Position paper issued by
ETSI Technical Committee Railways Telecommunications
And
European Union Agency for Railways

Subject: Railway vision on Next Generation Radio for Rails spectrum needs
Status: Final
Date: 1st July 2016

ABSTRACT: ***The purpose of this document is to provide a high-level vision on the spectrum needs for the European railway sector in the future, in the context of the preparation for a successor to the currently used GSM-R systems. This document represents the joint position of ETSI TC-RT, European Union Agency for Railways and Union Internationale des Chemins de Fer.***

1 Introduction

The purpose of this document is to provide a high-level vision on the spectrum needs for the European railway sector in the future, in the context of the preparation for a successor to the currently used GSM-R system.

GSM-R is a voice and data radio communication system for railway operation, mandated by the Control Command and Signaling Technical Specification for Interoperability (CCS TSI)[1], in the frame of the interoperability of the rail system within the Community Directive[2]. GSM-R is the sole radio communication system that can be used for interoperable railway operation as per the current regulation. GSM-R supports high speed trains under challenging radio conditions and is the cornerstone communication bearer of the European Railway Traffic Management System (ERTMS) that, in conjunction with the European Train Control System (ETCS), is a pillar for interoperability and safety in the Single European Railway Area.

The initial driver for this spectrum vision is the forecast obsolescence of the 2G-based GSM-R technology (GSM-R Industry Group committed to support GSM-R until 2030). A successor to GSM-R is currently being defined with trial implementations anticipated from 2022 in order to leave a sufficient period for migration and phase-out of the GSM-R system. Additionally new railway applications are foreseen: critical ones such as ATO (Automatic Train Operation), as well as operational ones such as remote monitoring and tracking, process automation, train approach warning system, etc.

The requirements for the GSM-R successor system are being defined by the UIC in its Future Railways Mobile Communication System (FRMCS) project, in close cooperation with European Union Agency for Railways and the railway sector. Based on current and future functional needs, system architecture and radio spectrum requirements are being defined. A traffic analysis is ongoing to assess the bandwidth requirements for future railway applications.

Requirements to minimise the economic impact of the migration to a new system will also be taken into consideration (i.e. European Union Agency for Railways studies on migration, cost-benefit analysis performed for TSI update).

GSM-R was designed as a railway specific system relying on the 2G system to benefit from economies of scale and wide product availability. However, the current market size is limited in terms of number of suppliers and the anticipated cost-benefit was not achieved. This is mainly due to the specific railway features in the standards and, in a lesser extent, to the specific radio spectrum. The successor system should consider the opportunity to significantly enlarge the market size and product ecosystem by following the main mobile telecommunications standards as is also anticipated by other users such as the Public Protection and Disaster Relief (PPDR) or Intelligent Transport System (ITS) communities.

In parallel, TC RT Next Generation Radio for Rail (NG2R) is working on a related ETSI System Reference document (SRDoc). It considers spectrum needs, with the current working assumption that the successor will be based on dedicated radio spectrum providing coverage on the entire railway network, similar to the current service offered by GSM-R. This does not exclude national decisions to allow the use of shared or public radio systems in parts of the railway network.

[1] COMMISSION DECISION (EU) 2015/14 of 5 January 2015 amending Decision 2012/88/EU on the technical specification for interoperability relating to the control-command and signalling subsystems of the trans-European rail system

[2] DIRECTIVE 2008/57/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008 on the interoperability of the rail system within the Community

2 Current GSM-R spectrum in Europe

Based on the 1999/569/EC Commission Decision of 28 July[3] 1999 and ECC Decision (02)05[4], all current GSM-R networks in Europe have the obligation to use the UIC band[5] for the radio communications between on-board and trackside. The GSM-R system benefits from an EU harmonized frequency band that has been implemented by all Member States. A key driver for this decision was the need for interoperability of the trans-European high-speed rail system (i.e. for European Railway Traffic Management System).

The UIC band is today used at its full capacity (19 frequencies), and in some specific cases shortage in capacity are seen: in very dense traffic conditions with ETCS Level 2 (European Train Control System), in large railway stations, and at the borders where not the entire set of frequencies is available due to coordination agreements. To cope with this situation ETSI is already considering some features to increase spectrum efficiency, e.g. ETCS over GPRS to relieve capacity constraints.

3 Using the UIC band

Reuse for the successor system of the current UIC band is regarded to be the most desirable spectrum option for a number of reasons.

