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Transferring standards: lessons from GSM-R in the railway sector

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Abstract

In the mid 1990s the European railway community – under the aegis of the Union Internationale des Chemins de fer (UIC) – opted for GSM as the standard to replace existing analogue railway radio systems. The decision was taken on two grounds: GSM was a non-proprietary standard (i.e. open standard) and it fulfilled the needs of railway operators. Other arguments put forward to support the choice was that choosing GSM would have the advantage to remain close to the development of the public market and to benefit from the experience on the applications and products level.

This paper looks at the transfer of a telecommunication standard to another industry (railways). In particular it studies whether the adoption of an "extended" version of the GSM standard (GSM-R) turned out to be an efficient choice. Unlike the telecommunication sector, the railway sector does not have a UN forum like the ITU where railway stakeholders can come together to solve technical and standardization issues – that role is carried out in large parts by UIC, ETSI and other standardization bodies and increasingly by the European Railway Agency (ERA).

Whereas the telecommunication sector has been undergoing liberalization for more than 20 years the European railway sector is by-and-large only beginning its reform process. The aim of creating a single European railway market has not been facilitated by the existence and persistence of strong technical boundaries at the national level. The transfer and deployment of GSM-R is of strategic importance to the success of another European railway project – European Railway Train Management System (ERTMS) – since the introduction of the new signaling system rests on achieving interoperability in radio-communication.

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Based on interviews from key stakeholders (telecommunication equipment manufacturers, railway operators and spectrum regulators) we discuss the viability of “piggybacking” on the GSM standard to answer the needs of railway operators.

The paper is divided in three parts. First we look at the adoption of an existing standard (GSM) and its extension and transfer to the railway sector. Second, we look at the issue of maintaining the GSM-R[2] standard. We are particularly interested in analyzing the interplay between the key stakeholders (ERA, UIC and ETSI) in establishing the locus for standard maintenance and ensuring harmonization of future developments. In the third part, we question the efficiency and the viability of “piggybacking” on the GSM standard to answer the needs of railway operators. The paper concludes that despite a number of remaining technological and institutional issues (such interference from public operators introducing UMTS, frequency management and coordination between numerous stakeholders), the adoption of GSM-R represents a successful case of standard transfer/extension.

Part I – Adoption and extension of the GSM standard to the railway sector

In the early 1990s, the International Union of Railways (UIC) was looking at ways to harmonize railway communications. Many railways used cable networks and analogue radio for voice and data communications. In Europe alone, there were more than 35 different platforms, and German Rail (DB) alone has eight different analogue systems[3]. The precedent international standard – developed for analogue train radio systems in the 1970’s and operating in the 450-470 MHz band – provided only limited compatibility for speech and the absence of standard mobile equipment limited trains to operate across national borders (Hofestadt, 1995). Maintaining and updating these disparate systems was becoming increasingly difficult and costly, and analogue systems were not compatible with many of the modern communications systems. In addition, the European Community pushed for an open mobile communication system in the railway sector – European Directive on High Speed Train Interoperability and by other forthcoming European Directives for railways (including the European Directive on Conventional Lines interoperability) considered standardization a key to achieving a European single rail market.

The European Conference of Postal and Telecommunications Administrations (CEPT) agreed in 1990 to reserve the bands 870-876 MHz (for uplink, i.e. mobile station transmit) and 915-919 (for downlink, i.e. base station transmit). The discovery of problems – the downlink band would have been to close to the GSM uplink band – prompted the CEPT to change its recommendation in 1995 and to assign the 876-880 uplink and 921-925 MHz downlink bands.

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[2] GSM-R uses the GSM technology but the specialized requirements for harmonized railway operation, in particular for high-speed trains, means that applications have to use the GSM system in a specific way.

[3] In the early days of railway communication, every national railway operator has had at least one proprietary radio communication system, mostly in the frequency band of 440 to 470 MHz, but with many different types of modulations, codes and signaling.

