB.
Receiver noise floor for 200kHz bandwidth	This is the thermal noise level at 200 kHz bandwidth of -121 dBm, plus the receiver noise figure. Hence, the noise floor of the receiver is -113 dBm.

Parameter	Explanation and reference
Total interference acceptable at radio connector	This is the total interference power that can be accepted by the GSM-R receiver at its input connector.
Total interference acceptable at train antenna	This is the same as the previous line, but translated to the level at the train antenna (by adding the hardware losses).
GSM-R internal C/I	This is the C/I due to the GSM-R system itself (combined effect of co-channel and adjacent channel emissions). GSM-R networks generally have a measured C/I of 20 dB or better.
GSM-R internal interference	This is the interference power due to the GSM-R system itself.
MFCN OOB level acceptable at radio connector, 50% value	This is the interference power level due to MFCN OOB (50% value) emissions that can be accepted by the GSM-R receiver in order to achieve the required C/(N+I).
MFCN OOB level acceptable at train antenna, 50% value	This is the same as the previous line, but translated to the level at the train antenna (by adding the hardware losses).

5.2 TOTAL EXTERNAL INTERFERENCE POWER

The total interfering power is cumulative over two or more sources (e.g. several BS sites operating in adjacent channels). This may be taken into account during the coordination process set out in section 7. However external interference power is usually dominated by the strongest interfering source. Self-interference of the GSM-R network is also taken into account in the above calculation.

6 WAY FORWARD

Due to commercial sensitivities financial implications for MFCN operators are not included in this Report.

6.1 WAY FORWARD ON ISSUES RELATED TO MFCN IN-BAND EMISSIONS

6.1.1 Considerations on the radio environment for the improved GSM-R receivers

In order to sustainably mitigate interferences due to blocking and intermodulation, the GSM-R radios need to be improved with respect to the receiver characteristics as defined in ETSI EN 301 515 [7] or ETSI TS 102 933-1 v1.2.1 [9]). GSM-R receivers have to be able to operate in the RF environment described in UIC's report O-8736 [4] to ensure full interoperability across all European GSM-R networks. This defines the following[8]:

-10 dBm for any 5 MHz within 925-960 MHz (this level may be caused by several wideband MFCN base stations)[9].

This considers a level of -98 dBm as the minimum 95% coverage level required by the CCS TSI (Decision 2012/696/EU) [16] / EIRENE SRS [6] (see section 3.3).

The level of -10 dBm should provide sufficient mitigation against intermodulation and blocking due to strong wideband MFCN signals. This also takes into account future MFCN system developments as currently foreseen.

ETSI TS 102 933-1 v1.3.1 [10] has then been developed to specify an improved receiver able to answer to this interfering radio environment. Note that in the ETSI TS 102 933-1 v1.3.1 [10] only LTE has been considered for the interfering wideband signal.

As a certain period of time is needed to implement GSM-R radios with improved performance in all trains within Europe, a transition period should be defined in which additional mitigation measures are required to avoid GSM-R interferences, such as coordination/cooperation between MFCN and GSM-R operators.

During this period, the acceptable levels for current GSM-R receivers are given in Tables 1 and 2 in section 4.1.1 (result of measurements). This is based on a level of -98 dBm as the minimum 95% coverage level required by the CCS TSI (Decision 2012/696/EU) [16] / EIRENE SRS [6] (see section 3.3). This is the worst case scenario.

It is expected that the above stated levels ensures full interoperability for trains within Europe. Any national deviation needs to ensure that interoperability is maintained.

6.1.2 Implementation, investment and cost aspects

According to latest information in March 2013, collected by ETSI TC RT in ETSI TR 103 134 [13], GSM-R (voice and data bearers) is deployed and covers around 68 000 km of tracks in Europe and this approximate figure is confirmed by the answers received in response to the WG FM questionnaire in 2013 [3]. In Europe, where the total railway network taken into account is 221 025 km, GSM-R coverage was planned for 149 673 km according to ETSI TR 102 627 [12], published in 11/2008, which also explains that in September 2007 the network comprised 60 507 km equipped with GSM-R infrastructure, of which 40 918 km were in operation by that date.

According to CER information:

- The cost to improve the GSM-R receiver to handle blocking and intermodulation (either an external filter or a new radio module) is estimated to be of the magnitude of 2 500 Euros, excluding additional costs for engineering, re-certification, installation and related immobilisation of trains.

[8] at the train antenna, at 4 m height and assuming 0 dBi antenna gain

[9] This level (-10 dBm) should be understood as a total average power measured over a 5 MHz bandwidth (for further details, see ETSI TS 102 933-1 v1.3.1 [10])

- Most locomotives use GSM-R only for voice so far; so they have 1 radio module. But, when ETCS is used, a train may have up to 3 radio modules on-board (2 for ETCS and 1 for voice). These numbers are doubled for trains such as ICE and TGV. The number of cab radios in Europe equipped with GSM-R technology is estimated around 50 850 in 2014 and the number of EDORs is estimated around 4 850. A cab-radio contains one radio module while an EDOR contains a minimum of two radio modules.

A European wide implementation of the improved GSM-R receivers may require a minimum investment of 50 850 cab radios x 2 500 Euros + 2 x 4 850 x 2 500 Euros (be it for improved radio module or external filtering) equalling about 151 million Euros over the following years. This amount doesn't take into account installation, immobilisation, certification and authorisation costs. The estimated overall cost of a European wide implementation of the improved GSM-R receiver is around 300 million Euros (excluding certification and authorisation costs) and may require between 3 and 6 years to be deployed on all vehicles.

Changes at the GSM-R radio equipment such as incorporation of a filter at trains (in front of cab radios or EDORs) or exchange of radio modules are thus expensive and time consuming.

This is seen as the only sustainable solution able to face changes in the E-GSM band (which could lead to new interference cases if no improved receivers are implemented) and resolve undetected interference locations. This observation is backed by measurements in the United Kingdom and the experience that the number of interference cases increased after switching from GSM to UMTS 900 in the United Kingdom before the Olympic Games in 2012.

Improved cab radio / EDOR receivers will become operational in the future after an appropriate transition period. Other elements as described in this report are necessary in order to secure this investment and avoid deterioration of the coexistence between GSM-R and MFCN due to further technical developments.

