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TECHNICAL REPORT

**System Reference document (SRDoc);
GSM-R networks evolution**

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document includes necessary information to support the cooperation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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Executive summary

Reliable and safe railways are a positive contributor to the cohesion of the European Union and many neighbouring countries. For both passengers and freight railway operations, mobile communication applications have become mission-critical. In its strategy to create a single, interoperable railway market in Europe, the European Commission adopted GSM based radio systems (GSM-R) as the mandatory train-to-track radio communication technology for services that are considered mission-critical and safety related. These services are conventional voice services (driver-controller calls, railway emergency calls, group calls, etc.) and data services for ERTMS/ETCS signalling systems. The implementation and use of the current GSM-R system by the European railways is still expanding.

As per the EU Regulation 2016/919 [i.2] and ECC Decision (02)05 [i.12], all current GSM-R networks in Europe use 876 - 880 MHz for the train-to-ground link and 921 - 925 MHz for the ground-to-train link. GSM-R thus has been granted a EU harmonised frequency band, the UIC frequency band. In addition to this, the band 873 - 876 MHz paired with 918 - 921 MHz has also been identified for GSM-R use on a national basis. New, updated or renewed trains are being equipped with radio equipment supporting this extended band.

GSM-R is facing a number of challenges:

- 1) There is a need to plan the end of life of the system, with current committed vendor support ending 2030.
- 2) On the mid-term, in more and more areas, additional capacity will be required to support railway operations, in part related to the increasing implementation of ETCS.

In parallel to the implementation of the successor to GSM-R (hereinafter called Future Railway Mobile Communication System - FRMCS), the GSM-R system needs continued operation to allow the upgrade of all rolling stock, until this technology is end-of-life and decommissioned.

Therefore the Union Internationale des Chemins de Fer (UIC), the European Union Agency for Railways, the GSM-R industry and other railway stakeholders across Europe are defining and specifying the next generation radio solution for railway operations, in close cooperation with ETSI. This will additionally result in an update of the EU legal framework in order to guarantee railway interoperability.

The approach for FRMCS taken in the present document is based on the following principles:

- 1) Separation of railway applications from the underlying network technologies, creating more flexibility, such as possible usage of different radio access technologies on different line categories (even within a country).
- 2) The new radio system is to be based upon the 3GPP technology roadmap.
- 3) For cost efficiency and migration purposes, the reuse of existing assets (radio sites, spectrum) is favoured.

In the present document, the following spectrum options have been explored:

- Use of the existing harmonised railway spectrum in the 2 x 4 MHz UIC frequency band (876 - 880 MHz / 921 - 925 MHz);
- Use of a combination of these 2 x 4 MHz plus 2 x 3 MHz, called the E-UIC frequency band, resulting in a total of 2 x 7 MHz (873 - 880 MHz / 918 - 925 MHz).

In order to calculate the amount of radio spectrum needed to fulfil the railway requirements, the present document has assumed the use of the latest 3GPP RAT. It is anticipated that the spectral efficiency of future 4G/5G RAT operating in the 900 MHz range, may improve as compared to current technologies. Coexistence studies will need to be performed with regard to the impact of such future radio access technologies.

In order to determine the amount of spectrum needed for FRMCS, a traffic model has been used, with several combinations of usage scenarios and operational conditions.

Based on the investigations made in the present document, the following conclusions are drawn:

- Railways need 2 x 7 MHz of dedicated spectrum to accommodate the current and (partially) future Critical railway applications and usages for the coming decades, taking into account the need for parallel operation of GSM-R and the successor technologies during the migration from GSM-R to the successor system.
- For additional railways applications (performance and business), other solutions such as sharing with other stakeholders (e.g. PPDR) and/or using MFCN, are anticipated.
- From economic efficiency perspective, using spectrum in the 900 MHz band is preferred, based on reuse of the existing GSM-R radio sites. Usage of the 700 MHz or 400 MHz ranges would lead to less reuse and/or re-location of existing sites. Furthermore, in the 700 MHz and 400 MHz range no possibility appears to exist for spectrum dedicated to railways.
- Usage of the 2 x 4 MHz spectrum for railways in 876 - 880 MHz / 921 - 925 MHz is not sufficient, extension with the 2 x 3 MHz in the 873 - 876 MHz / 918 - 921 MHz band, which has already been requested for railways in the ETSI TR 102 627 [i.7], is necessary. The introduction of FRMCS necessitates the harmonisation of the 873 - 876 MHz / 918 - 921 MHz band.
- Although the preferred solution for the migration period is to use 2 x 3 MHz in addition to the current 2 x 4 MHz, other carrier widths may be considered depending on spectrum availability in member states.
- Although the 900 MHz frequency band is preferred, other frequency bands may be considered depending on availability in member states, whilst ensuring the technical and economic viability.
- This spectrum needs to be identified by 2020, made available for trials per 2022, and available for operational deployment as of 2023.
- Decisions about spectrum allocation for railways have to be published in time, in order to be included in the 3GPP specifications and to allow the timely preparation for inclusion in the legal framework of railway interoperability.

The above conclusions result in the following requests:

- ECC is requested to harmonise the 873 - 880 MHz UL / 918 - 925 MHz DL band for railway purposes.

- ECC is requested to allow the use of other radio technologies than GSM in this band.
- ECC is requested to undertake the necessary coexistence studies.

In addition to this, 3GPP™ would have to add this band to the list of the 3GPP operating bands, possibly enhance some radio parameters and specify railway-related functions.

Introduction

The present document was developed by ETSI TC RT NG2R to support the cooperation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT).

It is intended to describe the spectrum requirements for a European system for operational railway communications between a terrestrial ground network and a train, based on 4G/5G technology, and operating in the band 873 - 880 MHz paired with 918 - 925 MHz, in coexistence with the already deployed GSM-R technology.

1 Scope

The present document applies to the next generation radio communication system for railway operations, intended to replace GSM-R, and hereafter referred to as Future Railway Mobile Communication System (FRMCS), which may require a change of the present frequency designation within CEPT and of the present regulatory framework for the proposed band(s).

The preferred regulatory approach for FRMCS is to reuse the same frequency bands that are currently designated for railway operations, within the 873 - 880 MHz paired with 918 - 925 MHz frequency band.

The present document, in particular:

- gives a GSM-R market overview;
- provides some technical information;
- investigates the harmonised UIC frequency band currently used for GSM-R, 876 - 880 MHz UL / 921 - 925 MHz DL, as well as the E-UIC frequency band, 873 - 880 MHz UL / 918 - 925 MHz DL for critical railways communications;
- notes the regulatory issues in order to ensure a smooth introduction of FRMCS as well as an efficient use of spectrum.

The FRMCS is used for communication between trains, portable UE and trackside communication entities, for applications directly related to railway operation. Passenger connectivity is out-of-scope of the present document.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] Directive 2008/57/EC on the interoperability of the rail system within the Community.
- [i.2] Commission Regulation 2016/919 on the technical specification for interoperability relating to the 'control-command and signalling' subsystems of the rail system in the European Union.
- [i.3] EIRENE FRS: "Functional Requirements Specification".
- [i.4] EIRENE SRS: "System Requirements Specification".
- [i.5] UIC: "Future Railway Mobile Communication System; User Requirements Specification".

NOTE: Available at: <http://www.uic.org/frmcs>.

- [i.6] Position paper issued by ETSI Technical Committee Railways Telecommunications and European Union Agency for Railway (RT(16)062023-Railway-vision-on-Next-Generation-Radio-for-Rails-spectrum-n.docx).

- [i.7] ETSI TR 102 627: "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference Document; Land Mobile Service; Additional spectrum requirements for PMR/PAMR systems operated by railway companies (GSM-R)".
- [i.8] ERA 2015 04 2 SC: "Coexistence of GSM-R with other Communication Systems" (final report).
- [i.9] ETSI TS 136 101: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (3GPP TS 36.101)".
- [i.10] ETSI TS 136 104: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (3GPP TS 36.104)".
- [i.11] ETSI TS 137 104: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception (3GPP TS 37.104)".
- [i.12] ECC Decision (02)05: "The designation and availability of frequency bands for railway purposes in the 876-880 MHz and 921-925 MHz bands".
- [i.13] ECC Report 82: "Compatibility study for UMTS operating within the GSM 900 and GSM 1800 frequency bands".
- [i.14] CEPT Report 40: "Compatibility study for LTE and WiMAX operating within the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands)".
- [i.15] ETSI TS 102 933-1 (V2.1.1): "Railway Telecommunications (RT); GSM-R improved receiver parameters; Part 1: Requirements for radio reception".
- [i.16] ECC Report 239: "Compatibility and sharing studies for BB PPDR systems operating in the 700 MHz range".
- [i.17] ECC Recommendation (05)08: "Frequency planning and frequency coordination for the GSM 900, GSM 1800, E-GSM and GSM-R land mobile systems".
- [i.18] ECC Recommendation (08)02: "Frequency planning and frequency coordination for GSM / UMTS / LTE / WiMAX Land Mobile systems operating within the 900 and 1800 MHz bands".
- [i.19] ECC Decision (04)06: "The availability of frequency bands for the introduction of Wide Band Digital Land Mobile PMR/PAMR in the 400 MHz and 800/900 MHz bands".
- [i.20] ETSI TS 145 005: "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (3GPP TS 45.005)".
- [i.21] ERC Recommendation 70-03 relating to the use of Short Range Devices (SRD).
- [i.22] ECC Report 200: "Coexistence studies for proposed SRD and RFID applications in the frequency band 870-876 MHz and 915-921 MHz".
- [i.23] ETSI TR 101 537: "Electromagnetic compatibility and radio spectrum matters (ERM); Second co-existence test between ER-GSM with RFID".
- [i.24] NG2R(16)004013: "Future Railway Mobile Communication System; Railway Traffic analysis for FRMCS" (contribution from the UIC).
- [i.25] NG2R(16)006011r2: "FRMCS Spectrum Demand Calculation" (contribution from the UIC).
- [i.26] Decision 2013/752/EU amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2005/928/EC.
- [i.27] CEPT Report 59: "In response to the EC Permanent Mandate on the "Annual update of the technical annex of the Commission Decision on the technical harmonisation of radio spectrum for use by short range devices"".