The UIC set up two projects were used between 1995 and 2000 to develop the European railway communications standard (GSM-R). Operators and engineers from the European railways worked with the recently created European Telecommunication Standards Institute (ETSI[4]) and industrial partners to develop a pan-European radio standard under the project name EIRENE (Watkins, 1996)[5]. The European Integrated Railway radio Enhanced Network (EIRENE) project was used to develop the specifications for and to facilitate the standardization of the GSM-R railway radio communication system. The Mobile Radio for Railway Networks in Europe (MORANE) project was used to test network coverage in difficult terrain and tunnels, and to test operating conditions for voice and data transfer in high-speed trains, plus new functions. MORANE served as the project to develop the GSM-R system in accordance with the EIRENE specifications and perform validation on the three trial sites[6]. In 1997, 32 European railways signed the EIRENE memorandum of understanding to build a European GSM-R telecommunications network. A plan to deploy GSM-R was agreed in 1999-2000 and roll-out has taken place quite successfully over the past few years (see Table 1 for the major milestones).

Table 1: Milestones of GSM-R development

Year	Milestone
1992	UIC establishes the EIRENE (European Integrated Radio Enhanced NEtwork) Project to develop the requirements for a new digital standard
1994	Standardization of Advanced Services Call Items (ASCI) features start at ETSI
1996	EU establishes the MORANE (MObile radio for RAilway Networks in Europe)
1997	32 railways sign the EIRENE MoU indicating their commitment to implement the GSM-R as an interoperable system (and no longer investing in analogue radio systems)
1999	18 railways sign the EIRENE AoI – a complement to the MoU - their intention to begin GSM-R implementation by 2003 at the latest on the sections of Trans-European Networks (TEN-T, TERFN) under their responsibility
2002	CEPT (European Conference of Postal and Telecommunications Administrations, 2002) assigns a specific part of the GSM frequency band 876-880 MHz (mobile station transmit) paired with 921-925 MHz (base station transmit) for international and national railway operations
2007	3 European Standards Organizations (ESOs) – CEN, CENELEC, and ETSI – sign a MoU with ERA clarifying their relations regarding the political and technical framework for cooperation on European standardization in the field of railway
2008	The European Commission and six organizations from Europe's railway sector sign a MoU aimed at speeding up deployment of ERTMS. It brings on board the GSM-R industry for the first time

Source: Compiled by author from Sarfati (2008) and UIC website

Choosing the standard

At the time the UIC faced two alternative/competing standards: Global System for Mobile communications (GSM) and Terrestrial Trunked Radio (TETRA). After extensive tests, GSM was found to

[4] For a historical perspective on ETSI see (Besen, 1990).

[5] The proposal for a new radio system for European railways was first considered by UIC in the mid eighties.

[6] Both projects/groups have now been disbanded but were replaced by a new UIC GSM-R project group.

be more suitable for use on the high-speed rail network taking shape in Europe – it can function at train speeds up to 500km/h. in addition, while both TETRA and GSM were digital mobile radio standards issued by ETSI, back in 1993 GSM was already the de facto standard for public cellular mobile communication whereas TETRA was still at the drafting stage/standardization process.

Watkins (1996) argues that the main reason why GSM was chosen were: 1) its application in the 900 MHz frequency band with international roaming capacity, 2) the possibility of modifying the standard to meet railway requirements, 3) the availability of equipment to meet the standard within the time scales set by UIC, 3) the maturity of the GSM standard and its lifetime, and 4) the economic viability of the standard. According to Hofstadt (1995), the UIC constraints left only the choice between TETRA and GSM. The UIC chose GSM on condition that changes could be made to the standard to meet railway requirements. According to the UIC, the actual decision process took place in three phases: 1) define "what we wanted", i.e. the functional requirements (FRs). For the FR we had to make a choice between TETRA and GSM[7], 2) find the technologies and 3) make a choice. In other words, no technology (i.e. GSM or TETRA) seems to have been favored *a priori*.

An additional element of choice laid in the characteristic that, contrary to the public GSM network where operators can switch technology rather rapidly, the railway sector needed a system that could last between 15 and 20 years – hence the importance of the "right choice". However, railways do not need to have the most sophisticated communication system in the world ("they are there to transport people and goods" which takes away the burden of having to be technological leaders in telecommunications.

The standardization process

As noted above the development of GSM-R was initiated by the UIC via two major projects (EIRENE and MORANE). However, an important part of the standardization work was carried out by ETSI. ETSI's goal in standardization of GSM-R were threefold: fulfilling railway requirements, no deviation from GSM standard and remaining as close as possible to the public GSM. During the development of the standards, a series of test lines was constructed so that the inter-operability of equipment from different vendors could be tested and verified[8]. ETSI's standardization activities for GSM-R centre on the *applications* of GSM for railway telecommunications (see appendix 1), including numbering and addressing, configuration aspects, system aspects and functional aspects and any additional services sought by the railways[9]. It does not include specification of the GSM technology itself (that is the task of the 3rd Generation Partnership Project, 3GPP), neither does it include safety aspects (which are standardized by CENELEC).

