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A Survey on Transferring Standards of GSM-R in Railway Sector

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Abstract

GSM-Railways (GSM-R), which is evolutionary railway mobile communication technology, are gradually replacing analogue radio systems. Although GSM-R is an impossible achievement in terms of European railway interoperability, from a telecommunication point of view, it is successive technology.

This study present the transfer of a telecommunication standard to another railways and it studies whether the adoption of an upgraded version of the GSM standard (GSM-R) turned out to be an efficient choice. The transfer and deployment of GSM-R is technically importance to the success of another European railway project. The introduction of the new signaling system rests on achieving interoperability in radio-communication.The study will focus on the GSM-R part of the ERTMS system and its interworking with ETCS.

1. Introduction

GSM-R is the first mobile communication standard designed specifically for railways. It is based on the Global System for Mobile Communication (GSM) standard, which is widely used in commercial mobile telephony networks. GSM-R provides two essential railway services [1]

• Train-to-ground data communication for ETCS Level 2 and 3.

• Voice communication with specific features necessary for railways. The GSM-R network replaces train-to-ground radio, tunnel radio, shunting radio and maintenance radio, i.e. it is a single solution fulfilling all railway voice communication needs. GSM-R is a network dedicated entirely to railways. This means that it is independent from other networks (e.g. commercial GSM networks) and it is not shared with entities other than railways (e.g. police or other public services).Also, GSM-R does not provide any services directly to the passengers, so their GSM terminals do not detect or connect to the GSM-R network..

2. Railways' choice of GSM-R

The work that eventually led to the development of GSM-R started in the late 1980s.At that time, concepts of a new communication-based signaling system started to emerge. These concepts later turned into ETCS. However, already in the 1980s, it was foreseeable that future railways would need new mobile communication systems. Therefore, UIC initiated a discussion on reserving some of the GSM radio spectrum for the future railway use [2].Railways wanted to adopt a well-proven technology and use it for their purposes with a minimum of modifications [2]. Two technologies were the strongest candidates: GSM and Terrestrial Trunked Radio (TETRA). GSM is a technology designed for commercial mobile telephony networks. TETRA is a network for public services, e.g. police, fire brigades; governmental institutions etc. Both technologies had their advantages and disadvantages. GSM had large support from the telecommunication industry and a large base of suppliers. On the other hand, TETRA could provide bigger coverage and offered various features, which were useful for railways, e.g. group calls and direct mode operation (without infrastructure). However, in 1990, TETRA was still in the standardization process. Therefore, GSM was chosen. The most important argument was that GSM had been an already proven technology with many products available on the market [3].

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3. Literature Survey

3.1 CorneliuMihail ALEXANDRESCU, Lăcrămioara-Mihaela NEMȚOI (2011)

They described the GSM-R radio planning parameters for Bucuresti –Constanţa railway corridor (225 km) according the ETSI-GSM-R standard and compliant with the requirement of mandatory demands specified by the International Union of railway (UIC).They designed everything in detail about every parameters of GSM-R radio communication. They setup minimum and maximum value of the parameters used in their design (i.e. coverage threshold =-95dB, S/I>14dB, S/IA>- 6dB). The handover and network coverage status are described with graphical simulation software. The clutter signal propagation loss was modeled by Fresnel"s ellipsoid formula for different type of terrain structure in the route deployed with GSM-R network [4].

3.2 Jørgen & Binningsbo (2006)

These people had studied about the guide lines of GSM-R network planning for Norwegian National Rail Administration. They set all the needed parameters to GSM-R radio network

Communications i.e. C/Ic>14dB and C/IA>-6dB, -95dB signal sensitivity. Procedures, steps and other required materials to radio planning had been elaborated and specified. Cell sectorisation, antenna tilting and polarization, BTS site selection, handover mechanism, quality and coverage calculation, capacity analysis, link budget and propagation loss, frequency allocation, fading margin analysis, minimum RxQual setting and other parameters had been carried out in this paper [5].

3.3 Valentin I. Popov, Andrei J. Baranovskii (2010)

This group of people had examined the basic principles of GSM-R network planning. This paper described the method of frequency channel distribution and frequency channel reuse techniques. The procedure of an operational planning is proposed. The principles of even radio coverage are considered for cells with mainly free radio propagation and for urban areas. Link budget was calculated encompassing all of the technical factors associated with the uplink and downlink transceiver to determine the maximum permissible air interface path loss [6].