6.2 WAY FORWARD ON ISSUES RELATED TO MFCN OUT-OF-BAND EMISSIONS

6.2.1 MFCN OOB level to trigger the coordination process

In addition to mitigating issues due to strong in-band emissions from the E-GSM band, interferences due to MFCN out-of-band (OOB) emissions have to be resolved in order to allow full coexistence between GSM-R and MFCN using UMTS/LTE.

The Excel sheet in section 5.1 defines the maximum MFCN OOB level below 924.9 MHz and anywhere at 4m above the rail tracks, which should trigger the coordination process. If the MFCN operator is not able to fulfil this level or if it wants to transmit higher maximum OOB level, then OOB coordination is required (see section 7).

6.2.2 External filter for MFCN BS out-of-band emissions

Fulfilling this maximum OOB level may require an external filter at the BS. Here are some elements to consider with regards to the implementation of an external filter.

The worst case is a 5 MHz LTE channel in the frequency block 925-930 MHz. Since it has an occupied bandwidth of 4.5 MHz[10], the highest possible carrier is equal to 930 - Roundup(4.5/2) = 927.7 MHz[11]. The frequency space for filtering is equal to 927.7 - 4.5/2 - 924.9 = 0.55 MHz. This is much lower than the 1 MHz available in the case of LTE vs. DTT coexistence at 790 MHz.

The frequency space to implement the filter can be as narrow as 550 kHz. Such a filter will induce some insertion loss leading to a loss of coverage. Furthermore there may be no space available to install the filter, in particular on pylons already heavily used and for BS with RRU which are becoming more and more common.

All these elements show that deploying that kind of filter is challenging, and sometimes impossible. In such cases, alternative mitigation techniques should be discussed by the stakeholders.

[10] For UMTS the occupied bandwidth might be smaller

[11] According to EC Decision 2011/251/EU [19], a frequency separation of 200 kHz or more between the UMTS/LTE channel edge and the GSM channel edge between a neighbouring UMTS/LTE network and a GSM network is required.

7 GENERIC COORDINATION/COOPERATION PROCESS

The following sub-sections describe a generic process that can be adapted to each national situation. In some countries, a national process may already exist (such as in Norway or Germany), therefore all the needs should be consolidated in one single process as there should not be two parallel coordination/cooperation processes at national level.

When a formal cooperation procedure is not yet defined but desired, discussions between GSM-R and MFCN mobile licensees should be held. In case no agreement is reached between the stakeholders when defining the process or when applying it, the national spectrum regulator may act as an arbitrator. Measures applied by the regulatory authorities may be limited by the rights of use already in force. However, future authorisations or licence modifications may also address this aspect. Modifications to existing rights of use mustn't drastically change the obligations of the operators: such modifications mustn't call into question their business model; some stability must be ensured.

These processes apply to both GSM and wideband radio technologies, such as UMTS and LTE. They can be used during the transition period to avoid/mitigate interference cases related to intermodulation or blocking, as well as once GSM-R improved receivers are rolled out to prevent interference from MFCN OOB emissions.

All concerned MFCN operators and the GSM-R operator shall exchange the necessary information regarding new sites and changes on existing sites, in order to ensure continued coexistence.

The number of interference cases into GSM-R from MFCN should decrease in Europe after proper cooperation processes have been established.

Possible technical measures to address interference cases between GSM-R and MFCN networks are described in ECC Report 162 [1].

7.1 PRINCIPLES FOR A COORDINATION/COOPERATION PROCESS

It is expected that the coordination/cooperation process will be a national decision, to be used for both new and modified sites as well as in reactive mode for resolving actual interference cases. Many different options are expected, taking into account national needs and available input data, e.g. using point-to-point HCM calculations as already used in Germany.

First, each MFCN licensee should provide a point of contact to the GSM-R licensee and vice-versa.

The following figure provides a generic process that is further detailed in the following sections.

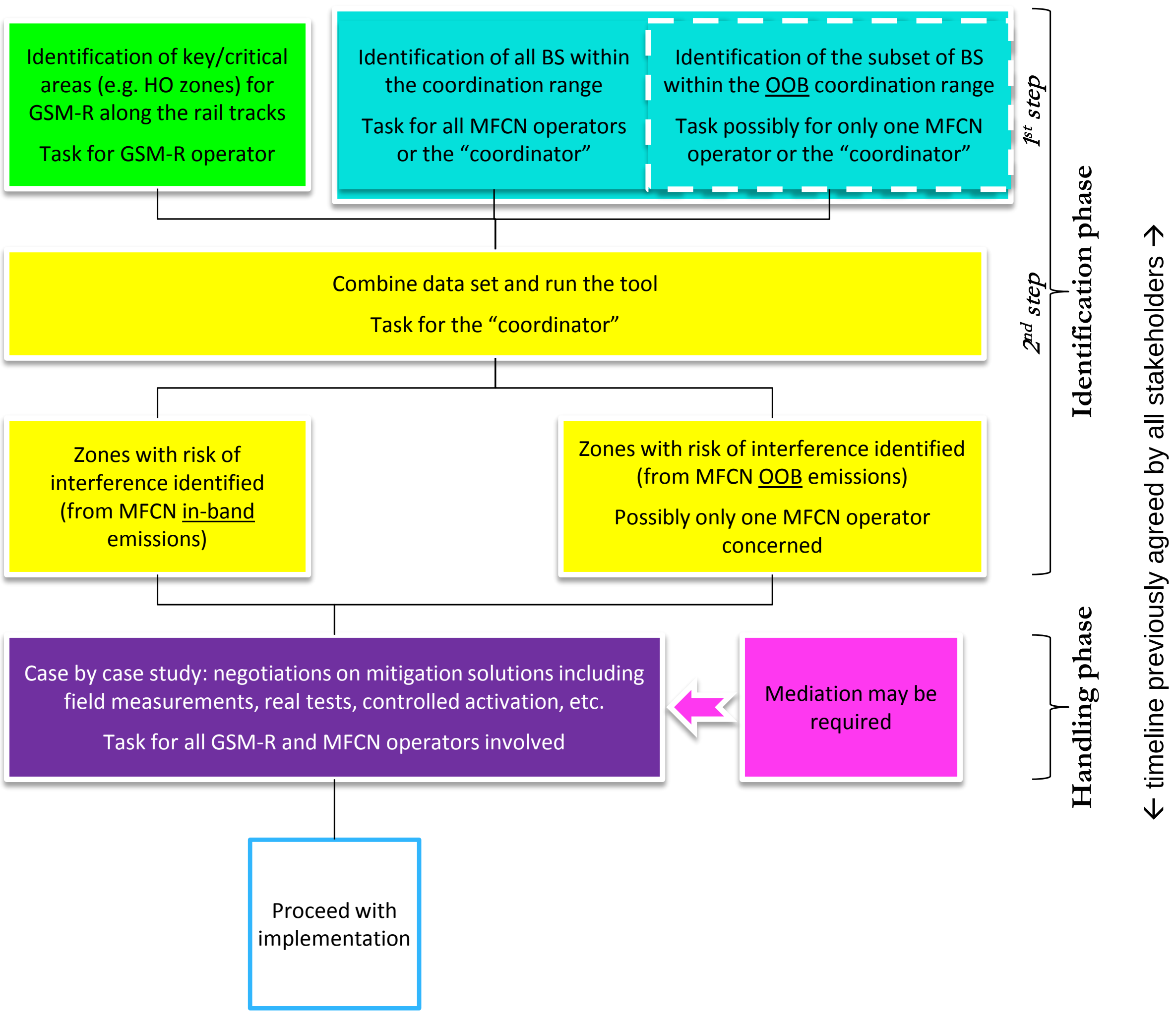
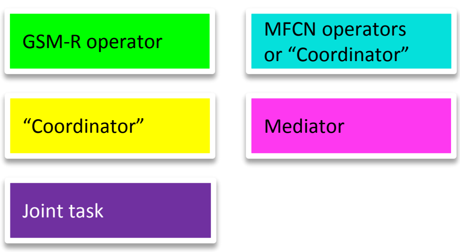