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[7] Functional requirements were not linked to the SIM. UIC didn't want to link the FR to GSM – system requirements (SR) may be linked to the SIM. This has implications for the future incorporation of technologies usch as WIMAX which doesn't have a SIM.

[8] Interoperability testing remains a core issue in the GSM-R approval process.

[9] These applications can be easily extended to PMR Networks based on GSM-R Functional Requirements Specifications.

The actual standardization work is carried out by a dedicated ETSI technical committee, Railway Telecommunications (RT). Currently, RT is working closely with the Third Generation Partnership Project (3GPPTM) on Advanced Speech Call Items (ASCI) features which could impact on the interoperability of railway telecommunications, particularly with a view to improving the efficiency of PMR operations. RT also has an ongoing liaison with 3GPPTM on enhanced Voice Group Call Service (VGCS), and work on the encryption of group calls. Finally, RT is also evaluating the possibility of using Direct Mode Operation (DMO) GSM-R for communications related to the requirements of the Technical Specification for Interoperability (TSI) for safety in railway tunnels.

The specificities of GSM-R

The objective of the pan-European GSM-R network is to allow trains to travel between countries with a seamless radio communication service (i.e. no need to change onboard radio communication equipment when passing over the border from one country to another)[10]. In a nutshell GSM-R is a radio system used to exchange information between the ground and the train. It is based on the GSM mobile telephony standard, but uses different frequencies specifically for the railways. It has some additional advanced functions. GSM-R offered other benefits such as digital mobile communication and location-independent connections. Other functions were and are being developed specifically for the railway sector, such as group calling and information targeted regionally. GSM-R allows roaming in Europe and information to be directed at specific groups of workers such as train conductors or track maintenance staff. For example, it allows drivers to speak with the traffic management centers and can be used to transmit the maximum permitted speed.

GSM-R technology differs very little from standard GSM technology. The core equipment for GSM-R is almost identical to that for GSM and is in mass production[11]. The mobile equipment has different packaging and some different software but the majority of the equipment design and software is identical with GSM handset and mobile design. There are many other core equipment elements but these are identical to the GSM components. In addition to the railway applications (track-side maintenance, wide area communications, shunting radio and vehicle radio), railway specific changes included: 1) coping with higher speeds, 2) call a train in a given area, 3) service precedence and preemption, 4) functional and location dependent addressing and 5) push-to-talk capability (Kastell, Bug et al., 2006). GSM-R has also specific requirements when it comes to quality of service (QoS)[12]. Perhaps the characteristics that sets really GSM-R apart from previous railway communication standard is that there are no proprietary elements in its specifications.

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[10] The radio communication environment in the railway sector comprises private mobile radio (PMR), maintenance radio, shunting radio, tunnel radio, radio for local and nationwide security authorities, radio control for locomotives, etc.

[11] The core equipment for a GSM-R system consists of the Mobile Switching Centre, the Operation Sub-System and an Intelligent Network.

[12] Actually the part on QoS is not in the standard but in the Technical Specifications for Interoperability (TSI).

While there could be a semantic debate on whether GSM-R is an extension or an adaption of GSM, there is no doubt that each one has its own business case: railways have at most 300'000 users in Europe while there is no mobile operator with less than a 1 million subscriber base.

Part II – Maintaining and developing the GSM-R standard

While the two UIC-led projects (EIRENE and MORANE) were central in the initial stages of GSM-R, maintaining and further developing the standard is of no lesser importance. Coming in the footsteps of the European Association for Railway Interoperability (AEIF)[13] the European Railway Agency (ERA) was set up to help create an integrated railway area by reinforcing safety and interoperability. Its main task is to develop economically viable common technical standards and approaches to safety, working closely with railway sector stakeholders, national authorities and other concerned parties, as well as with the European institutions. As it is the case for ETCS, ERA acts as the system authority for GSM-R. For instance ERA is in charge of revising the TSIs (e.g. those who indicate the exact format of the messages which have to be exchanged between the track and the train). It is important to note that designation of a system authority is not synonymous of reduction in conflicts of interests within the larger ERTMS ecosystem.