- [i.28] CER Study: "The economic footprint of railway transport in Europe".
- NOTE: Available at [http://www.cer.be/sites/default/files/publication/The Economic Footprint - web - final_final_30_Sept_0.pdf](http://www.cer.be/sites/default/files/publication/The_Economic_Footprint_-_web_-_final_final_30_Sept_0.pdf)
- [i.29] EU transport in figures, statistical pocketbook 2014, ISBN 978-92-79-37506-4.
- [i.30] ERA 2015 04 1 RS: "Study on migration of railway radio communication system from gsm-r to other solutions".
- NOTE: Available at <http://www.era.europa.eu/Document-Register/Pages/GSM-R-migration.aspx>
- [i.31] ETSI TS 136 201: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Long Term Evolution (LTE) physical layer; General description (3GPP TS 36.201)".
- [i.32] ETSI TR 136 912: "LTE; Feasibility study for Further Advancements for E-UTRA (LTE-Advanced) (3GPP TR 36.912)".
- [i.33] ETSI TR 102 628: "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference document (SRdoc); Land Mobile Service; Additional spectrum requirements for future Public Safety and Security (PSS) wireless communication systems in the UHF frequency range".
- [i.34] IEEE 802.11p:2010™: "IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments".
- [i.35] Commission Decision 1999/569/EC of 28 July 1999 on the basic parameters for the command-and-control and signalling subsystem relating to the trans-European high-speed rail system (notified under document number C(1999) 2475).
- [i.36] ETSI EN 301 502: "Global System for Mobile communications (GSM); Harmonized EN for Base Station Equipment covering the essential requirements of article 3.2 of the R&TTE Directive".
- [i.37] ETSI EN 301 511: "Global System for Mobile communications (GSM); Harmonized EN for mobile stations in the GSM 900 and GSM 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC)".
- [i.38] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 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 Text with EEA relevance.
- [i.39] ECC/DEC/(02)09: "ECC Decision of 26 June 2009 amended 02 November 2012 on the harmonisation of the bands 1610-1626.5 MHz and 2483.5-2500 MHz for use by systems in the Mobile-Satellite Service".
- [i.40] ECC/DEC/(02)10: "ECC Decision of 12 November 2010 on compatibility between the fixed satellite service in the 30-31 GHz band and the Earth exploration satellite service (passive) in the 31.3-31.5 GHz band".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Downlink: BS-to-UE link or ground-to-train link

E-GSM band: 880 - 915 MHz UL / 925 - 960 MHz DL

E-UIC frequency band: 873 - 880 MHz UL / 918 - 925 MHz DL

ER-GSM band: 873 - 915 MHz UL / 918 - 960 MHz DL

NOTE: The ER-GSM band includes the R-GSM band.

R-GSM band: 876 - 915 MHz UL / 921 - 960 MHz DL

NOTE: The R-GSM band includes the E-GSM band.

UIC frequency band: 876 - 880 MHz UL / 921 - 925 MHz DL

Uplink: UE-to-BS link or train-to-ground link

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

| | |
|--------|--|
| 3GPP | 3 rd Generation Partnership Project |
| AC | Alternative Current |
| BS | Base Station |
| BTS | Base Transceiver Station |
| CCS | Control-Command and Signalling |
| CEPT | Conférence Européenne des Postes et Télécommunications |
| CER | Community of European Railways |
| CP | Cyclic Prefix |
| DEC | Decision |
| DL | Downlink |
| EC | European Commission |
| ECC | Electronic Communications Committee |
| ECO | European Communications Office |
| EDGE | Enhanced Data rates for Global Evolution |
| EDOR | ETCS Data Only Radio |
| EFIS | ECO Frequency Information System |
| E-GSM | Extended GSM band |
| EIRENE | European Integrated Radio Enhanced Network |
| ERA | European Railway Agency |
| ERC | European Radiocommunication Committee |
| ER-GSM | Extended Railways GSM band |
| ERM | Electromagnetic compatibility and Radio spectrum Matters |
| ERTMS | European Rail Traffic Management System |
| ETCS | European Train Control System |
| EU | European Union |
| E-UIC | Extended UIC frequency band |
| E-UTRA | Evolved Universal Terrestrial Radio Access |
| FDD | Frequency Division Duplexing |
| FRMCS | Future Railway Mobile Communication System |
| FRS | Functional Requirements Specification |
| GSM | Global System for Mobile communications |
| GSM-R | GSM for Railway |
| IEEE | Institute of Electrical and Electronics Engineers |
| IoT | Internet of Things |
| IP | Internet Protocol |
| ITS | Intelligent Transport Systems |
| LPRA | Low Power Radio Association |
| LTE | Long Term Evolution |
| MFCN | Mobile/Fixed Communications Networks |
| MI | Mandatory for Interoperability |
| MIMO | Multiple-Input Multiple-Output |
| MSR | Multi-Standard Radio |
| NIB | Non Interference Basis |
| PAMR | Public Access Mobile Radio |
| PMR | Professional Mobile Radio |
| PPDR | Public Protection and Disaster Relief |
| RAT | Radio Access Technology |
| REC | Recommendation |

| | |
|-------|--|
| RFID | Radio-Frequency Identification |
| R-GSM | Railways GSM band |
| RIS | River Information Services |
| SESAR | Single European Sky ATM Research |
| SISO | Single Input Single Output |
| SRD | Short Range Devices |
| SRDoc | System Reference document |
| SRS | System Requirements Specification |
| TC RT | Technical Committee - Railway Telecommunications |
| TPC | Transmitter Power Control |
| TS | Technical Specification |
| TSI | Technical Specification for Interoperability |
| UE | User Equipment |
| UIC | Union Internationale des Chemins de fer |
| UL | UpLink |
| UMTS | Universal Mobile Telecommunications System |
| URS | User Requirements Specification |
| UTRA | Universal Terrestrial Radio Access |

4 Comments on the System Reference Document

4.1 Statements by ETSI Members

4.1.1 Silver Spring Networks

| Comment | Proposed Action |
|--|--|
| <p>Sub-GHz spectrum is an extremely scarce resource which must be used in the most efficient manner possible in order to satisfy the many demands of existing and emerging applications. Indeed the Radio Equipment Directive includes explicit requirements for 'efficient and effective use' of spectrum which must be respected in all applications and their corresponding Harmonised standards. The work item should have considered multiple spectrum ranges and different technologies and operating models to enable the selection of the most appropriate solutions. However, only one technological solution has been considered (and hence proposed) and therefore the RED requirement for efficient and effective use of the spectrum cannot be substantiated.</p> <p>As explained in the SRDoc typical antenna patterns are aligned to the rail tracks except for some locations such as busy yards or large stations. Consequently, geographical coverage is sparse across a given territory. The harmonisation - Europe-wide - of a further 2 x 3 MHz of spectrum dedicated to rail applications cannot be justified.</p> | <p>Add sections on alternative technical approaches to satisfy the specific scenario 1 requirements including frequency, network technology, costs, compatibility, etc. and provide technical comparisons to show why the selected proposed solution uses the spectrum in the most efficient and effective manner.</p> |