Figure 6: Generic coordination/cooperation process as example

Legend:



Roles:

- The coordinator is a trusted party, selected at national level, in charge of determining the zones with a risk of interference. Since, for competitive reasons, MFCN operators are unable to access each other's rollout data, the coordinator cannot be an MFCN operator. The coordinator may be the national spectrum regulator or an independent entity acceptable by all stakeholders.
- The mediator is a neutral trusted party, selected at national level, whose role is to help GSM-R and MFCN operators to find a solution in contentious cases. The mediator is likely to be the national spectrum regulator.
- The coordinator and the mediator may be different.

It could be envisaged that decision making power is given to the mediator by all relevant parties.

If all operators involved can reach a bilateral/multilateral agreement the administration shall be kept informed of the identified solutions.

A coordination/cooperation process should be reactive and reliable for all stakeholders taking into account continuous network optimisation needs such as for GSM900. Timeline, documentation (including the type of results), key performance indicators, milestones, and other inputs have to be agreed at national level prior to implementation of the coordination/cooperation process.

Base stations which have been coordinated may be followed in a dedicated database. A flag may be used to indicate cases where a solution was difficult to find.

Examples of national coordination/cooperation processes are provided in Annex 1.

In addition, descriptions of existing additional national measures to improve coexistence between MFCN and GSM-R are included in Annex 2.

Selection of the triggers of the coordination/cooperation process:

The coordination range must be agreed at national level. It should be defined in order to keep the volume of MFCN BS to be coordinated as low as possible. This enables lower operational burden and higher efficiency since it would be less time consuming for all involved parties. Otherwise the ability to rollout could be jeopardised for both MFCN and GSM-R. So the criteria should be kept simple and their values must be selected very carefully.

Furthermore, the risk of interference should be evaluated from the occurrence probability and the severity of its consequences, based on the critical GSM-R zones identified at the setup of the coordination process.

When is the coordination/cooperation process needed?

Such a coordination/cooperation process should be used before, during and after the transition period.

a) Before and during the transition period, the process is intended to avoid/mitigate interference cases related to intermodulation or blocking.

b) The process is also intended to prevent interference from MFCN OOB emissions before, during and after the transition period taking into account the predicted GSM-R signal level then confirmed by measurement if required. Visibility and exchange of information between the concerned stakeholders shall remain after the transition period to prevent any further issues.

The technical tool

The coordination/cooperation process will help sharing the information between operators but also provide a common view of the situation. During this process, a technical analysis of the situation is necessary.

This analysis is required to identify areas where a risk of interference (combination of occurrence probability and consequence severity) is foreseen and further investigation is required to identify the issue.

The identification of the areas to be looked at carefully is complex. For the initialisation phase of the coordination/cooperation process, all existing and planned MFCN and GSM-R base station information shall be collected. A large number of base stations is expected and the analysis will be long. However the coordination/cooperation process aims to focus the analysis on the key areas where the risk of interference is high.

The technical tool will take into account all the base stations (GSM-R and MFCN) as well as the pre-defined key/critical areas of interests. It will then identify the areas where an issue is foreseen and isolate the relevant base stations. This task is extremely important as it will reduce further the areas to be looked at in greater details.

Given the large number of base stations and key/critical areas involved it is anticipated that the use of a technical tool will help greatly the analysis by providing a large number of calculations.

Existing planning tools can be used to carry out these investigations. Most administrations will have the relevant tools to carry out this assessment however they may not be involved with the process at this level. In that case, the third party or GSM-R operator may need a technical tool. Existing national planning tools may be used or adapted to carry out the first task.

If the GSM-R operator takes on this task, it would be useful to standardise the data gathering exercise (common format for all operators) and use common settings to ensure a common view and understanding of the results.

A common tool is useful to identify the critical zones where a following deeper analysis and coordination is needed. The main benefit of the tool is the reduction of the number of cases for which further analysis and coordination is needed. The CEPT analysis tool SEAMCAT has been considered as a basis to carry out this task. SEAMCAT is not a planning tool but it could be enhanced to carry out the required first step analysis. The required MFCN and GSM-R inputs come from the concerned operators (see Figure 6). A second step analysis of the critical identified cases is necessary; to do so, SEAMCAT alone will not be sufficient. For this a planning tool is required.

The common tool would enable all stakeholders to use one agreed single solution which can run on any operating system and in support of a harmonised situation for the GSM-R with regard to coexistence with UMTS/LTE 900. The main task of such a tool would be to filter out / identify so-called ‘critical cases’ for which further coordination would be needed in a further step.

The report recommends the usage of a common tool, for example SEAMCAT. However, SEAMCAT is an interference assessment tool and not a network planning tool. The estimated cost of developing this customised module within SEAMCAT is around 40 000 €.

7.2 SITE PLANNING

When planning a new site or a major modification to an existing site (e.g. update of the frequency plan or rollout of a new technology), the MFCN operator should take into account the surrounding GSM-R existing sites. To do so, the following key characteristics of these GSM-R sites should be made available:

- exact location (latitude, longitude);
- antenna height;
- for each antenna: azimuth, tilt, frequency of each carrier and e.i.r.p.;
- handover zones along the rail tracks.