The current system is established on three levels:

1) Technical, where specifications are described. Specifications exist but there are some gaps (implementation and technology development); UIC receives implementation reports and other data coming from RU, ERA, etc. and drafts the specifications;

2) Specifications are discussed in the sector organization (CER and EIM);

3) Specifications are approved by ERA; formally ERA does not decide since it only makes recommendations to the Article 21 committee which votes[14].

The whole process is consensual since UIC cannot afford to send a specification change before everybody agrees (at least not until there tends to be a large majority). As noted, important information is gathered from field trials. The new ERTMS/GSM-R project (replacing EIRENE and MORANE) is made of three permanent working groups and a number of Ad Hoc groups integrated (see Figure 1 for the GSM-R ecosystem). In parallel to this railway oriented working groups the GSM-R suppliers have formed a separated group, called IG ((GSM-R) Industry Group) which works on two aspects : a marketing part, looking for common approaches to promote GSM-R worldwide and a technical part, which forms the interface to the railway groups FG and OG.

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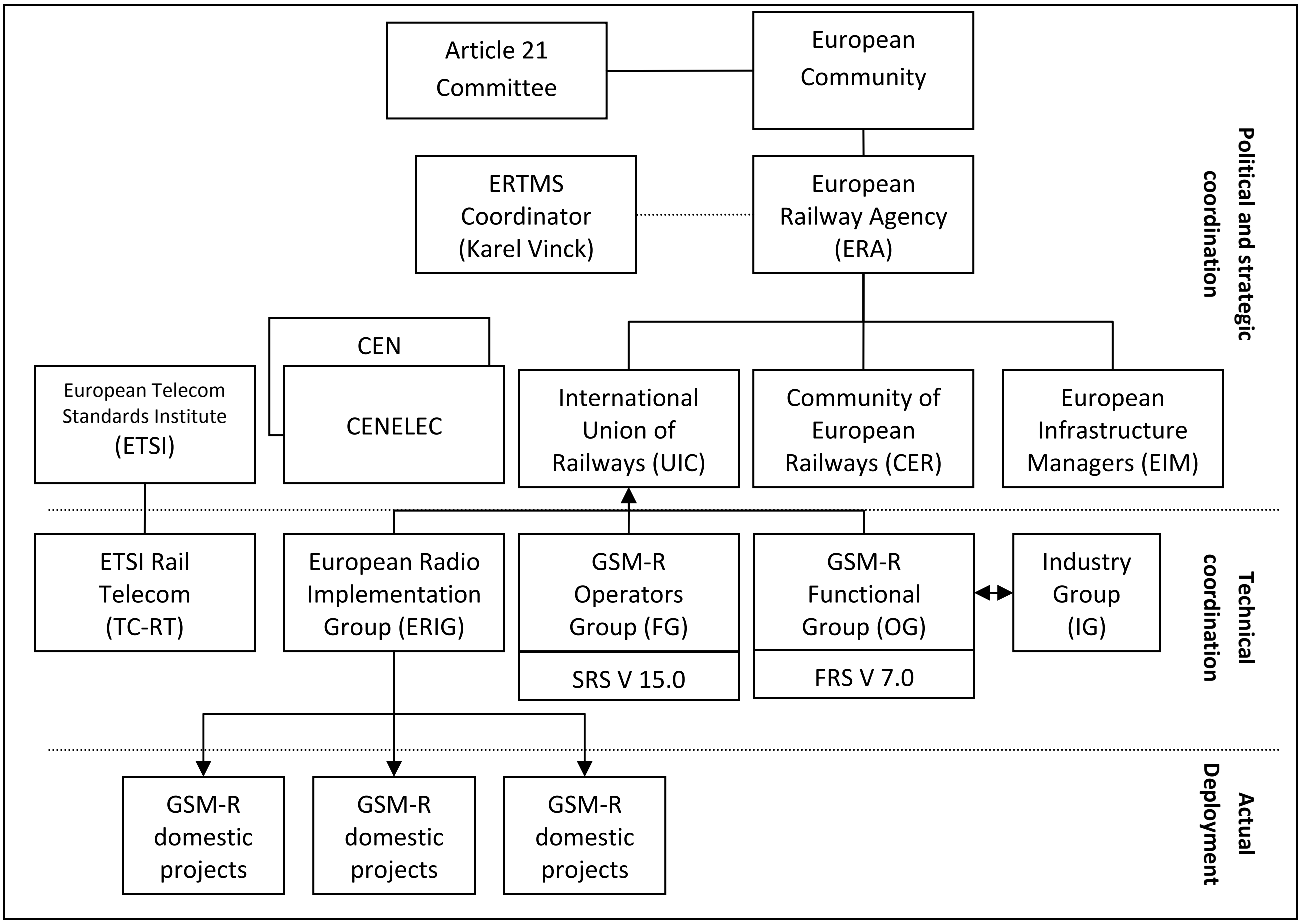
[13] In September 2006, the European Association for Railway Interoperability (AEIF) officially transferred all its documentation to the European Railway Agency. AEIF was the joint representative body mandated by the EU Commission to lay down the Technical Specifications for Interoperability (TSIs).

