Future Communication Scenarios for Next-generation Railways: a technical and economic analysis by the MISTRAL project

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The MISTRAL Project http://www.mistral-s2r-project.eu
MISTRAL approach

IP- based communication solutions offer significant improvements that could solve the limitations of the GSM-R. These future broadband communications will have sufficient capacity to enhance the operation, maintenance and safety. They will enable novel system for surveillance, passenger information, up-to-date travel information, access to online resources and much more. MISTRAL will investigate on all these aspects.

- **Technical viability**
  - MISTRAL will select and analyse potential communications candidates for train-to-wayside communications to verify their technical viability.

- **Economic viability**
  - MISTRAL will carry out business viability analysis to determine and optimize the total-cost-of-ownership of the new communication system.

- **Final proposition**
  - The results of the technical and business viability analysis will be used to elaborate a complete techno-economic proposition with optimized life-cycle cost and including innovative services for railways and passengers.
Technological candidates

4G LTE (Long Term Evolution) could be one candidate for the next generation of railway communication that would be able to support new services, as well as vital applications. LTE has become especially attractive for the railway industrial sectors since 3GPP – the standardization body responsible for LTE standardization – have determined to focus the development of the forthcoming Release 14 of their standards on mission critical functionalities, which are especially suitable for meeting the railway applications requirements.

The first set of standards 5G will be delivered by 3GPP with their Release 15. It is often assumed that 5G is an extension of the existing mobile radio standards. However, 5G is a fundamentally new technology that introduces new approaches to network architecture and will generate a new market. The core architecture of 5G is a native SDN/ NFV architecture covering aspects ranging from devices, (mobile / fixed) infrastructure, network functions and value enabling capabilities and support new multiple use cases and business models for various sectors.
VOIP vs VoLTE

IMS and SIP are important technologies for deployment of VoIP in an 4G LTE (and beyond) environment but it is ultimately the introduction of new RAN features that creates the differentiation between VoLTE and VoIP, specifically:

- prioritization of VoLTE audio packets (over all other best-effort traffic) with Dedicated Bearers
- to transport the audio traffic flexible scheduling reduces the complexity and overhead of the continuous allocation of downlink and uplink physical layer resource blocks
- Robust Header Compression
- SRVCC (Single Radio Voice Call Continuity) functionality provides the mechanisms to maintain an active voice call between different network technologies.
Future economic trends: ‘network as an asset’ to ‘network as a service’

Currently, railway enterprises own, operate and manage their GSM-R network infrastructures. This management model, usually referred to as “network as an asset” (NaaA), forces railway enterprises to cover in full the increasing GSM-R maintenance costs.

New wireless communications technologies could represent an opportunity for railway enterprises to outsource the communication network and gain economic benefits, switching from a NaaA approach to a “network as a service” (NaaS) management model.
The innovative services enabled by a new technology

**Services for passengers**

<table>
<thead>
<tr>
<th>Service</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-time video surveillance</td>
<td>high</td>
</tr>
<tr>
<td>Electronic ticketing</td>
<td>medium</td>
</tr>
<tr>
<td>Non-stop on-board entertainment</td>
<td>medium</td>
</tr>
<tr>
<td>Context aware marketing and services</td>
<td>medium</td>
</tr>
</tbody>
</table>

**Services for Railways**

<table>
<thead>
<tr>
<th>Service</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving block</td>
<td>low</td>
</tr>
<tr>
<td>Grade of Automation</td>
<td>medium</td>
</tr>
<tr>
<td>Improved Railway Emergency Call</td>
<td>low</td>
</tr>
<tr>
<td>Internet of Things maintenance</td>
<td>low</td>
</tr>
<tr>
<td>Monitoring of infrastructures</td>
<td>low</td>
</tr>
</tbody>
</table>
1. **NaaS scenario**: A railway-dedicated network, owned and managed by an IM. In this scenario, the technology is upgraded from the current GSM-R to a new broadband packet-based technology that can satisfy operative and QoS requirements of the railways communications. It is still NaaS scenario.

2. **An “incremental’ innovation**: A railway-dedicated network, owned and managed by a MNO. As in the previous case, a new technology is used to build the railway communication infrastructure using purpose-specific hardware, but, in this scenario, the MNO is in charge of building and managing the physical infrastructure.

3. **A ‘radical’ innovation**: A physical-shared network owned and managed by a MNO. This scenario requires a drastic change in the understanding of the network infrastructure since it is based on novel 5G networking concepts (e.g., network slicing) previously introduced. The network is built on shared generic hardware and several virtual networks can be created.
1. **Innovative services** are the most relevant part for economic analysis of business opportunity for IM and/or MNO. The main focus of the list should be to catch the added value coming from the deployment of new services with the comparison between NaaS and NaaS.

2. **Business cases**: Business models and Business cases will be analysed basing on the identified scenarios and determining the infrastructure and transversal variables belonging to them.

3. **Virtual Route Methodology**: This tool will be developed to analyse multiple scenarios and variables:
   - A realization of a theoretical (virtual) ‘route’ with a representative topological business cases.
   - Building a theoretical quali-quantitative (techno-economic) model both for NaaS and NaaS scenarios.
   - Models of prediction (e.g. Bass Model for innovators, new adopters and imitators) for number of users, pricing scheme, cost and revenue streams.
Thank you for your attention

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