When planning a new site or updating its frequency plan, the GSM-R operator should take into account the surrounding existing sites of the MFCN operators. To do so, the following key characteristics of these MFCN sites should be made available:

- exact location (latitude, longitude);
- antenna height;
- for each antenna:
  - azimuth;
  - tilt;
  - carrier types (2G, 3G, 4G) and respective channel bandwidth;
  - frequency and e.i.r.p. of each carrier.

Several possibilities exist to get this information. For instance, the GSM-R operator may request it to the MFCN operators when planning a new area; or the GSM-R operator may get it from the national spectrum regulator who consolidates this information when each MFCN operator registers a new base station. Some national spectrum regulators may not be in a position to provide this information due to unavailability or confidentiality.

In order to preserve the confidentiality of the rollout of each MFCN operator, a non-disclosure agreement between the involved parties may be necessary.

Stakeholders should then proceed with the site coordination process, see the next section.

7.3 SITE COORDINATION

The coordinator should be notified when a new MFCN or GMS-R site is planned or when a major modification to an existing site (e.g. update of the frequency plan or rollout of a new technology such as UMTS or LTE) is about to be put into operation within the coordination range (e.g. close to the rail tracks). The definition of the coordination range should be agreed between all relevant parties.

Here are some possible criteria among others:

- Distance from rail tracks[12];
- UMTS900/LTE900 antenna in line-of-sight of the rail tracks;
- Tracks located in a critical zone for GSM-R.

Then the coordinator should gather all relevant information from involved parties, in particular when combined effects have to be looked at. Once done, the coordinator should run the tool to assess the risk of interference on the GSM-R network and its potential consequences. How to evaluate the interference probability should be agreed by all involved parties.

If a risk is identified, the coordinator should request the MFCN and GSM-R operators to discuss possible technical and/or operational solutions that could be applied on both sides[13]. In case no agreement can be found, the national spectrum regulator may have the possibility to apply an appropriate measure.

The volume of MFCN BS to be coordinated should remain low otherwise the ability to rollout both MFCN and GSM-R could be jeopardised. Therefore the criteria and their values must be selected very carefully.

A timeline should also be agreed between all stakeholders, e.g.:

- the notification should be sent X working days prior the switch on;
- the coordinator has Y working days to identify a risk;
- discussions between GSM-R and MFCN operators should start Z1 working days after a risk is notified to the MFCN operator(s) and should end Z2 working days after.

It should also be considered that, if a high number of new base stations for the MFCN networks are to be coordinated within a rather short time frame, it might be difficult for the coordinator and the railway side to react in time. Therefore a sufficient time period should be provided for the coordination process. On the other hand, from the MFCN operators' point of view, the roll-out of the network should not be hampered.

Table 6: Examples of coordination/cooperation range in terms of distance from rail tracks

<table>
<tr><th rowspan="2"></th><th rowspan="2">GSM-R min. level 95%</th><th rowspan="2">GSM-R signal level 50% Note 1</th><th rowspan="2">Intermodulation threshold Note 2</th><th rowspan="2">Coupling loss Note 3</th><th colspan="2">Rural Note 6</th><th colspan="2">Urban Note 5</th></tr>
<tr><th>Antenna vertical discrimination Note 4</th><th>Ground distance</th><th>Antenna vertical discrimination Note 4</th><th>Ground distance</th></tr>
<tr><td>Voice</td><td>-98 dBm</td><td>-86 dBm</td><td>-36 dBm</td><td>97 dB</td><td>0.25 dB</td><td>992 m</td><td>13.81 dB</td><td>88 m</td></tr>
<tr><td>ETCS high speed</td><td>-92 dBm</td><td>-80 dBm</td><td>-34 dBm</td><td>95 dB</td><td>0.25 dB</td><td>872 m</td><td>13.81 dB</td><td>80 m</td></tr>
</table>

Note 1: Interference degradation margin of 3 dB and slow fading margin of 9 dB assumed.
Note 2: Translated from the intermodulation threshold of -40 dBm (MFCN carrier at 927.6 MHz) when the GSM-R signal is at -98 dBm.
Note 3: MFCN BS EIRP of 61 dBm assumed.
Note 4: Kathrein 80010825 antenna assumed at 30m height with a 3° down-tilt.
Note 5: Propagation model used: Extended Hata – Urban.
Note 6: Propagation model used: Hata – Rural quasi-open area, valid for distances greater than 500 m.

[12] The value of this parameter depends on the minimum or planned coverage level selected by the GSM-R operator.
[13] In some cases, the GSM-R operator may prefer to act alone without involving the MFCN operator(s).

These results depend on the input assumptions (see notes above). Different assumptions will lead to different distances. These assumptions have to be systematically reviewed at national level.In practice, the vast majority of intermodulation cases are seen when the MFCN BS is closer than 250m from the rail tracks.

7.4 INTERFERENCE RESOLUTION

Interference resolution starts with a measurement report from the GSM-R operator. Such a report should include the following elements:

- exact location of the interference zone, including GPS coordinates;
- operational impact on GSM-R (e.g. poor voice quality, drop call, no network connection, etc.);
- frequency of the problem (permanent or temporary);
- map with the rail tracks, the position of the GSM-R sites and their azimuths;
- for GSM-R: ARFCN, signal levels, RxQual;
- for MFCN: ARFCN, signal levels of each carrier (be it GSM or UMTS/LTE) in the whole E-GSM band and identification of the suspected neighbouring sites;
- date and hour of the measurements;
- dominant interference source(s).

Signal levels should be RMS values.

Then stakeholders should proceed with the coordination process.

A detailed example of a measurement report as used in the United Kingdom when GSM-R faces an interference case is shown in Annex 4.

8 CONCLUSIONS

This Report provides guidance to administrations as well as GSM-R (GSM for Railway) and MFCN (Mobile/Fixed Communications Networks) licensees at 900 MHz to enable a better coexistence between GSM-R and MFCN. To this regard, it proposes a systematic approach based on a coordination/cooperation process and guidelines for the dialogue amongst administrations as well as GSM-R and MFCN licensees.