[14] ERA's recommendations have for the time being always been ratified by the Article 21 Committee.

Figure 1: GSM-R Ecosystem



Source: Compiled by author

Notes: ERIG (European radio Implementation Group) – ERIG forms the assembly of railways having signed the MoU and the AoI (Agreement of Implementation). The main goal of this group is to exchange information about ongoing implementations based on results already achieved and discussion about gaps in the specifications or implementation reports related to national or international functions Information is also given on the work of the different permanent and Ad Hoc-groups and the presentation of actual Change requests together with their status. This group is mainly a dissemination platform. Functional Group – The main task of this expert group is to maintain the FRS, to check incoming implementation reports concerning impact to functional requirements and to raise change requests related to the FRS. The FG is also responsible for creating a new version of the FRS. The FG works with OG and the GSM-R industry Group (IG) to find the right solutions and requirements. The FG takes responsibility for the migration of functional requirements towards new and future technologies to ensure consistent railway operation. Operators Group – The name of this group could more appropriately, be called the Technical Group. The main task of this expert group is to maintain the SRS, to define technical solutions for functional requirements, to liaise with ETSI, the standardization Body for GSM related to railway requirements, to create change requests, based on implementation reports, to liaise with the TIG (technical part of the Industry Group) to find solutions and to ask for technical improvement. The OG is also responsible for creating a new version of the SRS and upgrading of former MORANE documents.

To protect the specific railway features of GSM and to improve the development of the GSM standard, UIC has created, together with ETSI, an interface group that has the status of a technical committee in ETSI. Based on liaison-statements with the different committees in ETSI this group is in a position to improve the standards and to protect them against commercial encroachment from public suppliers. ETSI's TC-RT group is in charge of developing and maintaining ETSI standards for application of GSM-R to railways – a requirement of the European Directives. Its scope is complementary to other technical bodies inside ETSI and to CEN and CENELEC. TC-RT specifies how to use GSM to comply with European Directives on Interoperability. In fact, besides a few companies that agreed to work on GSM-R (e.g. SAGEM, Nortel, Nokia-Siemens), most of the work is done at ETSI.

One of the central task of the GSM-R community is to maintain the EIRENE functional and system specifications (FRS and SRS). To do so, an intricate process of change request (CR) has been put in place[15]. When it comes to change request, a lot of work is conducted by UIC. Over the past months ERA has become part of all the working groups for increased transparency (normally ERA should organize this but for now UIC is in charge).

Part III – Efficiency of transferring the GSM standard to the railway sector

One of the interesting questions raised by the adoption of GSM for the railway sector is whether it is efficient.

Funk (2008) argues that the transfer of standard-setting to ETSI reflected the increasing power of manufacturers, leading in the end to service providers revoking their claim for a common intellectual property rights policy (Bekkers, Duysters et al., 2002; Bekkers, Verspagen et al., 2002). The success of GSM further promoted policies of openness leading to the integration of the GSM alliance within the ITU. However the era of standards which prevailed for 2G no longer applied for mobile Internet standards – manufacturers being unable to agree on standards. Funk argues that the open-standard approach works well with modular problem-solving, whereas mobile Internet requires integral problem-solving. In the case of the mobile Internet, one has returned to quasi-vertical integration of service providers.

An unusual feature of GSM-R is that because it is an open platform to ensure interoperability, manufacturers are both competitors and collaborators (Briginshaw, 2003). While this state of affairs in not uncommon in many other industries, it is rather novel in the railway sector which has been under vertically integrated models of development with one supplier per country working with one railway (de Tilière and Hultén, 2003; de Tilière, 2005).

