The evolution of rail communication

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Introduction

Over the recent years the public transport sector has undergone significant transformations. Global dynamics demand highest performance, flexibility and reliability from the transport sector. With ever increasing road congestion, capacity shortages in the aviation and a global drive to a greener transport with a reduced carbon footprint rail transport for passenger and cargo benefits from more visibility from many sectors in the market. Today we see railways operating in a competitive environment with trains seamlessly operating across multiple countries.

Following the railway telecom market since the late nineties I wanted to share with you in this article my vision about where modern railways telecom demands will lead us to and how this all fits into today's technology. Your feedback and comments are welcome.

The birth of digital rail telecommunication

Modern railways undergo a constant transformation process providing yet higher speeds, more efficiency and quicker services to their customers.

The ever increasing capacity demand, limited capacity of the existing rail infrastructure and prohibitively high costs of rail infrastructure capacity expansion translates to a complex set of economic and operational challenges.

GSM-R a wireless telecommunication system that has been specified by rail operators for their rail operational voice and data demands certainly has been one of the cornerstones for this transformation allowing railways to yet increase further efficiency of their existing rail operational infrastructure.

When in the nineties railways decided about which technology to best use as a basis for a globally acceptable rail telecom solution GSM was selected thanks to its strong market presence and superior maturity of technology compared to their candidates.

In the same time, in addition to the new wireless communication systems, due to the large number of video, data services, long distance, high-capacity and high reliable transmission system is also widely used. A variety of digital devices to provide information for passengers also appeared continuously. You need new IT infrastructure to provide faster, safer and more comfortable service for passengers.

The quite evolution of GSM-R

Having been personally involved in creating the GSM-R standard as member of the MORANE group in 2000 it seems surprising so little functional evolution has been put into the GSM-R standards since then.

Of course a stable base line is key for cross-border interworking and will always be pre-condition to any evolution applied but one should consider that cross-border interworking and evolution are evenly important to railways.

It is therefore understandable that from a functional point of view of course railways are very carefully amending the GSM-R standard. However, hidden to the technophobe's eye GSM-R already underwent many technology changes allowing railway operators benefitting from efficiency improvements introduced to the large GSM, UMTS and potentially LTE market.

A typical example of such a technology evolution is the introduction of a modern IP based Release 4 core network. Initially GSM-R networks were rolled in the traditionally TDM based design with a core network based on ETSI Release 99 architecture. In the early 2000th this was an acceptable design implemented by many GSM operators globally.

But soon in the public GSM/UMTS market the IP evolution took place and traditional TDM based architectures were considered as inefficient with regards to OPEX, geographic redundancy and complexity to managing underlying subsystems such as transmission networks.

With growing maturity of the IP based technology GSM-R suppliers introduced these IP benefits also to GSM-R operators which greatly appreciate the slim and energy efficient design and most importantly the introduction of geographic redundancy that suddenly allowed national GSM-R networks to maintain operation even in case one core network location is lost due to i.e. an earthquake.

The above is a good example of how GSM-R technology undergoes a quite "internal" evolution maintaining identical rail operation functionality towards the GSM-R users while at the same time improves efficiency through new features.

A further example on how GSM-R operators directly benefited from the "quite" GSM-R evolution is the concept of the Distributed BTS as single Radio Access Network. Today's mobile network operators run multiple wireless networks. Many of them started with GSM technology then added

UMTS services to their network and today operate GSM, UMTS and LTE services. The most efficient way of running a 2G, 3G and 4G networks in parallel is allowing synergies to take place by using the same underlying hardware. The very same concept has been introduced to the GSM-R operators some years ago and today opens the doors to become a Smart Railway which will be described in more detail in the following section.

The introduction of the IP core and the use of Distributed BTS are two superb examples validate the decision taken by the railway stakeholders to go for GSM based architecture. This decision today allows railways globally to benefit through a "quite" evolution from the vast investment in the GSM/UMTS/LTE market.

The Evolution of Rail telecom, the enabler of a "Smart Railway"

Innovation in the rail telecom sector is the one factor that will help railways to not only answer demands from today's competitive rail transport sector but can also be a facilitator for new evolution scenarios options such as LTE for Rail.

When we talk about Smart Rail it is of upmost importance to ensure that this means all aspects of an ICT solution have to be brought together - GSM-R is being one of them. Key is that a truly integrated ecosystem for rail requires having a manufacturer aside that can bring these system islands into one Smart Rail solution with local staff right at their doorstep.

Smart Railway means, that the rail operator is put into a position to have full visibility of all aspects that have impact to its rail operation, can process them and is in a position to efficiently react through anticipatory means. This means that information needs to be collected from a multitude of different sources such as balises, CCTV, seat reservation systems, train time scheduling, ground based and on-board staff just to name a few. Then this information have to be transmitted, processed and converted into reactive measures updating time schedules and Passenger Information systems and maintenance systems accordingly. In this regard a railway operation can be compared to a human organism that has a very complex sensing network, processing and a vast set of reactive measures to respond to these triggers. As more of these sensors are connected to a control centre, as better rail operation can be adapted to its present demands. In telecommunication terminology we are talking about a complex ICT solution that turns railways into Smart Railways.

But what about the passengers?

Turning a railway into a Smart Railway through intelligent implementation of ICT solutions is certainly helping railways to further improve efficiency of their day to day operation.

Today's High speed train links are competitive as they provide direct links into city centres offering superior comfort to continue work while travelling. Standardisation efforts in numerous fields of the High Speed Rail sector contributed to this success. However, one aspect has been left aside when defining high speed rail transport services. Public telecommunication services offered to passengers on board of such trains are considered as one of the weaknesses in today's rail transport sector.

Providing broadband data inside the train does not only have benefits to the rail passenger but also answers some demands to improve security through video surveillance but also customer satisfaction through on board information systems that provide real time travel information.

GSM-R allows railways to answer such demands to some extend but when it comes to passenger communication and broadband data services other technologies such as LTE are more efficient.

A further benefit of LTE is that it has been developed with broadband data and mobility in mind. Flexible channel bandwidths operating in channels of between 1.4 MHz and 30 MHz allow flexible allocation of throuput profiles for individual on board services. A superior channel bandwidth is key for delivery of higher access speeds.

Thanks to the generic concept of LTE being considered as the "Long Term Evolution" of wireless networks significant synergies between GSM-R and LTE networks are applicable. Solutions such as the singleRAN BTS is one example of how easily a rail operator can "upgrade" their existing GSM-R network to also providing LTE coverage for broadband data on board the train. Such as provide Wifi for passengers and provide communication channels for carriers' telecom network in High-speed Railway.

Beyond these, you can provide online or telephone ticket booking; you can provide dynamic PIS (Passenger Information System), PA (Public Address), Clock system, etc. to provide End to End real-time information services for your passengers.

The evolution of GSM-R

With the easy upgrade path from GSM-R to LTE one can not only consider using LTE services for mobile broadband application on board (i.e.

passenger, video surveillance) but also using LTE as a bearer for rail operational voice and data services. From a technology and economical standpoint there are many arguments that speak for such a migration considering the benefits that would come along with introducing LTE into the train. The public wireless telecom market is currently undergoing exactly such kind of a migration by maintaining multiple wireless networks and shifting voice/data subscribers based on the service usage profile across the different networks. Railways could consider a similar approach and with the technology available today the migration is mainly a question on how today's GSM-R functionalities are to be provided through LTE.