In any case, railway interoperability, i.e. ability for trains and staff to run uninterruptedly across railway networks, must be ensured. Requirements and conditions for the provision of harmonised functionality along the railway lines are defined in EIRENE FRS (Functional Requirements Specification) and SRS (System Requirements Specification). Those related to interoperability are legally binding in Europe, since they are part of the Interoperability for Control Command and Signalling Technical Specification (CCS TSI), which is published through the European Decision [16] and its amendments.

Both GSM-R and MFCN licensees use their assigned radio spectrum in compliance with the relevant European and national regulations.

Measurement campaigns performed during 2013-2014 concluded that current GSM-R receivers are affected by intermodulation products generated from a wideband signal such as UMTS/LTE, two narrowband signals such as GSM, or a combination of wideband and narrowband signals. Wideband signals can impact the whole GSM-R downlink frequency range. UMTS, LTE/5MHz and LTE/10MHz have similar interference potential.

In order to sustainably mitigate interferences due to blocking and intermodulation, the standard for GSM-R radios has been improved with respect to the receiver characteristics and published in June 2014 as ETSI TS 102 933-1 v1.3.1 [10]. GSM-R radios compliant with this new specification are robust against MFCN emissions in the E-GSM band.

Field tests carried out in the UK clearly showed the improvements achieved by the radio module vendors. They result from the use of a built-in filter function which prevents the creation of IM3 products inside the GSM-R RF-frontend and the improvement of the linearity of the receiver chain.

As a certain period of time is needed to implement GSM-R radios with improved performance in all trains within Europe, a transition period should be defined in which additional mitigation measures are required to avoid GSM-R interferences, such as coordination/cooperation between MFCN and GSM-R operators.

Before and during the transition period, the process is intended to avoid/mitigate issues related to intermodulation or blocking. Nevertheless, improved receivers may still be impacted by MFCN out-of-band (OOB) emissions falling into the receiving band of the GSM-R radio. Thus the process is also intended to prevent interference from MFCN OOB emissions before, during and after the transition period. Visibility and exchange of information between the stakeholders shall remain after the transition period to prevent any further issues.

The process is described in section 7 and can be adapted to meet national needs; it remains a national decision, noting that there are existing processes in use in some CEPT countries. The process is to be used proactively for existing, new and modified sites as well as reactively for resolving actual interference cases.

Changes at the GSM-R radio equipment such as incorporation of a filter at trains (in front of cab radios or EDORs) or exchange of radio modules, as well as changes on the MFCN network side, are expensive and time consuming.

The coordination volume and effort should be kept as low as possible for all involved parties; otherwise the ability to rollout both MFCN and GSM-R could be jeopardised. Furthermore, the risk of interference should be evaluated from the occurrence probability and the severity of its consequences on railway operation. Therefore, a pre-filtering of critical zones is suggested to be conducted before detailed coordination is triggered.

This Report also includes in its section 5.1 a calculation method that gives the maximum MFCN OOB level below 924.9 MHz and anywhere at 4m above the rail tracks, which should trigger the proactive coordination process. It should take into account national GSM-R parameters.

To support the technical analysis, a single agreed technical tool could be developed. It would allow GSM-R and MFCN operators, as well as the spectrum regulator, to use the same tool, thus avoiding mutual misunderstandings. The report recommends the usage of a common tool, e.g. SEAMCAT, which is an interference assessment tool and not a network planning tool.

ANNEX 1: DESCRIPTION OF EXISTING NATIONAL COORDINATION PROCEDURES TO IMPROVE THE COEXISTENCE BETWEEN MFCN AND GSM-R

A1.1 COORDINATION PROCEDURE IN GERMANY

In Germany, the licensing processes for MFCN and GSM-R networks are generally based on two steps. A nationwide licence is granted to the operator in the first step. This licence already contains the general frequency usage conditions, e.g. Block Edge Mask conditions, power limitations etc. The individual parameters for each base station are designated by the NRA in a second step. The second step provides the possibility to take into account additional requirements, such as cross-border issues, protection of other systems which are relevant locally or regionally.

The procedure is applicable for the protection of GSM-R (below 925 MHz) from UMTS base stations transmitting above 925 MHz. Currently, a UMTS site is rejected if the channel within 925-930 MHz generates more than 74.3 dBµV/m at 4 m above the railway line. Point-to-point HCM calculation is used. By taking into account the fact that the unwanted emissions caused in reality are below the limits as allowed by the standards, this level can be increased to 88.8 dBµV/m at 4 m above the railway line. Field tests have shown that the spurious emissions are 8 dB lower by using the next frequency block (930-935 MHz) for UMTS. Hence the level caused by UMTS base stations operating in this block could be increased to 96.8 dBµV/m at 4 m above the railway line. See also document CG-GSM-R(13)035 [20]. Higher UMTS field strengths can be tolerated if the GSM-R field strength is higher. The GSM-R network operator knows the GSM-R field strength levels along the railway lines.

In Germany the coordination process is based on the European HCM agreement and makes use of the available HCM calculation tools. These calculations are based on maximum permissible field strength values and allow an efficient and straightforward coordination of GSM-R and MFCN networks.

A1.2 COORDINATION PROCEDURE IN THE NETHERLANDS

In the Netherlands a joint approach has been agreed on between the mobile network operators, the GSM-R operator and the spectrum regulator, to tackle the issue of blocking/intermodulation on an interim basis, in advance of a sustainable solution. The agreement defines proactive measures aimed at avoiding interference due to blocking/intermodulation, and to obtain a recovery scenario when such a situation occurs. Interference of the train radios due to unwanted emissions is outside the scope of this agreement.

The agreement, that is valid until 1 July 2015, does not have a legal basis, instead it appeals to the social engagement of the parties involved.

Risk assessment and coordination process prior to activation of a new or modified base station
Not later than 1 week prior to activation of new or modified GSM, UMTS or LTE base stations within a range of 500 m of the railway tracks, the mobile network operator will inform the spectrum regulator (maximum number of 50 sites/week). The spectrum regulator will use the information to carry out a risk assessment that is based on evaluating both the probability of blocking/intermodulation and, accordingly, the impact at a particular location.

The flowchart below outlines the steps of the risk assessment and coordination procedure that will be carried out before the activation of a site.