A number of studies (de Tilière, Emery et al., 2003; de Tilière and Hultén, 2003) have pointed out that a shift regarding innovation has taken place in railway systems during the early 1990s. Before that leading

[15] There were 108 CRs between January 2001 and December 2006. In 2005 and 2006, 53 CRs were studies and 34 of them were finalized (5 were rejected).

countries mainly had a national market with a national operator working with a main manufacturer for a defined scope of supply (i.e. market share between national manufacturers according to key technologies). National industrial policies were always in the background and the relation between operators, institutions and governments were very tight (see Dobbson 1994; Quinet 1999; de Tilière 2001)[16]. The change agents for the system architecture were the duo operator-manufacturer. The manufacturer proposed technological specifications according to the degree of innovative solutions required by the operator (at the system level). Except for international trains, there was neither real need nor demand for trans-border standardization. One could even argue that standardization was seen as a threat by suppliers – the potential economies of scale realized by the suppliers being offset by rents extracted from their captive clients.

The turn of the 1990s saw the end of this "national rail market" equilibrium. Supranational legislations started to impose new rules on domestic jurisdictions. For example, procurement rules imposed by the World Trade Organization now prevent the past practices of contract study allocations. Efforts at market liberalization at the European level also created a fundamentally new environment with different actors operating under different power relations – the most obvious example is the vertical separation of infrastructure management from train operations.

The question therefore is whether the current institutional framework for standard-setting matches the technology and the users requirements in the railway sector (Laperrouza, 2008b, 2008a).

An interesting lesson from transferring GSM to the railway sector is that a number of functionalities that were specifically developed could be "imported" back into GSM. For example, Director Mode Operation (DMO) could fulfill the needs of emergency services

Table 2: Functionalities of GSM-R not currently supported by GSM

Standard and railways functionalities	Notes
VBS/VGCS/Railway emergency calls	ASCI features are not supported by all public GSM network suppliers
Location-Dependent Addressing (LDA)	Public GSM network coverage is not suited and optimized to support a cell-based LDA

Source: Compiled by author

IV – Discussion and conclusion

As noted above, GSM-R and ETCS are part of a wider European project called European Railway Train Management System (ERTMS). The pace of adoption/migration of the two systems is quite different With more than 60'000 kilometers of GSM-R constructed by September 2007[17] (of which more than 40'000 kilometers in operation), one can wonder why the two components of ERTMS fare so differently when it comes to actual deployment (UIC, 2008). According to Kastell, Bug et al. (2006) unification was driven by the fact that some operators had to change their communication band as licenses for some

[16] Unsurprisingly, national industrial policies played a key role in the development of rail innovations.

[17] The total railway network planned with GSM-R is above 140'000 kilometers.

frequencies expired and were not re-granted by local regulation authorities and, with increasing cross-border traffic, by the fact that operators wanted to simplify communications between entities of different operators.

Of course, if ones looks at the level of investment you are looking are two different things because GSM-R in a sense is easier; moreover it has not such a strong safety-relevant impact. The second major difference is that the system is different: the specifications for GSM-R are done by UIC.

In terms of power-plays and conflict within the stakeholders, GSM-R seems to fare better than ETCS. According to the UIC for GSM-R the problem is lesser because the UIC group that does the specifications works very closely with the industry groups (the organization is quite different and I don't want to discuss ETCS).

In spite of the significant success achieved by GSM-R in standardization and deployment across Europe (technical interoperability is close to 100%[18]), a number of issues still need to be tackled. The diversity in spectrum requirements across Members States (European Commission, 2008) illustrates well the difficulty in reaching an optimal spectrum policy at the European level. For example, Germany has demands for additional spectrum for railway applications on a regional and local basis[19], something that may not be completely unrelated to its privatization: even if the spectrum can only be used by the railway company, it has significant value and would likely increase the public offering. A number of other countries have either identified the need for further spectrum (France), assume there will be further needs (Spain) or are going to conduct studies to determine whether there are further needs (Norway)[20]. The additional spectrum requirements vary among countries (2 x 5 MHz for Austria, 2 x 4 MHz for France and 2 x 3 MHz for Germany). In addition, one of the central issues is that GSM-R may not deliver in high-density areas. The problem of high-density could be two-fold. Since GSM-R is also a data caterer for the European Train Control System (ETCS) there may be problems when transmitting data to many trains in complex stations. In addition, there may also be voice communication overload (especially in big shunting yards)[21]. In practice, there is no problem as today[22]. Mandoc et al. (2007) argue that GSM-R's main asset is frequency spectrum. One of the main problems for the GSM is spectral limitation. Since