First, it is an EU harmonized frequency band, allocated and available for the GSM-R networks in all EU Member States. Thus, there would be no need to identify and make available new spectrum. Continued usage of this band for the successor system would allow reuse of the existing radio site infrastructure (physical sites, masts, power, etc. – around 18.000 base stations in Europe), resulting in very significant investment savings.

Also for rolling stock, this would result in cost savings as the existing 900 MHz antennas can be reused. Similarly, protective measures against interferences like filters tailor-made for UIC band may be reused. Change to a different frequency band would most likely require replacement of on-board antennas, leading to longer periods where the rolling stock has to be taken out of service.

However, to make it possible to reuse the UIC band a number of aspects need to be resolved.

Current EU and national regulations only allows the usage of GSM-R technology in the UIC band. Therefore, in order to allow usage of 4G or 5G technology[6], this frequency band needs to be made technology neutral. This will also require a coexistence analysis for the adjacent spectrum usages, to be developed and approved by CEPT/ECC.

Likewise, would the successor system be based on a 3GPP 4G or 5G standard, the UIC frequency band would need to be introduced in the selected standard.

For the migration from the current GSM-R system to the successor system, a migration period will be necessary, in which, at least on a subset of the railway tracks, simultaneous operation of both

[3] COMMISSION DECISION 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

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

[5] UIC band [876-880 MHz UL / 921-925 MHz DL] / Extended UIC band [873-880 MHz UL / 918-925 MHz DL]

[6] 3GPP family systems look like serious candidates. With 5G, ubiquitous radio access should be enabled, including WiFi and potentially Satellite

systems will be required for a number of years. This need arises from the fact that it may not be possible to guarantee that all (national and international) trains using a particular track will be equipped with dual mode[7] (i.e. GSM-R + the successor system) train radios. A European Union Agency for Railways study is ongoing on the question whether or not it is actually possible – from radio coexistence, capacity and operational point of view – to have the coexistence of GSM-R and its successor at the same locations in the sole UIC band.

In case further analyses demonstrate that such simultaneous usage of both systems within the 2x4 MHz of the UIC band is not possible due to coexistence or capacity issues, it will be necessary to identify and make available other spectrum. In order to be cost-effective in reusing the existing infrastructures (radio sites civil works), such new spectrum needs to be below 1 GHz. Options to be considered are the Extended-UIC band, the 700 MHz and the 400 MHz ranges. Other frequency bands below 1 GHz that have an ITU land mobile destination are not available nor currently under discussion.

4 Using the Extended UIC band

In case it is not possible or sufficient to use the UIC band for the successor system the next best option would be to use fully or partly the Extended UIC band made of the UIC band and of an additional band just below it. For this band, the same cost-benefit would apply as described above for the UIC band.

This additional band has already been defined in ECC/DEC/(04)06[8], which states "*that this ECC Decision also provides a possibility for a GSM-R extension into the bands 873-876 MHz and 918-921 MHz on a national basis*". So far, a limited number of Member States have actually implemented the Extended UIC band, even though GSM-R products supporting this band are available. Seven countries have a provision for this in their national frequency plan: Germany, Hungary, Liechtenstein, Switzerland, Croatia, Czech Republic and Latvia.

However, the ECC Decision also states that the duplex frequency band 870-876 MHz / 915-921 MHz is also designated for Defense systems in ERC Report 25[9]. At the time of writing, this frequency band is under discussion for usage by Short Range Devices (SRD), including Radio Frequency Identification (RFID) equipment. Therefore, further study is required to assess the compatibility between the successor system and SRD, as well as Defense systems.

In order to enable usage of this Extended UIC band for the successor system it will be necessary to make it technology neutral, perform coexistence studies with adjacent spectrum usage, and introduction of this band into the 3GPP 4G/5G standards.

[7] European Rail Infrastructure Managers are of the view that the possibility to equip international trains with dual mode systems is a viable option if that is a precondition for migration.

[8] 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

[9] THE EUROPEAN TABLE OF FREQUENCY ALLOCATIONS AND APPLICATIONS IN THE FREQUENCY RANGE 8.3 kHz to 3000 GHz (ECA TABLE)

5 Using the 700 MHz range

In the situation where neither the UIC band nor the extended UIC band can be used for the successor system, it becomes necessary to identify some alternatives.

One alternative to consider is the 700 MHz range (uplink 698-736 MHz, downlink 753-791MHz)[10]. In current discussions on the usage of this land-mobile band, it is anticipated that a larger portion will be made available for public mobile networks, with possibly some part allocated to PPDR services.