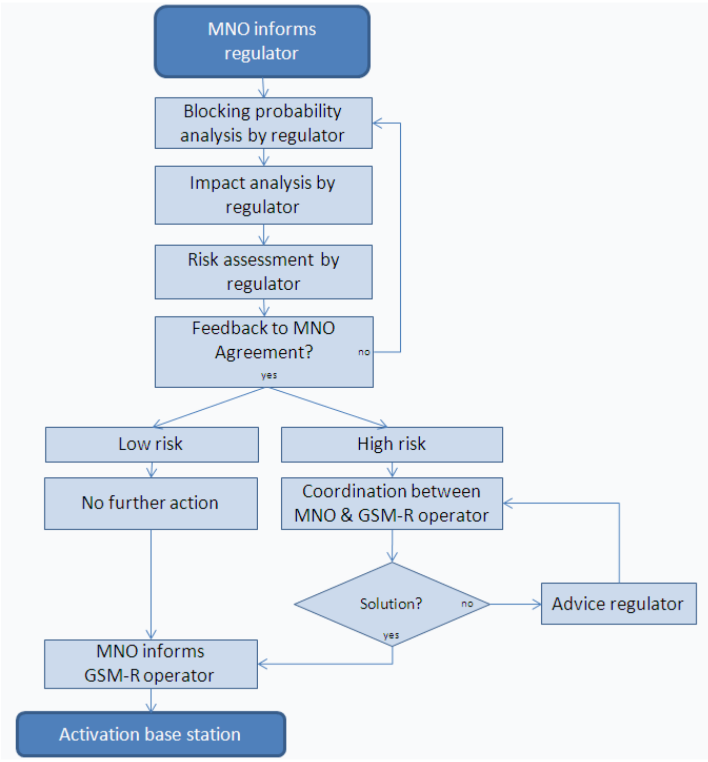


Figure 7: Pre-activation coordination process

Analysis of the blocking/intermodulation probability is done using both simulation data from a specifically developed propagation estimation tool and measurement data, acquired from train-based signal strength measurements, plotted in a geo-tool.

The impact analysis is based on geographical and usage type information provided by the GSM-R operator. It consists of areas where loss of the GSM-R connection might cause safety issues or significant disruption of the railway operations.

The combination of both blocking/intermodulation probability and impact analysis is used to determine the overall risk. If the risk is considered high, a process of coordination between the mobile network operator(s) and the GSM-R operator will take place, during which arrangements will be made for achieving a manageable situation. If parties disagree on the outcome, a re-evaluation of the risk assessment will be carried out.

Procedure in case of disturbance of GSM-R train radios.

The GSM-R operator will actively monitor if disturbance of the GSM-R communication takes place. If so, the GSM-R operator will report this to both the mobile network operator(s) and spectrum regulator. In case of severe disturbance, the mobile network operator(s) will switch off the base station(s) or sector(s) within 4 hours after the alert. A severe disturbance requiring urgent action is characterised by criteria such as: non-departing trains at a railway station, dropped calls for ERTMS trains, large-scale outages of traveller information systems, repetitive dropped calls at a location. For less critical disturbances, all parties involved will discuss possible mitigation measures, and their implementation. In the following flowchart the described procedure is shown schematically.

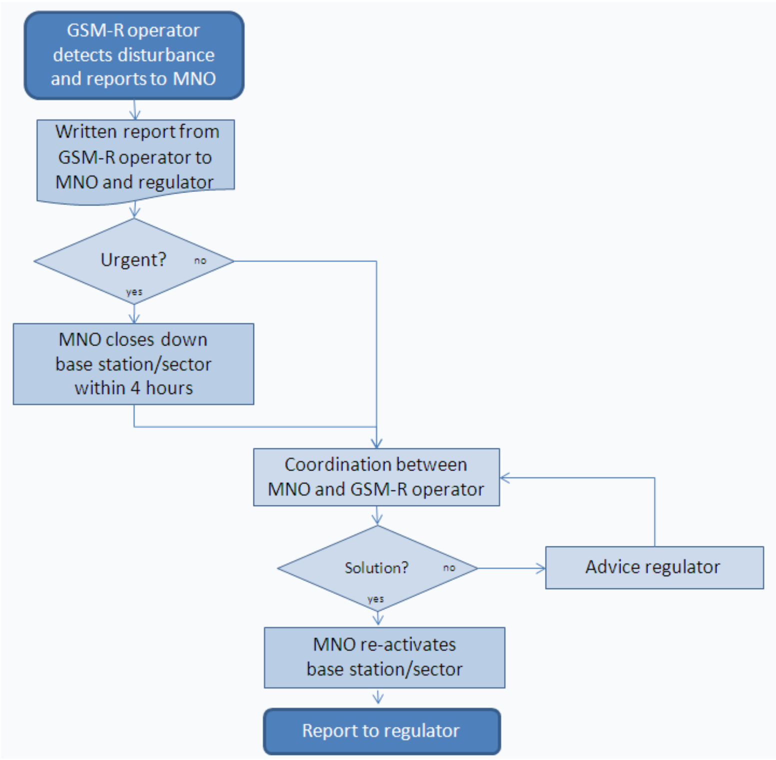


Figure 8: Post-activation interference management

Interference due to unwanted emissions

The coordination process described above does not apply when interference due to unwanted emissions occurs. Interference due to unwanted emissions is treated in accordance with EU decision 2009/766/EC [19], considering ‘appropriate protection’[14], which is included in the license. The interpretation of appropriate protection is such that a C/I approach is chosen, i.e. the power relationship between the level of unwanted emissions of MNO base stations and wanted GSM-R signal is taken as a measure to determine whether appropriate protection is given. Mid 2014 the Dutch regulator has sent out a proposal to all parties involved describing a code of conduct, including the following statements with ongoing discussions at the time of the production of this report:

- Appropriate protection only deals with interference due to unwanted emissions;
- Appropriate protection is given if the C/I is at least 17 dB, wherever ERTMS is or will be used along the railroads. Anywhere else, a C/I of at least 12 dB should be applied;
- If the minimum coverage level of GSM-R is less than -72 dBm (50% place/time probability), the licensee is not obliged to offer appropriate protection. In this case, the railway operator is responsible to tackle the GSM-R ‘weak spot’;
- If the level of unwanted emissions is lower than -92 dBm (50% place/time probability), the licensee is not obliged to offer appropriate protection. This applies to the trajectories where ERMTS is or will be used;
- For the trajectories where ERTM is not or will not be used, the licensee is not obliged to offer appropriate protection if the level of unwanted emissions is lower than -85 dBm (50% place/time probability).

The above given figures are based on a maximum GSM-R co-channel interference level of -92 dBm.