| Comment | Proposed Action |
|---|---|
| <p>The present document which was agreed by ETSI members included in its scope the consideration of dedicated land-mobile spectrum in 400 MHz or 700 MHz bands and developing sharing options with the PPDR community or other like-minded service providers.</p> <p>No consideration of use of any spectrum other than the UIC or e-UIC bands (in the 900 MHz band) is presented. The main argument for not meeting the requirements of the Work Item Scope are that it would potentially cost more money (no analysis is provided) if other spectrum than existing GSM-R frequencies were used. The value of the additional spectrum request has been evaluated in non-railways studies and is measured in billions of Euros.</p> | <p>Add detailed technical and commercial analyses of alternate frequency range solutions and justify why they should not be considered for FRMCS.</p> |
| <p>ETSI TR 102 628 [i.33]: 'Additional spectrum requirements for future Public Safety and Security (PSS) wireless communications systems in the UHF frequency range' - considers evolution of Broadband Public Protection and Disaster Relief systems (BB-PPDR) towards LTE-based dedicated networks which may support similar critical communications requirements as those identified for FRMCS. Clause B.4.3 describes possible sharing of such a dedicated network resource via definition of common technical frameworks for critical infrastructures including railway systems. The BB-PPDR networks are foreseen in 400 MHz and 700 MHz frequency ranges.</p> <p>The Work Item should specifically include consideration of sharing with PPDR which benefits from harmonised dedicate spectrum across Europe. A reference to ETSI TR 102 628 [i.33] V1.2.1 (09/2014), therefore, should be added and a proper analysis made of potential advantages of sharing. It should be noted that the Executive Summary states that FRMCS should be designed to decouple the railways applications from Network technology and so there should be no technical reason why those applications which could share PPDR resources could not do so.</p> <p>It is noted that such a solution has been selected in South Korea where state authorities confirmed that future LTE-R will also be linked with Public Safety-LTE (PS-LTE), a high-speed communications network for public securities, to help streamline the nation's safety control tower and its operations. i.e. a common network for future railway communications and BB-PPDR. See http://www.railprofessional.com/news/korea-rail-set-lte-network , http://www.telecomasia.net/content/huawei-introduces-lte-m-offering-railways.</p> | <p>Add considerations of possible use of harmonised dedicated spectrum for BB-PPDR as described in ETSI TR 102 628 [i.33] and explain why the proposed common technical framework is not a suitable (partial) solution for FRMCS.</p> |
| <p>Although the SRDoc states in the Executive Summary that the approach taken is based on separation of the railway applications from the underlying network technologies, no discussion is provided of any network technology other than 1,4 MHz LTE. Many related network technologies, including Narrow Band LTE (LTE-M or LTE-IoT in 200 kHz) may be applicable and may have superior deployment characteristics than the single network technology considered. Indeed, these options have already been studied for BB-PPDR and other services relevant to the scope of this Work Item.</p> | <p>Explain why no other technology than 1,4 MHz LTE should be considered for FRMCS. In particular explain why proposed 200 kHz LTE solutions would not be suitable for any FRMCS application.</p> |
| <p>The main demand for harmonisation of 873 - 876 MHz / 918 - 921 MHz spectrum, dedicated to railway applications, is that the long transition time required by the railways systems from one generation to the next requires that the existing GSM-R system be run in parallel with the new FRMCS throughout Europe. However, it is unclear under what circumstances simultaneous operation will actually be required. Dual mode equipment will be provided in trains implies only one system needs to be operated at any given location.</p> <p>At a minimum, the details of the migration strategy from GSM-R to FRMCS need to be much more carefully considered in order to minimize excessive spectrum demand. Alternative migration scenarios which do not require additional spectrum have not been discussed.</p> | <p>Add more detail on the proposed migration plan explaining what the requirements for parallel operation are, where and for how long. Include the transition timing correlated with the demand for spectrum action timing.</p> <p>Explain why no alternative migration strategy could be proposed.</p> <p>Compare options if there alternates and demonstrate how the selected option makes best use of the spectrum resource.</p> |

| Comment | Proposed Action |
|--|--|
| <p>The 870 - 876 MHz and 915 - 918 MHz bands have been largely unused for many years. The railways option to use the 873 - 876 MHz / 918 - 921 MHz extension for GSM-R is only available on a National Basis and has only been taken up by a small number of countries. The limited take-up being dependent on the availability of standards compliant equipment is not consistent with the long term planning requirements of rail operations.</p> <p>Other demands for sub-GHz spectrum have developed Harmonised standards for the 870 - 876 MHz and 915 - 921 MHz bands over the last 5 or more years including many evolved applications critical to European Energy management and Carbon Footprint Decisions. This includes RFID critical to commerce operations and utility applications critical to efficient operation of energy distribution networks.</p> <p>The deployment of these non-rail applications is not compatible with dedicated use of 50 % of this scarce spectrum resource by rail applications.</p> | <p>Add an analysis of the impact of harmonising the e-UIC band, dedicated to railways applications, will have on other applications deployed in the spectrum, taking into consideration the on-going activities to exploit this spectrum for SRD and other non-railway applications.</p> <p>Add a cost analysis of the impact on the proposed spectrum rules on other users of the spectrum.</p> |
| <p>The traffic model quoted in the load scenarios is referenced to an external document. The make-up of the quoted traffic demand needs to be explained in order to understand how the application demand maps to spectrum demand. The BB-PPDR SRDoc (ETSI TR 102 628 [i.33]) provides an example of how this load-to-spectrum demand should be calculated.</p> <p>However, it is clear that the proposed spectrum demand is to provide resources for parallel operation of two systems and therefore the actual spectrum demand for the railways requirements cannot be the amount demanded (2 x 7 MHz).</p> <p>The possibility of alternates, e.g. by sharing with other critical infrastructure systems or by use of other spectrum, is completely lacking in the SRDoc and missing from the conclusions leading to the spectrum demand.</p> | <p>Explain how the proposed traffic load translates into a spectrum demand. Use the approach in ETSI TR 102 628 [i.33] as a basis for computing the spectrum mapping.</p> <p>The traffic model should be broken down into applications classes to demonstrate the proposed solution is the best approach for each class for efficient and effective use of the spectrum.</p> |
| <p>A key conclusion of the recent ETSI Workshop on 'Managing Rail Mobile Communications Evolution' (see www.etsi.org/news-events/events/1109-workshop-managing-rail-mobile-communications-evolution) was that FRMCS should be flexible and not rely only on a dedicated network solution in one frequency range (e.g. 900 MHz). The future system should use the core GSM-R Harmonised band, possibly extended by 1 MHz to allow 5 MHz LTE operation, but should also use other resources from the vast mobile spectrum allocations as well as evolving 4G/5G technologies which will be deployed in the timeframe envisaged. Sharing with other critical infrastructure was again a strong conclusion.</p> <p>This further evidence of the misalignment of the SRDoc with consideration of scarce spectrum resources which must satisfy many interests apart from railways.</p> | <p>Justify why the SRDoc proposes a solution for FRMCS which disagrees with conclusions reached at the ETSI Workshop, and expressed elsewhere including in the Executive Summary, that FRMCS should be based on a flexible approach independent of any specific network technology.</p> |

4.1.2 ANITEC

| Comment | Proposed Action |
|---|-----------------|
| <p>With regard to clause 8.1.1, table 2: "traffic demand", it appears that when comparing clause 8.1.2, table 3: "minimum required spectrum" the respective outlined Scenario 1 never exceed 3 MHz bandwidth, thus well-fitting within the 4 MHz UIC frequency band (uplink 876 - 880 MHz, downlink 921 - 925 MHz). Scenario 1 covers the Critical Communication Applications + the Critical Support Applications.</p> <p>It therefore appears that the major claimed justification for additional 3 MHz bandwidth (i.e. the E-UIC spectrum) comes from non-critical applications such as Performance Communication Applications + Performance Support Applications + Business Communication Applications. However there is not any explanatory SRDoc section which explains and defines what is intended about these non-critical mission applications. This is key missing information for a SRDoc which is requesting a Harmonised European 2 x 3 MHz spectrum allocation.</p> | |
| <p>Similarly to above, another key missing information is about the factual element that the expected migration from GSM to LTE will undoubtedly increase the traffic capacity and data rate too.</p> | |
| <p>Finally it seems that the only provided justification for the 2 x 3 MHz E-UIC spectrum is claimed due to the foreseen switch over (parking spectrum alike) meanwhile dismantling the GSM old base stations.</p> <p>The SRDoc it is itself conflicting because it outlined the intention of base station GSM sites reuse for new LTE installations as well as the use of train's mobile multimodal unit (GSM + LTE).</p> <p>It is therefore really strange the claimed need for additional 2 x 3 MHz "parking spectrum" since it is very common, even for critical communications, the so-called "instantaneous night switchover procedure" when replacing the electronics of a base station (to date very compact size).</p> <p>Therefore the SRDoc claims of that additional 2 x 3 MHz as above is not at all efficient and effective which could be seen in contrast with the Radio Equipment Directive 2014/53 [i.38].</p> | |