3.4. Jan MagneTjensvold (2007)

Even though my work is on GSM-R radio network, it is interrelated with domestic GSM network and it is advisable to take some important points about the nature of the overall structure. It provided an estimate cost of the required infrastructure in these two cities. The designer set the minimum required signal to noise ratio of 14dB for the GSM network of the design. He also stated the bandwidth of the channel to 200 kHz and he used time division multiple access (TDMA) media access system. He assumes 1% GoS of the service quality. Signal to noise ratio (SNR) had calculated for both Omni-directional and sectored antennas of the system and he got 27.55dB and 17.62dB respectively which satisfied to the minimum requirement. He calculated traffic capacity of each city, number of cells, cell size etc. [7].

4. Development of GSM-R

The development of GSM-R in this paper is divided into three parts. First we look at the adoption of an existing standard (GSM) and its extension and transfer in railway sector. Second, we look at the issue of maintaining the GSM-R standard. And third is GSM-R toward LTE. We are particularly interested in analyzing the internal between the key ERA, UIC and ETSI i.e. stakeholders in establishing the locus for standard maintenance and ensuring harmonization of future developments. In third part the efficiency of transferring the GSM standard to the railway sector.

4.1 Adoption and improvement of the GSM standard to the railway sector

In the beginning of 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. Only in Europe alone, there were more than 35 different platforms, and German Rail (DB) alone has eight different analogue systems3. The precedent international standard – developed for analogue train radio systems in the 1970’s and operating in the range 450-470 MHz band – provided only limited compatibility and the absence of standard mobile equipment limited trains to work across national borders. Maintaining and updating these dissimilar systems was becoming increasingly difficult and more price and analogue systems were not suitable with many of the modern communications systems. The European Community focus on an development an open mobile communication system in the railway sector European Directive on High Speed Train Interoperability and by other upcoming European Directives for railways considered standardization a key to achieving a European single rail market.

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

The UIC set up two project in 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 (ETSI4) 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 to facilitate the standardization of the GSM-R railway radio communication system. The Mobile Radio for Railway Networks in Europe project 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. These projects develop the GSM-R system in accordance with the EIRENE specifications and perform validation on the three trial sites6. In 1997, 32 European railways signed the EIRENE memorandum of understanding to build a European GSM-R telecommunications network.

The standardization process:

As discussed 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. Goal of the ETSI in standardization of GSM-R were threefold: fulfilling railway requirements, no deviation from GSM standard and as close as possible to the public GSM. In between the development of the standards, a series of test lines was constructed so that the interoperability of equipment from different seller be tested and verified. ETSI's standard activities for GSM-R centre on applications of GSM for railway telecommunications including numbering and addressing, configuration aspects, system aspects and functional aspects and any additional services found by the railway. In railway does not include specification of the GSM technology itself (which are standardized by CENELEC).

4.2 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 source 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, for example 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.
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. In parallel to this railway 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.

4.3 Spectrum challenges

The biggest challenge on GSM-R is spectrum availability, and this is a main issue that the railway (industry) as a whole needs to address. The 900 MHz spectrum in Europe is a conspicuous candidate for LTE data transmission under the extended GSM-R band which exists today. There is bandwidth available in the range 2·6 GHz, but LTE gives excellent transmission speeds but over shorter distances. The LTE can provide good performance, although increased range is offset by lower transmission speeds. As in case for GSM, the rail industry must take a strong stance and relevant licensing authorities for the spectrum it needs. But regardless of its many other benefits, ultimately LTE will stand or fall based on how it handles train control functions. In other words, we have to make sure we get signaling over LTE absolutely right. The currently being modified is ETCS level. And run over General Packet Radio Services is tested, a sort of ‘2·5G’mobile communication technology which is being introduced in busy hubs, where GSM-R is to provide enough capacity. ETCS, currently use sold-fashioned but reliable circuit for operating. However, to run on GPRS, ETCS must use packet switching at that time is Internet Protocol. Once ETCS is successfully tested on GPRS, it will by default be ready for LTE, which is base on IP base technology. Once we have an IP version of ERTMS compatible with LTE, the rail industry can accelerate its journey to4G telecoms.

5. Conclusions

In this paper, GSM-R communication system towards a new railway train radio system has been assessed. LTE is considered to be the natural evolution for GSM-R. We analyzed the top challenges of LTE to become the new railway train radio system. The pace of adoption of the two systems is quite different with more than 60’000 kilometers of GSM-R build. 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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