[18] The addition of a number of new applications to GSM-R and new GSM features have been completed or are still ongoing – applets (SIM and Mobiles), packet data (GPRS/EDGE) and location systems. There are also some small problems with different cab-radio constructions; there are a number of interoperability issues but none are crucial. For GSM-R issues remain but EIRENE 8/16 should almost close the door to interoperability issues (e.g. the "yellow button" in the UK - The yellow button was accepted on the condition that "foreign" trains are not obliged to implement it – or periodical retrial in Italy).

[19] Germany would like to see the upper part of the adjacent duplex bands (870-876 MHz and 915-921 MHz) attributed to railways.

[20] The French administration considers that the designation of additional spectrum should be done at the European level.

[21] The basic issue is linked to the fact that there are 4 MHz reserved for GSM-R and there are only so many available channels within it these 4 MHz.

[22] At this stage of ETCS development and even if GSM-R is much more widely used it has not yet been proved that it is not sufficient for shunting of voice-specific communication.

2002 the reserved bandwidth for GSM-R has been part of the TSI for high-speed lines and since 2004 part of the TSI for conventional lines (respectively 2002/731/EC and 2004/447/EC)[23]. The economic use of frequencies is of special importance to operator railway communications, since the International Union of Railways (UIC) frequency band is limited to 4 MHz – 20 digital network channels or, in circuit-commuting mode, 150 traffic channels (Santos, Soares et al., 2005). In the 1990 the most suitable band allocation (900 MHz) was agreed between UIC and the CEPT but proved to be unsuitable. A draft report of the European Radio Office (ERO) recommended a revised allocation for the UIC at 876-880 and 921-925 MHz (Watkins, 1996)[24].

Beyond the technical issues already mentioned, there are a number of other issues such as the coordination between train operating companies (TOCs) and Infrastructure Managers (IMs). The alignment of these two groups has been made more difficult with the vertical separation pushed by the European Commission.

Like with ETCS, technological interoperability is only one part of challenge. Harmonization of operational rules can also cause significant blockades in achieving interoperability. For example there are different views across Europe's National Safety Authorities when it comes to TNV contact – a software timer which supervises how long contact has been lost with the Radio Block Center[25]. A number of issues such as operational rules at border crossing seem to have already been solved. For example roaming agreements have been signed between France, the Netherlands, Germany and Belgium.

Finally a lot of work remains to be conducted so that every stakeholder "understands GSM-R the same way". The integration of current voice-oriented and ETCS data applications has been achieved[26].

Conclusion

According to Sarfati (2008), there are 3 drivers for the introduction of GSM-R: cost reductions, service improvement and rail market deregulation. Whereas the former two present immediate advantages to the railway undertakings, rail deregulation actually plays a more ambiguous role. On one hand the introduction of competition can bring dynamism to a sector. On the other hand the vertical and horizontal separation of formerly integrated railway undertakings has slowed down investment decisions since business cases are not the same for infrastructure managers or train operators.

This paper has shown that Europe's heterogeneous communication networks are being replaced by a uniform, standardized technology (GSM-R) with frequencies harmonized at the European/international level and exclusively reserved for the railway sector.

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[23] The introduction of GSM-R also liberated frequencies presently used by railways.

[24] Several authors have pointed out technical shortcoming such as the duration of cell reselection and handover (Kastell, Bug et al., 2006).

[25] While in Switzerland it is between 50 and 60 seconds, in Italy it is 10 seconds. Behind this there is the whole philosophy of movement authority.

[26] This includes present fixed lines applications and ETCS using circuit-switched data.

Such a standardized communication technology considerably simplifies cross-border traffic and enhances the possibility of competition in the railway market at least in a number of segments[27]. In addition, its compatibility with the public GSM network will allow the introduction of new services to passengers (including rail connections, platforms and delays).