4.1.3 Low Power Radio Association (LPRA)

| Comment | Proposed Action |
|--|-----------------|
| <p>The LPRA represents many companies providing radio equipment in the SRD category. LPRA members have been actively supporting European efforts to develop Harmonised standards for the largely unused 870 - 876 MHz / 915 - 921 MHz bands over the last 5 or more years.</p> | |
| <p>The LPRA does not agree with the proposed spectrum demand to Harmonise 873 - 876 MHz and 918 - 921 MHz dedicated to railway use</p> | |
| <p>The LPRA finds the proposal to operate two parallel systems for periods of 10 or more years in 2 x 7 MHz of scarce sub-GHz spectrum to be incompatible with the requirements of the Radio Equipment Directive to ensure 'efficient and effective use of the spectrum'.</p> | |
| <p>The SRDoc fails to provide adequate consideration of alternative solutions using other spectrum resources or sharing with other service providers which was part of the scope of the Work Item agreed by ETSI members.</p> | |
| <p>The argument given that other frequencies would result in less cost savings for the railway operators is not a sufficient reason to restrict development of this extremely valuable resource by many industries with resulting benefits for European industry and citizens.</p> | |

| Comment | Proposed Action |
|---|-----------------|
| The LPRA does agree that FRMCS should be based on an approach to separate the railway applications from the underlying network technologies. | |
| However, the SRDoc provides no insight in how this separation would lead to benefits in spectrum usage since it only considers one possible network technology (1,4 MHz LTE). | |
| Many industries are considering narrow band LTE for IoT applications. Such LTE services can run in 200 kHz which would be highly compatible with the existing 200 kHz channel spacing of the GSM-R. LTE-M can also run in guard bands available in the cellular spectrum allocations. | |
| The LPRA finds the description of the migration from GSM-R to FRMCS to be minimal. It is simply stated that two systems need to be run in parallel for ten years or more and therefore the railways need 2 x 7 MHz dedicated spectrum. | |
| Rail systems are not universal coverage systems and SRDoc evens explains that typical antenna patterns are aligned to the rail tracks except for some locations such as busy yards or large stations. | |
| The requirement for European harmonised allocation which would severely limit use of this scarce resource by other applications is not justified. | |
| ETSI sponsored a workshop on managing rail communications which was attended by many contributors to the SRDoc. However the conclusions of that Workshop are not reflected in the SRDoc. The need for flexibility which was a major theme of the workshop is totally lacking in the proposed spectrum demand. | |

4.1.4 Great Circle Design

The migration itself

The case for the migration itself is not well made. Further and better justification should be provided for why it is needed and what benefits it will bring. At the moment it looks as if it is based on the idea that long term supplies of current equipment are not guaranteed.

Most industries cope with this situation without throwing everything out and starting again. This appears to be migration for the sake of migration.

The migration details

Further details of the migration to FRMCS should be provided. At present it is not clear what the end technology is. It is not clear how the rollout of new technology will proceed.

It would seem unwise to start on a migration without knowing the destination or the route.

Whether the migration needs extra spectrum

Most industries cope with migration to new technology without needing extra spectrum. In fact migration to new technology usually frees up spectrum.

In the present document, the claim is that the migration will require extra spectrum because the old and new systems will have to be run in parallel. This rests on a series of assumptions that should be further examined.

The traffic model.

One assumes that running two systems in parallel means having each one available. Presumably it is not necessary to send all the data twice. So there is no increase in traffic that necessitates a corresponding increase in the spectrum requirement.

Technology reason

The question here is whether GSM-R and FRMCS can co-exist in the same band. Leaving aside the fact that FRMCS is not fully defined, clause 7.3.3 discusses this question but does not reach a firm conclusion.

This discussion is not actually relevant. Obviously two systems can use the same band at different times, and they can use the same band in different locations. Whether they can use the same band in the same place at the same time simply depends on the traffic load and is only of passing interest.

Is parallel operation actually needed?

This comes down to the details of the migration.

Clause 6.3 says:

"From a Railway Undertaking standpoint, dual mode on-board radios will be needed if country A only supports GSM-R and country B only supports FRMCS".

and:

"From an Infrastructure Manager standpoint, if international trains only support GSM-R, simultaneous operation of GSM-R and FRMCS networks will be needed, leading to a higher spectrum demand."

In the first case, only one system will be operational at any one time.

In the second case, the international train will not be able to enter country B.

When planning the migration, it will be discovered that it is not necessary to have both dual mode trains and dual mode countries. Only one is needed.

If dual mode trains are selected as the migration route, then it is never necessary to run both systems at the same time in the same place. This applies even if a country does not change its whole infrastructure overnight.

This simple point about migration planning is missing from the present document.

If dual mode trains are chosen as the migration route, then there is no need for extra spectrum.

Geographic and time limitations

There is a further point: high traffic load only occurs in a certain number of fixed locations, so the peak spectrum requirements apply only in certain known locations. Also, if the peak requirement is linked to poorly planned migration, then it is only for a limited duration.

Therefore, peak spectrum requirements should not be met by harmonised spectrum, but instead by national designations that can be linked to the traffic hotspots.

5 Presentation of the system

European railways currently use GSM-R for functionalities defined in the Eirene FRS [i.3] and SRS [i.4], which are considered to be mission-critical and safety related. For the successor of GSM-R, i.e. FRMCS, these functions as well as additional ones are described in the User Requirements Specification document (URS) [i.5].

The intention of FRMCS is to separate the applications from the underlying access bearer service in a way that these applications can be operated over any access bearer. In the light of the deployment timeframe, it is expected that FRMCS will use 3GPP 4G/5G RAT(s).

NOTE: Other RAT such as IEEE 802.11p [i.34], satellite or wireline access, may be used for additional services, as defined in the URS [i.5].

The major building blocks of the end-to-end FRMCS architecture are:

- an infrastructure on-board the train, portable FRMCS UE;
- a terrestrial radio access network with backhaul links;
- a core network for session, mobility, subscriber and security management, as well as service invocation and IP connectivity to external packet data networks;

- operation and maintenance tools;
- various service delivery platforms.

Railways are currently using a dedicated system in dedicated spectrum, in order to manage the network and the subscribers in a fully independent way. Railways require a strict control over the subscriber base, the entitlements of each user and over the level of coverage and service availability in all the geographical extension of the railway lines supported by the system. This is key to ensure the fulfilment of their operational needs.

Since there already is a large GSM-R installed base, and railway life cycle is in the range of 15 - 50 years, the successor system will coexist during a period of time of no less than 10 years with the existing GSM-R. This implies that spectrum for both continued GSM-R operation and FRMCS will be necessary during such a transition period.

6 Market information

6.1 The economic footprint of railways in Europe

The railway sector in Europe is dynamic and strong, creating revenues and jobs that make the European railway industry one of the most successful. In 2014, CER (Community of European Railway) tasked Ecorys to study the economic impacts of the railway sector [i.28]. The following key figures have been extracted from this study:

- Annual Gross value added:
 - Direct (railway sector only): 66 Billion Euro
 - Including indirect effects: 142 Billion Euro (= 1,1 % of EU)
- Employment:
 - Direct (railway sector only): 1 Million employees
 - Including indirect employees: 2,3 Million employees

The railway infrastructure is very well developed in Europe, according to the EU statistical pocketbook 2014 [i.29] (figures reflecting the 2012 situation):

- Km of main railway lines in operation: 215 000 of which 7 300 High Speed (> 250 km/h)
- Locomotives and trainsets/railcars: 57 000 (mainline railways only)
- Total passenger kilometre (pkm) on mainlines: 418 Billion (6,5 % of EU total pkm)
- Total tonnes kilometre (tkm): 407 Billion (11 % of EU total tkm)
- Turnover railway sector (passengers and freight): 78 Billion Euro

Regarding the deployment of the GSM-R system, the following figures are to be considered (source: Systra Study on Migration of railway radio [i.30]):

- GSM-R coverage on: 162 000 line km is planned, of which 114 000 km are operational (2015)
- Planned number of voice cab-radios: 64 000 of which 48 000 are operational (2015)
- Planned number of on-board ETCS data only radios: approximately 7 000, of which 2 400 are operational (2015)

6.2 The importance of railway radio communication in support of the European Rail Traffic Management System (ERTMS)

GSM-R provides the communication bearer of the European Rail Traffic Management System (ERTMS) that, in conjunction with the European Train Control System (ETCS), is a pillar for interoperability and safety for a Single European Railway Area. The railways are recognized by the EU as a vital part of the Union transport sector moving towards achieving sustainable mobility.

The European Union is developing since several years policies to enable the harmonised operations of trains for goods and passengers all across Europe. This is to fulfil the objective that the concept of Single European Railway Area has forged, where the deployment of ERTMS is a key element to achieve harmonised signalling capabilities and free circulation of trains.

GSM-R is part of the ERTMS system, as it is the radio bearer supporting the exchange of signalling information when ETCS Level 2 or 3 is deployed, and the system that provides voice communication capabilities between the staff of board of the train and the railways traffic control centre. To ensure the interworking of ERTMS in all EU Member States, the Directive on railways interoperability, and the Control Command and Signalling Technical Specification for Interoperability mandate essential requirements for the signalling (ETCS) and radio (GSM-R) components of ERTMS. Further details can be found in Annex B railways interoperability and Technical Specification for Interoperability.

The achievement of the European Union objective of establishing a Single European Railway Area relies on the deployment of ERTMS, which requires the support of a common radio communication system to allow the harmonised operation of the traffic in the Area.

6.3 Consequences of interoperability on migration scenarios

Following the EU policy in implementing a Single European Railway Area, the need for interoperability of the radio communication system in support of ETCS is a strong requirement that has consequences on the spectrum needs.

At EU level, in order to maintain interoperability of international train services, several aspects need to be considered:

- From a Railway Undertaking standpoint, dual mode on-board radios will be needed if country A only supports GSM-R and country B only supports FRMCS:
 - Taking into consideration the very long time needed to upgrade on-board radios, and the fact that interoperability directive does not allow to force retrofit in existing rolling stocks.
- From an Infrastructure Manager standpoint, if international trains only support GSM-R, simultaneous operation of GSM-R and FRMCS networks will be needed, leading to a higher spectrum demand (see clause 7.3.3).