A possible way forward would be to consider spectrum sharing between PPDR[11] and railway communities, which as a concept seems to be very much in line with current trend[12] at both Commission and Member State levels. In addition, this has been positively discussed at conceptual level between Railway and PPDR representatives. However a number of aspects needs to be carefully assessed, mainly non-technical: priority between PPDR and railway users in case of calamity; additional investments to cover the rail tracks; service level agreement; compatibility of both maintenance processes; coexistence with adjacent MFCN; etc.

This may also create an increased, common market for radio equipment, reducing the risk of niche markets.

6 Using the 400 MHz range

Another alternative to consider is the 400 MHz range. This frequency range is under discussion within CEPT for usage by PPDR and broadband PMR. Regarding PPDR the sharing mode would be quite similar to the above-described 700 MHz case.

Sharing the 400 MHz range with PMR still needs to be further investigated; several scenarios can be envisaged: band sharing, geographical sharing, radio network sharing, etc. Sharing possibilities depend on the PMR use cases and requirements, and on their compatibility with railway ones.

Adaptation of the existing radio propagation models to this frequency range may be required.

7 Using other spectrum for non-critical applications

Currently the document on the railway requirements includes both critical and non-critical applications. At this moment, it is not yet clear if all those applications need to or should be supported by the successor system. It may be considered to offload non-critical applications to public networks. In this case, if different terminals would be required, a cost-benefit analysis would be relevant, to understand the impact on the railway vehicles, the on-board staff, as well as in general on railway operations. Synergies with ITS shall also be considered.

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[10] without considering the SDL band plan

[11] Taking in consideration the example of the French 700MHz allocations, sharing could be considered for a 5MHz (698-703 resp. 753-758MHz) and/or 3MHz (733-736 resp. 788-791MHz) part of this band (see Draft ECC Report 218. For the 5MHz part, limitations have been defined on its usage intensity, leaving the 3MHz part as the best option for sharing. This 3MHz part then could be used as of the migration period from GSM-R to its successor.

[12] https://ec.europa.eu/digital-single-market/sites/digital-agenda/files/com-ssa.pdf

8 Summary

1. GSM-R is the only available radio communication system as per the regulation today to support ERTMS, railway operational and safety voice and data radio communications. It benefits from harmonised spectrum across CEPT countries.
2. GSM-R support is committed by industry until 2030. A successor to GSM-R is currently being defined with trial implementations anticipated from 2022.
3. Several options for a successor system are considered, based on requirements for future railway applications and a cost-benefit analysis of the alternatives.
4. From a spectrum perspective, also several options are considered:
   a. Reuse of the 2x4 MHz of the current UIC band;
   b. Use of the 2x3MHz of the Extended UIC band in addition to the UIC band;
   c. Use of other bands (700 MHz, 400 MHz), possibly in sharing mode with PPDR or PMR;
   d. Offloading non-critical applications to public networks.
5. Those options need to be assessed against various criteria:
   a. Licence and ownership model – dedicated versus shared (public operators, PMR or PPDR);
   b. Capacity to serve current and future railway application needs;
   c. Spectrum efficiency (including sharing scenarios);
   d. Reuse of existing assets and other cost reductions related to market size and supplier competition;
   e. Interoperability, requiring terminals to support all frequency bands available for railways in EU (dedicated, shared, public).
6. All the spectrum options considered require further development of standards and spectrum regulation. EU regulation (CCS TSI) can only mandate a successor system with the support of CEPT/ECC and the Member States in their sovereign role for spectrum regulation.

Abbreviations:

ATO	Automatic Train Operation
CCS TSI	Command-Control and Signaling Technical Specification for Interoperability
CEPT	Conférence Européenne des Administrations des Postes et des Télécommunications
ECC	Electronic Communications Committee
ETCS	European Train Control System
ERTMS	European Railway Traffic Management System
EU	European Union
FRMCS	Future Railways Mobile Communication System
GPRS	General Packet Radio Service
ITS	Intelligent Transport System
MFCN	Mobile/Fixed Communications Networks
RFID	Radio-Frequency Identification
TC RT NG2R	TC RT Working Group Next Generation Radio for Rail
PPDR	Public Protection and Disaster Relief
PMAR	Private Mobile Analogue Radio
PMR	Private Mobile Radio
SRDoc	System Reference Document
UIC	Union Internationale des Chemins de Fer