While the initial choice of GSM vs. TETRA can be discussed at length from the point of view of technological advantages, the real “tour de force” lies in having achieved harmonization/standardization of telecommunication across the European railway sector (and potentially in markets like China or India). That said, the achieved standardization level as well as the successful deployment of GSM-R across Europe should not lead to underestimate the difficulties faced by GSM-R throughout its history. In addition to having to solve a number of crucial technological issues (frequency management and harmonization), the whole activity of change request management (officially in the hands of ERA but largely coordinated by UIC) will play an important role in determining the solidity and longevity of GSM-R in its present form as well as in its future version.

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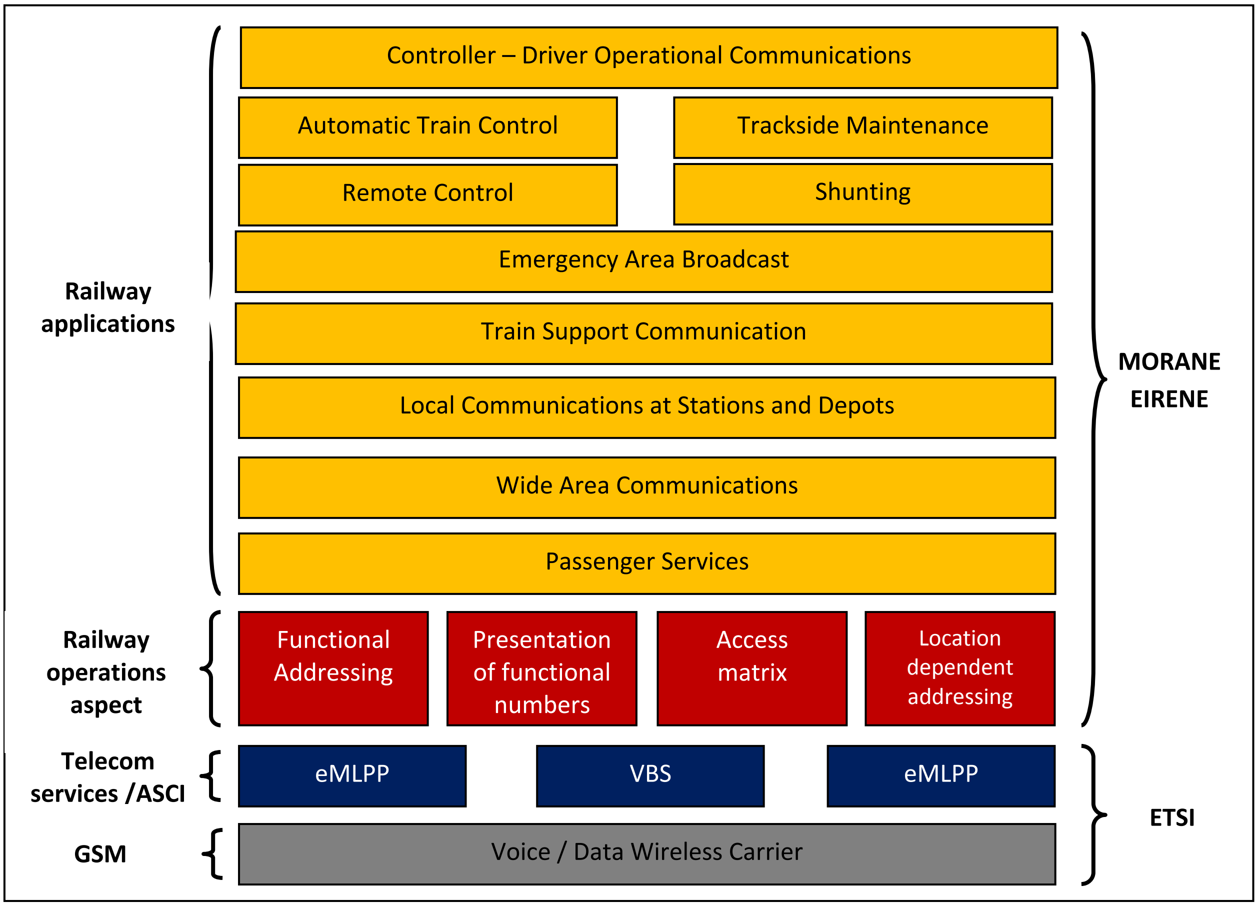
[27] For example, in Switzerland, « full GSM-R » will be limited to the main lines. Regional traffic will be able to use the main functions of GSM-R through a public network’s operator.

Appendix 1: GSM-R Applications



Source: Sarfati (2006)

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