In addition, at Member State level similar aspects should be considered:

- From a Railway Undertaking standpoint, the national rolling stock will need to be upgraded, which will take a very long time due to logistic constraints in order to keep railway services operational.
- From an Infrastructure Manager standpoint, an overnight switch over from GSM-R to FRMCS is not feasible, therefore coexistence of both networks will be needed, thus leading to the need for more spectrum than currently in use.
- The coexistence of legacy GSM-R networks and FRMCS is needed during the transition period, until all trains in the EU are equipped with FRMCS receivers.

6.4 Railway digitalization

The Digital Single Market is one of the ten priorities of the European Commission.

In the railway domain, digitalisation is mentioned since there is existing legislation for intelligent transport systems within specific modes:

- SESAR (aviation),

- RIS (River Information Services),
- ITS (Intelligent Transport Systems for road),
- ERTMS (railway), etc.

Specific measures on access to transport data and recognition of electronic documents can stimulate better mobility services and new business models. Therefore, the Commission is currently looking at the internal processes in each transport mode and intramodal processes, since all of them need to act as an ecosystem.

Digital solutions bring added value to increase safety, increase reliability, performance and efficiency, while contributing to sustainability (providing assistance for eco-driving, monitoring in real time the energy consumption) and to facilitate a simplified framework for placing on the market of rolling stock, safety certification and authorization.

The Commission also promotes and supports (e.g. by legislation) the technical harmonisation (interoperability) of railways and the prevention or removal of technical barriers for a single railway area. One of the examples of interoperability is ERTMS. Future radio applications and the underlying radio system require harmonised and interoperable solutions.

6.5 Market evolution

In 2015, the GSM-R Industry Group has indicated that support of GSM-R products and services are guaranteed until 2030. Based upon this information, the railway sector has to mitigate the risk of non-availability of GSM-R as radio system for train operation after this date. Replacement of GSM-R equipment (on-board and trackside) by new equipment offering potential new services while maintaining interoperability has to be considered in a global timeline.

Independently of the selected radio technology and spectrum, the replacement of all GSM-R on-board equipment by other radio equipment (supporting GSM-R and/or other technologies and spectrum) on a European scale is expected to take at least 10 years. The railway infrastructure managers have to prepare the timely introduction of FRMCS based communication services. National implementation and migration plans may be possible, as long as railway interoperability is ensured.

According to a Position paper issued by ETSI Technical Committee Railways Telecommunications and European Union Agency for Railway [i.6], the deployment of new radio equipment (on-board and trackside) should be possible by the end of 2022 in order to leave sufficient time for the migration from GSM-R to any new radio system. This means that the relevant specifications have to be included in the EU legal framework around that date. Consequently, activities in the context of Proof-of-Concept are planned in the period between 2019 and 2021 and preparation of the production of on-board equipment and network equipment should be ready around 2022.

Therefore it is necessary that an agreement on the future spectrum to be used by railways is identified by 2020 and that formal allocation and assignment are possible between 2020 and 2022 for trials, and for operational deployment as of start of 2023.

It is to be noted that during the migration period, both GSM-R and its successor need to be simultaneously operational on the same railway tracks. This implies that sufficient spectrum has to remain available until the end of the migration period. Based on the previous experiences for migration of technologies in the railway environment (radio communication and signalling), a period of at least 10 years can be envisaged. At this stage, the transition period as of today is foreseen starting in 2022, depending on EU legislation and member state decisions.

6.6 Economic benefit of reusing the UIC or E-UIC frequency band

In Annex A of the present document, the economic benefit of re-using the UIC or E-UIC frequency band for FRMCS is described.

From a spectrum perspective, several options could be envisaged for FRMCS as the successor to GSM-R. An essential aspect to take into consideration when identifying the preferred FRMCS spectrum is the value of the installed base of GSM-R radio sites. Currently, around 18 000 radio sites have been put into operation, representing an investment of approximately 3,1 Billion Euro, with more sites still being added due to the ongoing (major) network roll out and expansions of the existing networks in many EU countries.

Re-use of essentially all of these sites is possible when using the UIC and/or E-UIC frequency band for FRMCS. In that case, also the costs for modifications to rolling stock and tunnel installations will be limited. The total economic benefit would be in the order of 3,9 Billion Euro.

When selecting other spectrum for FRMCS, e.g. in the 700 MHz or 400 MHz ranges, these economic benefits can only be partially realized. Usage of the 700 MHz or 400 MHz ranges would lead to less reuse and/or re-location of existing sites. Also, it is noted that in the 700 MHz and 400 MHz range no possibility appears to exist for spectrum dedicated to railways.

In case FRMCS would be forced to use spectrum above 1 GHz, significantly more base stations sites will be required, leading to high additional investments in the order of several Billion Euros.

Therefore, from an economic perspective, the best spectrum option for FRMCS would be to reuse the UIC or E-UIC frequency band.

7 Technical information

7.1 System technology

In the light of the deployment timeframe, it is expected that FRMCS will use 3GPP 4G/5G RAT(s). Furthermore, on-board and track-side equipment will be designed to meet the additional requirements contained in the CCS TSI [i.2].

The present document assumes that FRMCS will be using a dedicated spectrum of either:

- The existing harmonised spectrum in the 2 x 4 MHz UIC frequency band (876 - 880 MHz / 921 - 925 MHz).
- Or a combination of these 2 x 4 MHz plus 2 x 3 MHz, called the E-UIC frequency band, resulting in a total of 2 x 7 MHz (873 - 880 MHz / 918 - 925 MHz).

In order to calculate the amount of radio spectrum needed to fulfil the railway requirements, the present document has assumed the use of the radio interface as specified in ETSI TS 136 201 [i.31] (E-UTRA LTE physical layer: general description) and ETSI TR 136 912 [i.32] (Feasibility study for Further Advancements for E-UTRA (LTE-Advanced)).

7.2 Technical parameters

For the purpose of the coexistence studies in the UIC and E-UIC frequency bands, the radio transmission and reception characteristics to be used are specified in ETSI TS 136 101 [i.9] for the UE and in ETSI TS 136 104 [i.10] and ETSI TS 137 104 [i.11] for the BS. Table 1 shows the parameters, as specified in the SRS [i.4], that will be used for GSM-R and FRMCS

Table 1: Radio parameters for GSM-R and FRMCS

| Parameter | Value |
|--|----------------|
| Maximum BS output power | 46 dBm |
| BS antenna gain below 1 GHz (including coupling and cable loss) | 14 dBi |
| BS antenna height | 30 m |
| On-board UE antenna gain | 0 dBi |
| On-board UE losses (cable, ageing, etc.) | 6 dB |
| On-board UE antenna height | 4 m |
| Handheld UE antenna height | 2,5 m |
| FDD channel bandwidth in the UIC frequency band | 1,4 MHz, 3 MHz |
| FDD channel bandwidth in the E-UIC frequency band | 1,4 MHz, 5 MHz |

From a deployment point of view, railway radio site infrastructure typically has an almost linear structure along the railway tracks (see figure 1). For large railway stations and shunting yards, an alternative arrangement may be used.

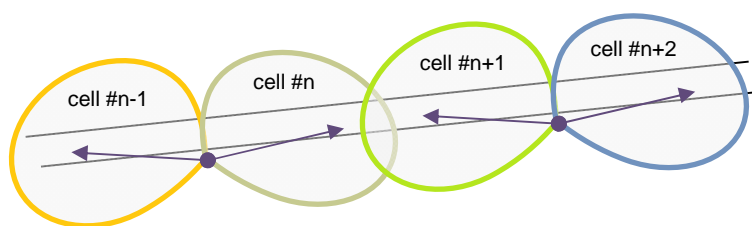


Figure 1: Cell arrangement

Figure 2 shows a typical antenna pattern to be used.

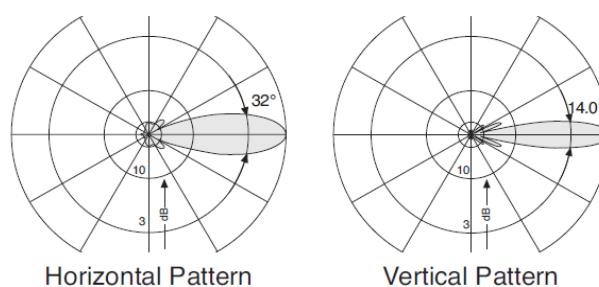


Figure 2: Typical antenna pattern

A coverage probability of 95 % over a track section of 100 m is required for GSM-R, as specified in the SRS [i.4]. The same applies to FRMCS.

The GSM-R system supports seamless communication for train speeds up to 500 km/h, as required by the FRS [i.3]. The same applies to FRMCS.

Below 900 MHz there is an economic limitation on the design of the network. Above 900 MHz, both technical and economic implications would have to be investigated.

In order to deal with high-speed, a fast fading margin needs to be applied in the cell planning process.

7.3 Implications on spectrum

7.3.1 Considered frequency bands

7.3.1.1 UIC frequency band

The UIC frequency band is defined as 876 - 880 MHz UL / 921 - 925 MHz DL. It is the current operational spectrum available for GSM-R networks. To date 39 CEPT administrations have implemented ECC Decision (02)05 [i.12] which harmonises the UIC frequency band for railway purposes.