[14] ‘Member States shall ensure that other systems referred to in Article 3 and Article 4(2) and paragraph 1 of this Article give appropriate protection to systems in adjacent bands’

A1.3 COORDINATION PROCEDURE IN NORWAY

In Norway MFCN licences in the 900 MHz band were changed after a substantial refarming process back in 2009/2010. They are now technology neutral and contain special conditions to protect the GSM-R operation.

When transmission technology other than GSM is introduced in the commercial mobile networks, GSM-R operating in the frequency band 876-880 / 921-925 MHz shall be protected at the same level as when GSM is the technology used (in the commercial networks).

The licensee is obliged to cooperate with the GSM-R operator in the planning phase and before a base station with other technologies than GSM is put into operation. This applies both for new base stations (new sites) and where the licensee changes technology from GSM to another technology on existing base stations.

When a new base station is planned, a notification shall be sent before site acquisition. When a change is made to an existing base station, a notification shall be sent before the base station is put into operation.

The basic principle in the coordination procedure is that all parties are responsible for their own networks. The party experiencing interference is obliged to undertake necessary and possible measures to improve the network quality in their own network in order to ensure a reasonable quality of service before any measures should be undertaken by the counterpart.

Costs for making changes in a network shall be paid by the owner of the network in which changes are made.

The licensee shall notify the GSM-R operator when the following conditions are met:

- The distance from the base station to a railway line is less than or equal to 700 meters. For base stations without line of sight to the railway line, or which are mounted indoors, there is no notification requirement.

The revised licenses were issued in June 2011.

If arbitration ends without reaching an agreement, NPT might take a decision that is legally binding, including setting conditions necessary to reach an agreement between the parties. Such a decision may be appealed under the provisions of the Public Administration Act. It has not yet been necessary to take such a decision as the parties, in these cases, always have been able to reach an agreement.

A1.4 COORDINATION PROCEDURE REQUIRED FOR 3G OR 4G DEPLOYMENT UNDER THE PUBLIC WIRELESS NETWORK LICENCES COVERING THE 900 MHz BAND" AS PUBLISHED BY OFCOM, UNITED KINGDOM

This specifies the coordination procedure that Ofcom considers is necessary to ensure the protection of existing GSM-R equipment from potential harmful interference from the deployment of 3G or 4G equipment in the neighbouring spectrum bands (the E-GSM bands 880-890 MHz paired with 925-935 MHz). For any 3G or 4G sites that are likely to exceed the protection threshold, the document specifies the coordination procedure that must be followed before that site can be brought into operation. The procedure applies to the protection of GSM-R base station sites and GSM-R train mounted equipment in operation at the time a new 3G or 4G site is deployed or its technology or e.i.r.p. changed such that specified thresholds are breached. The coordination procedure is not applicable to the protection of future GSM-R base stations.

ANNEX 2: DESCRIPTION OF ADDITIONAL NATIONAL MEASURES TO IMPROVE THE COEXISTENCE BETWEEN MFCN AND GSM-R

A2.1 REGULATION IN SWEDEN

In Sweden there are protection conditions above GSM-R enabled railway tracks in out and out of Band:

The first adjacent MFCN block has an emission limit of -33dBm/5MHz and the other channels to -23dBm/5MHz

The out of band emission of MFCN networks is limited to – 107 dBm/ 200KHz to protect legacy GSM-R operation. The MFCN operator can request to increase its emission to -95 /98 dBm where the GSM-R operator increases its signal level; signal level.

The first adjacent channel (925-930 MHz) has a emission limit of -33 dBm/5MHz until the 30 June 2015 and thereafter -5 dBm/5MHz, the other channels (930-960 MHz) has a emission limit of -23 dBm/5MHz until the 30 June 2015 and thereafter -0 dBm/5MHz.

The out-of-band emission of MFCN networks is limited to -107 dBm/200 kHz to protect legacy GSM-R operation. The MFCN operator can request to increase its emission to -95 dBm/200kHz (for channel 925-930 MHz) and -98 dBm/200kHz (for channels in 930-960 MHz) where the GSM-R operator when has 6 months' time to increases its signal level if needed.

A2.2 REGULATION IN SWITZERLAND

For uncoordinated network rollout in Switzerland the median of the OOB emissions from base stations of the MFCN systems in the 900-MHz-band should not exceed the level of -107 dBm on frequencies below 925 MHz in the bandwidth of 200 kHz at the measurement height of 4.5 m above the track. The measurement antenna has a gain of 0 dBi. Higher OOB emission levels must be coordinated with the GSM-R operator.

Furthermore, in case a wideband system (e.g. UMTS, LTE) deployed in 925-960 MHz and 1805-1880 MHz bands causes interference to GSM systems, including GSM-R, mitigation techniques must be applied on the wideband system.

ANNEX 3: RESPONSES FROM CEPT ADMINISTRATIONS TO THE QUESTIONNAIRE ON INTERFERENCE INTO GSM-R CAUSED BY MFCN

34 CEPT administrations provided a response to a CEPT questionnaire to CEPT administrations in 2013 on interference into GSM-R caused by MFCN.

Table 7: Country GSM-R situation in 2013 (from [3])

Situation	Country
GSM-R network implemented and in operation and interference cases officially reported to the national regulatory authority	Austria, Finland, France, Germany, Norway, United Kingdom
GSM-R network implemented and in operation and no interference cases officially reported to the national regulatory authority	Czech Republic, Greece, Italy, Lithuania, Portugal, Russian Federation, Slovak Republic, Spain, Sweden, Switzerland, Turkey
GSM-R network in process of being implemented / tests / trial phase	Belarus, Denmark, Hungary, Ireland, Macedonia, Poland
GSM-R implemented in the national frequency plan but no network implementation yet.	Bosnia Herzegovina, Croatia, Estonia, Latvia, Moldova, Montenegro, Serbia, Slovenia
No railways	Cyprus, Iceland, Malta