The UIC frequency band for FRMCS would provide as advantages:

- benefit from the existing regulatory framework setting the UIC frequency band as the European harmonised radio spectrum for railways;
- allow the reuse of existing GSM-R radio sites and thus provide significant cost savings for the deployment of FRMCS.

It has to be noted that this spectrum is shared on the borders between several GSM-R networks (see clause 9.1) and in some countries with Defence systems.

7.3.1.2 E-UIC frequency band

The E-UIC frequency band is defined as 873 - 880 MHz UL / 918 - 925 MHz DL, thus adding 2 x 3 MHz to the UIC frequency band. ECC Decision (04)06 [i.19] on digital PMR/PAMR, driven by railways' requirements within ETSI TR 102 627 [i.7] published in November 2008, offers the possibility to CEPT administrations to make available this 2 x 3 MHz extension for GSM-R in response to market demand. With the equipment standardization process completed at the end of 2015, equipment is now becoming available. This explains why only a few countries have provisions for the E-UIC frequency band in their national table of frequency allocations (according to EFIS): Germany, Austria, Hungary, Switzerland, Liechtenstein, Croatia, Czech Republic and Latvia. In addition, some countries are not yet listed since the introduction process is in progress based on equipment availability from manufacturers.

The E-UIC frequency band for FRMCS would provide as advantages:

- benefit from the existing regulatory framework for the UIC frequency band (as per the previous clause), by adding the 2 x 3 MHz;
- allow the reuse of existing GSM-R radio sites and thus provide significant cost savings for the deployment of FRMCS (as per the previous clause);
- provide additional spectrum to ease the migration from GSM-R to the new system and where additional traffic capabilities are required (after the GSM-R switch-off, the full E-UIC frequency band could be used for FRMCS).

It has to be noted that railways would have to coordinate this spectrum with Defence systems in many countries.

7.3.2 Sharing and compatibility studies to be considered

With regard to the UIC frequency band, the following issues need to be assessed:

- In case of simultaneous use of GSM-R and FRMCS in the UIC frequency band, is there enough spectrum to answer capacity needs from both GSM-R and FRMCS;
- From a radio perspective, can GSM-R and FRMCS coexist in the same band;
- Can FRMCS coexist with adjacent MFCN.

With regard to the E-UIC frequency band, the following additional issues need to be assessed:

- coexistence with MFCN BS receiving below 915 MHz;
- coexistence with SRD, in particular 500 mW IoT BS and 4W RFID, operating in 870 - 876 MHz and 915 - 921 MHz bands;
- coexistence with Defence systems operating in 870 - 876 MHz and 915 - 921 MHz bands.

7.3.3 GSM-R and FRMCS coexistence in the same band

An early assessment of the simultaneous use of a 4G system with the existing GSM-R has been undertaken as a request from the European Union Agency for Railways, for the UIC and E-UIC frequency band [i.8].

This coexistence study considered the feasibility of having a 1,4 MHz LTE FDD carrier in parallel with an GSM-R radio bearer. Based on theoretical analysis and lab testing the main conclusions are as follows:

- It is only possible to implement an LTE carrier within the UIC frequency band with a number of technical mitigating measures, most notably [i.8]:
 - the LTE Base Station and the existing R-GSM Base Station are co-sited;
 - the use of transmitter power control (TPC) for R-GSM UE;
 - improvement of the performance of the LTE UE and network equipment (for example lower base station out of band emissions, UE narrow band blocking level, GSM intermodulation threshold);
 - GSM-R receivers meet the requirements specified in ETSI TS 102 933-1 [i.15].

- The impact of coexistence of a 1,4 MHz LTE carrier with existing GSM-R network within the UIC frequency band will lead to traffic capacity reduction of GSM-R and lead to a degradation of the GSM-R quality of service:
 - especially in areas where frequency resources are in high demand (e.g. in areas of dense rail traffic or in border areas between countries implementing an LTE carrier and those which do not), the traffic capabilities of GSM-R radio would be severely reduced.

The ECC has already performed some studies on the coexistence between GSM and UMTS/LTE within the same band. See ECC Report 82 [i.13] and CEPT Report 40 [i.14]. These reports conclude that GSM and UMTS/LTE can coexist; but they are applicable to MFCN which have a global statistical approach in terms of quality of service.

7.3.4 FRMCS coexistence with adjacent MFCN

Legacy GSM-R UEs can suffer from one of these phenomena: intermodulation products, generated by the receiving chain from one or more MFCN signals; blocking and MFCN out-of-band emissions. In order to sustainably mitigate interferences due to blocking and intermodulation, the GSM-R receiver characteristics have been successively improved in ETSI TS 102 933-1 [i.15].

FRMCS UEs will face the same phenomena. This is shown in ECC Report 239 [i.16] on coexistence between PPDR and MFCN in the 700 MHz range. The report concludes that increasing PPDR UE selectivity and intermodulation threshold enables the PPDR UE to operate in a sparse network when adjacent in frequency to a dense network. The same conclusion is anticipated for the 900 MHz range.

As for GSM-R UE [i.15], in order to ensure interference-free operation with adjacent MFCN, it would be necessary to specify higher UE blocking levels and intermodulation thresholds for FRMCS UEs operating in the UIC frequency band.

A CEPT/ECC coexistence study would be needed to assess these issues, taking into account the railways specific usage and deployment scenarios.

7.3.5 FRMCS coexistence with MFCN BS receiving below 915 MHz

To ensure coexistence with MFCN BS receiving below 915 MHz, ETSI TS 145 005 [i.20] specifies reduced output power for GSM-R BS transmitting in the 918 - 921 MHz band unless coordination between GSM-R and MFCN users exists. This is valid for GSM, UMTS and LTE based MFCN. It is anticipated that a similar approach may be necessary for FRMCS BS operating in that band. It should be noted that coordination to lift restrictions would involve, for each FRMCS radio site, the FRMCS operator and all MFCN operators who have a neighbouring radio site operating in the upper part of the E-GSM band.

7.3.6 FRMCS coexistence with SRD

ERC Recommendation 70-03 [i.21] defines regulatory parameters for low-power and high-power SRD, including in the 870 - 876 MHz and 915 - 921 MHz bands. These parameters are derived from ECC Report 200 [i.22] which studies coexistence between GSM-R and SRD/RFID in those bands. Where protection of GSM-R is required, some mitigation techniques are defined.

In addition to the ERC/REC 70-03 [i.21], the European Commission has adopted in November 2006 a harmonisation decision on the radio spectrum to be used by SRD. In its latest version [i.26], the bands 870 - 876 MHz and 915 - 921 MHz are not included. CEPT is currently working on a harmonisation approach for these bands, which will be documented in the addendum to CEPT Report 59 [i.27] planned for November 2016.

In countries where there is no provision for GSM-R in the 873 - 876 MHz / 918 - 921 MHz band, SRD may already be rolled out without any constraint when FRMCS is rolled out. Furthermore, an SRD device bought in a country where there is no constraint could, although not allowed, be used in another country where GSM-R/FRMCS is rolled out.

Would the UIC or E-UIC frequency band be selected for the successor system, in both cases FRMCS will have to coexist with SRD operating below. FRMCS, as a radio application within the status of the primary mobile service, may not be interfered by SRDs or by other radio applications with a NIB status.

From ETSI TR 101 537 [i.23], it can be concluded that interference-free operation for GSM-R can be ensured if a centre frequency offset of 500 kHz can be achieved between GSM-R and RFID carriers. This results in a 200 kHz guard-band. More generally, to avoid blocking on railway base stations and UEs, it is anticipated that a 200 kHz guard-band may be required between GSM-R/FRMCS and SRD.

A CEPT/ECC coexistence study would be needed to determine the impact of SRD/RFID onto FRMCS. Likewise, another CEPT/ECC coexistence study may be needed to assess the coexistence of SRD operating in the 870 - 876 MHz band and FRMCS UE transmitting in either the 876 - 880 MHz UL band or the 873 - 880 MHz UL band, taking into account the low density of FRMCS UEs.

7.3.7 FRMCS coexistence with Defence systems

ECC Report 200 [i.22] in its annexes A1.3 and A1.4 provides the technical characteristics of the existing Defence systems operating in the 870 - 876 MHz and 915 - 921 MHz bands. These are tactical radio relays and unmanned aircrafts which are also used in peacetime. More than ten European countries have Defence systems in that band.

As for SRD vs. Defence, a CEPT/ECC coexistence study would be needed to determine whether coexistence of FRMCS and Defence systems is feasible.

7.4 Information on relevant standards

As the UIC and E-UIC frequency bands are not currently included in the list of 3GPP operating bands defined for 4G, the selected band will need to be added by 3GPP for both 4G and 5G families.

If the coexistence studies were to demonstrate that FRMCS needs strengthened radio characteristics, this should also be handled by 3GPP and/or ETSI standardization.

8 Radio spectrum request and justification

8.1 Traffic model and bandwidth requirements

8.1.1 Traffic model

In the document "Railway Traffic analysis for FRMCS" [i.24], a traffic model has been developed with the purpose to estimate the traffic volume due to track to train communications, which is to be supported by FRMCS. The model has been filled with data for a number of usage scenarios and areas of operation, resulting in the needed traffic handling capacity for both downlink and uplink, as shown in the table 2.

Table 2: Traffic demand

| | Scenario 1 | Scenario 2 | Scenario 3 |
|-----------------------------|-------------------------------------|--|--|
| Application category | Critical Communication Applications | Critical Communication Applications | Critical Communication Applications |
| | Critical Support Applications | Critical Support Applications | Critical Support Applications |
| | | Performance Communication Applications | Performance Communication Applications |
| | | Performance Support Applications | Business Communication Applications |
| | | | Performance Support Applications |

| | Scenario 1 | Scenario 2 | Scenario 3 |
|---|--------------------------|--------------------------|--------------------------|
| Area of operation | Downlink / Uplink (Mbps) | Downlink / Uplink (Mbps) | Downlink / Uplink (Mbps) |
| Station Stockholm | 1,38 / 1,27 | 2,47 / 149,88 | 116,79 / 178,50 |
| Station Zürich | 2,88 / 1,60 | 4,20 / 354,63 | 221,74 / 409,05 |
| Station Utrecht | 2,13 / 2,03 | 3,09 / 216,40 | 135,19 / 249,45 |
| Conventional high traffic line (4 km cell size) | 1,4 / 1,4 | 2,1 / 150 | 90 / 170 |
| High speed line (4 km cell size) | 0,2 / 0,2 | 0,3 / 22 | 14 / 25 |

8.1.2 Bandwidth requirements

In the document "FRMCS Spectrum Demand Calculation" [i.25], the methodology and calculation model has been provided, with which the FRMCS traffic demand has been converted to a spectrum need.

For these calculations, the following assumptions have been made:

- Use of the radio interface as specified in ETSI TS 136 201 [i.31] (E-UTRA LTE physical layer: general description) and ETSI TR 136 912 [i.32] (Feasibility study for Further Advancements for E-UTRA (LTE-Advanced)).
- The UIC frequency band (uplink 876 - 880 MHz, downlink 921 - 925 MHz) and extended UIC frequency band (uplink 873 - 880 MHz, downlink 918 - 925 MHz) are considered as operating frequencies.
- By selecting the (extended) UIC frequency band the same cell size is considered to be used as for GSM-R currently. On average this is 3 km per cell for a macro site used along tracks. For high traffic localized areas such as stations and shunting yards, smaller cell sizes in the range of 1 km are used.
- Within LTE, Cyclic Prefix (CP) length is a method to increase the robustness against multipath propagation. In the calculations CP is assumed to be "Normal" length.
- On high-speed lines, trains may travel with a speed up to 500 km/h. Fast fading effects impact the achievable user capacity of an LTE carrier. The current calculations use some assumptions for the loss of throughput, however further study is needed to improve these estimations. Also the frequent cell change is more critical when a user is moving at 500 km/h.
- In order to benefit from the increased transmission capacity of an LTE carrier compared with the use of SISO, the use of MIMO has been assumed in the bandwidth calculation. Currently it is unknown if MIMO antenna techniques can actually be used for rolling stock due to the often very limited available roof space.
- Redundant radio coverage scenarios are not taken into account in the calculation.
- 1,4 MHz, 3 MHz, and 5 MHz carrier bandwidth have been considered as they can fit within the UIC and respectively the E-UIC frequency band.
- Calculations have been based on coverage quality at the cell edge / handover point.
- Frequency reuse (factor) of 1.

With these assumptions the table 3 has been derived, showing the minimum spectrum need for combinations of usage scenarios and the area of operation. It is to be noted that the minimum spectrum need is determined by the uplink traffic demand as shown in table 2.

Table 3: Minimum required spectrum for FRMCS only

| | Scenario 1 | Scenario 2 | Scenario 3 |
|--------------------------------|-----------------------|---------------------------------------|---|
| | Critical applications | Critical and performance applications | Critical, performance and Business applications |
| Large railway stations | 3 MHz | >> 7 MHz | >> 7 MHz |
| Conventional high traffic line | 3 MHz | >> 7 MHz | >> 7 MHz |
| High speed line 300 km/h | 1,4 MHz | >> 7 MHz | >> 7 MHz |

Speeds higher than 300 km/h are for further study.

This table shows that for scenario 1 Critical applications, the FRMCS could fit in the UIC frequency band and in the E-UIC frequency band.

During the migration period from GSM-R to the new system, both GSM-R and FRMCS would simultaneously be operational in the same spectrum. The results of the ERA coexistence study [i.8] however show that only under a set of limiting conditions it may be possible to operate a GSM-R radio network plus one 1,4 MHz LTE carrier within the UIC frequency band. Thus a 3 MHz LTE carrier cannot be used simultaneously with a GSM-R system in the UIC frequency band. This implies that FRMCS would have to use as much as possible of the additional 2 x 3 MHz of the E-UIC frequency band.

The table also shows that scenarios 2 and 3 would need much more than the maximum 2 x 7 MHz available from the E-UIC frequency band.

In order to support a larger set of applications than those contained in scenario 1, it is anticipated that after deactivation of GSM-R, the initial 3 MHz carrier will be upgraded to a wider carrier. This will still only support a subset of the additional set of applications of Scenario 2. For the amount of traffic that cannot be supported, including that for scenario 3, other solutions such as sharing with other stakeholders (e.g. PPDR) and/or using MFCN, will need to be identified; this may be addressed at a later stage.

8.2 Radio spectrum request

Based on the analysis provided in the present document, the FRMCS has the following spectrum needs:

- In order to cover the needs for scenario 1 Critical applications:
 - a) Railways need 2 x 7 MHz of spectrum to accommodate within the same band the current and future Critical railway applications defined in scenario 1, taking into account the need for parallel operation of GSM-R and FRMCS during the migration from GSM-R to the successor system.
 - b) This spectrum needs to be EU harmonised.
- This spectrum needs to be identified by 2020, made available for trials between 2020 and end of 2022, and available for operational deployment as of start of 2023.
- Decisions about spectrum allocation for railways have to be published in time, in order to be included in the 3GPP specifications and to allow the timely preparation for inclusion in the legal framework of railway interoperability.
- In order to cover the needs for scenarios 2 and 3 alternative solutions such as sharing with other stakeholders (e.g. PPDR) and/or using MFCN, need to be identified, possibly leading to additional spectrum demand to cover all stakeholder needs.
- Although the preferred solution for the migration period is to use 2 x 3 MHz in addition to the current 2 x 4 MHz, other carrier widths may be considered depending on spectrum availability in member states.
- Although the 900 MHz frequency band is preferred, other frequency bands may be considered depending on availability in member states, whilst ensuring the technical and economic viability.

9 Regulations

9.1 Current regulations

Today's railway communication system GSM-R is based on the Command-Control and Signalling Technical Specification for Interoperability first defined by Commission Decision 1999/569/EC [i.35]. It supports the specific railway needs and consists of additional functions and amendments, and represents an enhancement of the commonly used GSM technology. The relevant harmonised European standards for GSM-R are ETSI EN 301 502 [i.36] for the base stations and ETSI EN 301 511 [i.37] for the mobile stations.

This radio network is used to fulfil the operational requirements of railway communications, especially for voice and data communications both supporting safety related applications. These applications have to be implemented according to the European-Rail-Traffic-Management-System (ERTMS) where for instance the European-Train-Control-System (ETCS) is a part of. GSM-R networks need to comply with the Directive 2008/57/EC [i.1] of the European Parliament and of the Council on the Interoperability of the rail system and the Commission Regulation 2016/919 [i.2] on the technical specification for interoperability relating to the control-command and signalling subsystems of the trans-European rail system.

GSM-R is based on several ECC Decisions. The main one is ECC/DEC/(02)05 [i.12] which harmonises the UIC frequency band, 876 - 880 MHz for the train-to-ground link paired with 921 - 925 MHz for the ground-to-train link, for railway usage. The free circulation of GSM-R UEs was granted with ECC/DEC/(02)09 [i.39], and exemption from individual licensing with ECC/DEC/(02)10 [i.40]. This means that administrations should designate this frequency band in their national frequency allocation table and make it available.

ECC/DEC/(02)05 [i.12] was amended in 2013 to refer in its considering h) to ECC/DEC/(04)06 [i.19] which offers the possibility to CEPT administrations to make available for GSM-R the 873 - 876 MHz paired with the 918 - 921 MHz. This additional band can be used on national basis although it is not part of the interoperable requirements expressed in the Commission Regulation [i.2]. Note that new, updated or renewed trains are being equipped with radio equipment supporting this extended band:

- Regarding cross-border coordination, the current framework is as follows:
- ECC Recommendation (05)08 [i.17] which provides recommendation for cross-border coordination for GSM in the E-GSM band as well as GSM-R in the UIC frequency band.
- ECC Recommendation (08)02 [i.18] which provides recommendation for cross-border coordination for UMTS and LTE in the E-GSM band.
- No ECC Recommendation on cross-border coordination for GSM-R in the 873 - 876 MHz / 918 - 921 MHz band.