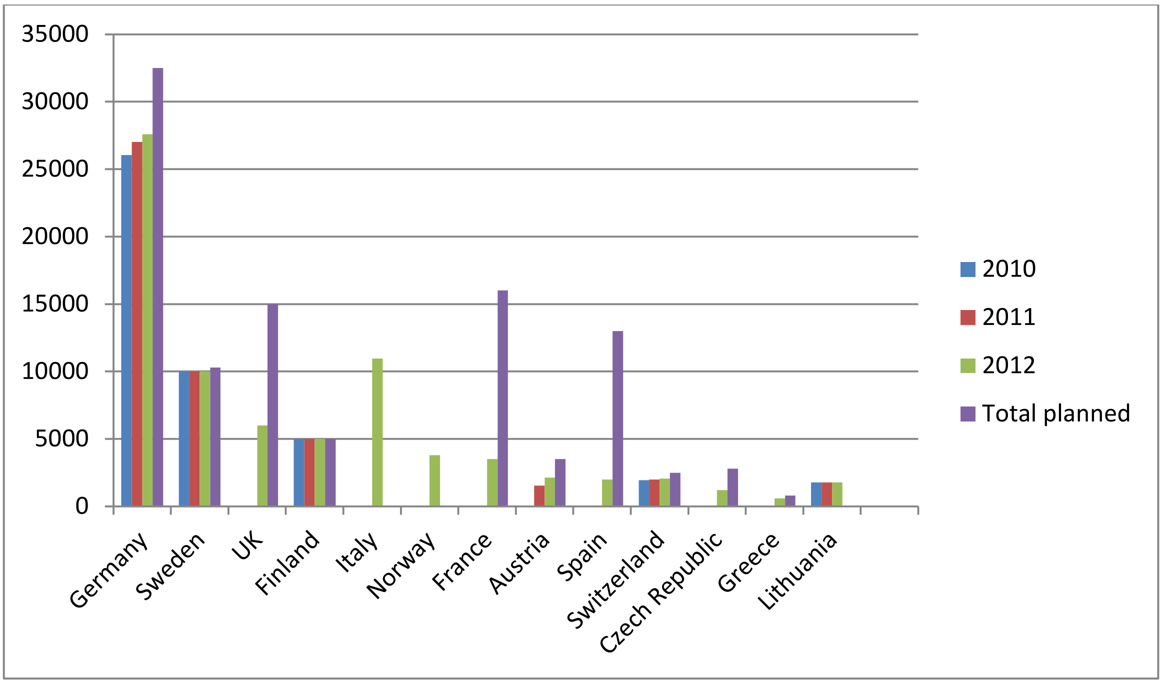


Figure 9: Country related implementation information (from [3])

Figure 9 includes the equipped distances of the railway tracks in the respective year with GSM-R technology. Portugal had in 2013 8 BS covering 40 km railways, Slovak Republic had only 17 BS covering 100 km and the Russian Federation was deploying GSM-R systems in the Krasnodar Territory and Kaliningrad Region.

Spain, UK: estimates from ETSI TR 102 627 (11/2008) [12] are included in Figure 9.

The summary on the questionnaire [3] includes information from CEPT administrations on how much interference was experienced, the causes of interferences into GSM-R. In addition, CEPT administrations informed about which technical measures have been carried out to overcome the interference situations and whether there was already cooperation amongst GSM-R and MFCN operators in place.

Blocking and intermodulation products were reported as the main reasons for the interferences. In most of the cases reported, it seemed that both networks (MFCN and GSM-R) were compliant with their allowed emission limits and minimum coverage requirements.

ANNEX 4: EXAMPLE OF MEASUREMENT REPORT AS DONE BY NETWORK RAIL (UK)

A detailed example of a measurement report as used in the United Kingdom when GSM-R faces an interference case is shown in the following table.

Table 8: Example of details provided in a measurement report

Dominant interferer source	
Cell Id of interferer	
Technology of interference	
Interference issue suspected	
Approximate distance site to boundary	
P-GSM ARFCN	
P-GSM level dBm	
BSIC	
E-GSM ARFCN	
E-GSM level dBm	
UMTS900 level dBm	
SC	
GSM-R Cell Id	
GSM-R ARFCN	
GSM-R level dBm	
Rx Quality of call	
Idle Mode observations	
Distance to serving GSM-R cell km	
Date of testing	
Operational impact	
Grid reference	

Regarding MFCN suspected sites, the following data may be included:

- for GSM: distinction between BCCH and TCH ARFCN, RxLev
- for UMTS: RSSI

ANNEX 5: LIST OF REFERENCES

[1] ECC Report 162: Practical mechanism to improve the compatibility between GSM-R and public mobile networks and guidance on practical coordination; version of May 2011

[2] FM(13)134r2: Compatibility measurements GSM/UMTS/LTE vs. GSM-R (with 8 annexes); version 3 of January 2015

[3] WGFM CG-GSM-R(13)09: Responses to the Questionnaire to CEPT Administrations on interference into GSM-R caused by MFCN

[4] UIC O-8736-2.0: UIC Assessment report on GSM-R current and future radio environment

[5] UIC O-8740: Report on the UIC interference field test activities in UK

[6] EIRENE SRS v15.4.0: System Requirements Specification

[7] ETSI EN 301 515: GSM; Requirements for GSM operation on railways

[8] GSM TS 05.05 v6.7.1 (ETSI EN 300 910 v6.7.1): GSM; Radio transmission and reception

[9] ETSI TS 102 933-1 v1.2.1: RT; GSM-R improved receiver parameters; Requirements for radio reception; version of December 2011

[10] ETSI TS 102 933-1 v1.3.1: RT; GSM-R improved receiver parameters; Requirements for radio reception; version of June 2014

[11] ETSI TS 137 104: E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception

[12] ETSI TR 102 627: ERM; System Reference Document; Land Mobile Service; Additional spectrum requirements for PMR/PAMR systems operated by railway companies (GSM-R)

[13] ETSI TR 103 134: RT; GSM-R in support of EC Mandate M/486 EN on Urban Rail

[14] Directive 2008/57/EC on the interoperability of the rail system within the Community

[15] Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC

[16] EC Decision 2012/88/EU on the technical specification for interoperability relating to the control-command and signalling subsystems

[17] EC Decision 1999/569/EC on the basic parameters for the command-and-control and signalling subsystem relating to the trans-European high-speed rail system

[18] ECC Decision (02)05 on the designation and availability of frequency bands for railway purposes in the 876-880 MHz and 921-925 MHz bands

[19] EC Decision 2011/251/EU Commission implementing Decision of 18 April 2011 amending Decision 2009/766/EC on the harmonisation of the 900 MHz and 1800 MHz frequency bands for terrestrial systems capable of providing pan-European electronic communications services in the Community

[20] WGFM CG-GSM-R(13)035: Federal Network Agency: Current GSM-R - Protection against neighbouring UMTS block in Germany

[21] ETSI TS 102 932-1 v1.1.1: Railway Telecommunications; ER-GSM frequencies; Part 1: ER-GSM additional radio aspects

[22] Red-M UMTS900 – GSM-R Interference Measurements. A Report prepared for OFCOM, 20 June 2011