9.2 Proposed regulation and justification

In order to ensure railway interoperability between EU Member States and to support the development, migration and operation of FRMCS in the 900 MHz range, the 873 - 880 MHz UL / 918 - 925 MHz DL band needs to be fully harmonised for railway purposes allowing both FRMCS and GSM-R. To achieve this, both ECC Decisions (02)05 [i.12] and (04)06 [i.19] need to be amended or replaced.

Regarding cross-border coordination, introducing FRMCS in the E-UIC frequency band would require to extend ECC/REC/(05)08 [i.17] and ECC/REC/(08)02 [i.18] to the E-UIC frequency band.

Annex A: Economic impact analysis of spectrum and models

A.1 Introduction

The purpose of this annex is to analyse the economic advantages when migration of GSM-R to the next generation radio system for railways (FRMCS) is done using the existing UIC frequency band, 876 - 880 MHz UL / 921 - 925 MHz DL, or the E-UIC frequency band, 873 - 880 MHz UL / 918 - 925 MHz DL.

A.2 Reusing the UIC frequency band or the E-UIC frequency band

A.2.1 Radio sites

Deploying FRMCS in the existing UIC and/or E-UIC frequency band would allow reusing all of the existing GSM-R radio sites from a radio planning perspective. This would result in re-using all the physical infrastructure of those sites, antenna masts, power supply and possibly transmission.

For situations where a swap from the current GSM-R to the new FRMCS technology can be done, even all antennas and feeders could also be reused, and only the GSM-R BTS would need to be replaced with a FRMCS base station. For situations where GSM-R and FRMCS need to be operational in parallel during a migration period, normally new or additional antennas and feeders would be required for FRMCS, leading to additional costs.

Based on information from railway organizations (e.g. information from infrastructure managers, construction and installation companies) an average cost can be estimated, including the following items:

- Mast (12 - 42 meters)
- Shelter/Technical hut including air-conditioning
- Transmission
- AC power, incl. battery backup
- Building permits
- Antennas and feeders
- Site engineering
- Acquiring land for the site
- Site integration and optimization
- Construction
- Project management

Currently a total of approximately 18 000 GSM-R BTS have been deployed, covering 160 000 km of track (2016).

A.2.2 Tunnel radio systems

In addition to regular base station sites, in most countries also tunnel coverage is essential. The technical requirements for tunnel coverage are quite different from country to country. As radiating infrastructure, either leaky coaxial cables or antennas can be used, with fibre fed base stations, remote radio heads, channel selective repeaters, etc.

In Europe, approximately 2 000 km of railway tunnels with GSM-R coverage exist.

Using the UIC or E-UIC frequency band for FRMCS would mean that the radiating infrastructures in tunnels can be reused. Depending on the active components used in the existing tunnel systems, all or parts of that can be reused as well. Remote radio heads and channel selective repeaters probably are not reusable for 4G or 5G, but band selective or wideband repeaters probably would be.

A.2.3 Installations in rolling stock

The impact of spectrum choice on installations in rolling stock (HS trains, locomotives, trainsets, maintenance vehicles, etc.) needs to be considered as well. Current antennas for GSM-R (cab-radio and EDOR) on the train roofs are optimized for the 900 MHz frequency band. In total, approximately 70 000 vehicles are operational(2016), of which 64 000 engines are equipped with cab-radios and 6 000 with EDOR, each of which with separate antenna and cabling.

Migrating to other spectrum means that all existing roof antennas should be replaced by approved (electrical safety) antennas that are optimized for the new frequency band. This needs further consideration about antenna separation and isolation, which is difficult to realize because of the limited space available on the roof top of rolling stock.

Experience from other projects when radio equipment has been installed on trains shows that this type of work (taking trains out of operation, and the installation itself) is very complex and time consuming, and therefore very costly for the train operators. Logistic difficulties related to the taking out of operation of the trains easily results in migration periods of multiple years.

The average cost per cab-radio or EDOR (equipment and installation) is approximately 18 000 Euro, of which 8 000 Euro is related to the antenna system, including cabling.

A.2.4 Investment reuse

As argued in the previous clauses, when re-using the UIC frequency band and/or the E-UIC frequency band for FRMCS, this would allow re-using the existing radio sites with virtually all of its equipment except the bases station equipment itself. To some extent this also holds true for tunnel installations, and antenna installations on rolling stock.

The Systra Report on Migration [i.30] assumes that approximately 50 % of the initial investment in the GSM-R network could be reused. In this report the indicated capex for the network is approximately 60 000 Euro per kilometre of track. Based upon the figure of 170 000 km of covered tracks, a cost saving of approximately 5 Billion could be realized.

For rolling stock a similar reduction of costs could be achieved.

A.3 Conclusion

From a spectrum perspective, several options can be envisaged for FRMCS as the successor to GSM-R. An essential aspect to take into consideration when identifying the preferred FRMCS spectrum is the value of the installed base of GSM-R radio sites. Currently, around 18 000 radio sites have been put into operation with more sites still being added due to the ongoing (major) network roll out in e.g. France and other countries.

Reuse of essentially all of these sites is possible when using the UIC and/or E-UIC frequency band for FRMCS. Then also the cost for modifications to rolling stock and tunnel installations will be limited. The total economic benefit could be in the order of 5 Billion Euro for the infrastructure itself .

When selecting other spectrum for FRMCS, e.g. in the 700 MHz or 400 MHz ranges, these economic benefits can only be partially realized. Usage of the 700 MHz or 400 MHz ranges would lead to less reuse and/or re-location of existing sites. Also, it is noted that in the 700 MHz and 400 MHz range no possibility appears to exist for spectrum dedicated to railways.

In case FRMCS would be forced to use spectrum above 1 GHz, significantly more radio sites will be required, leading to high additional investment needs, in the order of several Billion Euros.

Therefore, from economic perspective the best spectrum option for FRMCS would be to use the UIC and/or E-UIC frequency band.

Annex B: Railway interoperability

B.1 Railway interoperability

B.1.1 Current railway regulatory framework

The word interoperability is used in different sectors with a sense that may not always be the same. In the railway environment, the meaning of interoperability is 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 definitions in the next clause are extracted from the Railway Interoperability Directive 2008/57/EC [i.1], the associated European Decision 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, to ensure technical compatibility between Member States and safe integration between train and track. The specific requirements for the different aspects of the railway subsystems are specified in the Technical Specifications for Interoperability (TSIs). The specification of the radio communication system to be used for the operation of the railway subsystems under the scope of the Directive is contained in the Control Command and Signalling TSI (CCS TSI) [i.2].

B.1.2 Definition of railway interoperability

The differences between Member States and individual lines in terms of rolling stock, technology, signalling systems, safety regulations, braking systems, traction currents and speed limits present a difficulty in the establishment of seamless traffic between any two given points.

In the Directive 2008/57/EC [i.1] 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;"*

In this framework, the requirements are set up for the radio communication system to be used by railways. In the CCS TSI [i.2], there are two subsystems described: the trackside subsystem (corresponding to the infrastructure) and the on-board subsystem (corresponding to the vehicle). Both of them have elements related to radio communication. The features of the subsystems, contained in the TSI [i.2], 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 [i.2] specifies and mandates only the requirements that are necessary to ensure the interoperability of the trans-European rail system (trackside and on-board subsystems) and the compliance with the essential requirements defined in it.

B.2 GSM-R as the radio communication system in CCS TSI

B.2.1 Introduction

The radio communication system mandated in the CCS TSI is currently GSM-R. This is defined in the basic parameters included in its section 4 of CCS TSI [i.2]. The air interface is characterized and the functionalities required are defined in the EIRENE documents.

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) [i.3] and SRS (System Requirements Specification) [i.4]. 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 [i.3] and SRS [i.4] 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.

Only some of the requirements in the EIRENE specifications are legally binding in Europe; these are the requirements considered as related to interoperability. Only these are part of the CCS TSI [i.2], and they are classified as Mandatory for Interoperability (MI) in the corresponding documents.

For instance, currently, only the frequency band 876 - 880 MHz UL / 921 - 925 MHz DL is Mandatory for Interoperability (MI); regarding functionalities, the Railway Emergency Call is Mandatory for Interoperability, but other functionalities described in EIRENE (such as sending and receiving Short Messages) are not mandated.

B.2.2 Process for placing a subsystem in service and migration

Before a vehicle can run on a railway infrastructure, there are a number of steps that have to be completed, from the verification of the technical characteristics required in the different legal texts, to a number of processes ensuring the safe integration of the elements in the vehicle.

These processes for putting 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.

Consequently, changes in the railway and GSM-R environments follow a stringent process that can take time.

In addition, the overall objective of achieving interoperability does not allow implementing a change without a transition period, where the previous solution and the new solution proposed have to coexist. The life cycle in the railway sector is longer than in other sectors, which makes the transition period longer (approximately 7 - 10 years). During the migration phase, the operation has to be warranted for all the vehicles (the ones already running with the new solution and the ones that have not implemented it yet). This situation imposes the need of providing compatible basic functionalities on both technical solutions.

Annex C: Bibliography

ECC Report 229: "Guidance for improving coexistence between GSM-R and MFCN in the 900 MHz band".

ETSI TS 136 213 (V13.1.1): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (3GPP TS 36.213 version 13.1.1 Release 13)".

History

| Document history | | |
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