GSM-R
• Introduction to GSM-R
• Railway Applications
• Network Features & Functions
• Vendor’s Solution
GSM-R specificity

- Private networks dedicated to Railway operators
- High speed trains communications: up to 500 km/h
- Cab radio: train mounted terminals
- New features supported to meet Railway operators needs
- Separate frequency band
Issues with the current architecture

- Multiple communication systems needed for different applications
- Different frequencies utilized
- Multiple country standards

• High Training, Operation & Maintenance costs
• Low spectrum efficiency, increases costs
• Limited support for cross-border traffic

Lower cost solutions required
Requirements developed for a new common communication standard for the railways

GSM selected as preferred standard

In charge of development & testing of a GSM-R system based on EIRENE’s defined specifications

GSM-R Definition

GSM-R, Ready for deployment
GSM-R frequencies

20 GSM channels available for GSM-R frequencies

Uplink

Downlink

GSM-R Terminals
GSM-R Advantages

- Lower infrastructure costs
- Interoperability with international networks
- Benefits from global GSM R&D program and economies of scale

- Simplified maintenance

- High Reliability
- Improved responsiveness

- Reduced licence fees

- Reduced training costs
- Improved operational efficiency

- Improved passengers satisfaction
- New revenue generation source

EIRENE’s business case identified GSM-R as the most appropriate technology
**Track to train communications**

**Controller - Driver Communications**: provide communications between the controller(s) and driver to control and enhance the safety of train movements.

**Automatic Train Control** is the process by which the movement of a train is influenced without any action by the driver.

- Sending of **Position Information** Messages from the Train to the TCC
- Sending of **Movement Authority** Messages from Train Control Center to Train

**Remote Control** supports bidirectional data flow between fixed center and the train.

- Air conditioning
- Brake testing equipment
- Fixed installations such as points or level crossing barriers
Emergency Area Broadcast

Emergency Area Broadcast is required to alert other railway staff in a specific area of an emergency situation.

The feature supports:

- Fast Call Setup
- Area definition
- Single emergency key stroke: Red button
- Origination from controllers or other wireline subscribers, train driver, shunting, trackside worker or any other type of user at risk
Shunting and Trackside Maintenance

Communications between:
- shunting leader
- shunting driver
- other shunting team members
- signal man (fixed network)
- shunting manager (fixed network)
- train controller (fixed network)

Voice group calls between workers at a site
Wide area communication: workers at a site, distant workers or fixed network positions (controllers, stations, technical department,..)
Supports automatic track warning systems
And other services ...
Covered Areas

Railways

Train Stations

Tunnels

Railroad Depots
- Introduction to GSM-R
- Railway Applications
- **Network Features & Functions**
- Nortel’s Solution
Network features and functions

Railway Applications
- Controller-Driver Operational Communications
- Automatic Train Control
- Remote Control
- Emergency Area Broadcast
- Train Support Communications
- Local Communications at Station and Depots
- Wide Area Communications
- Passenger Services

Railway Operation Aspects
- Functional Addressing
- Presentation of Functional Numbers
- Access Matrix
- Location Dependent Addressing

Telecommunication Services - ASCI
- eMLPP
- VBS
- VGCS

GSM Infrastructure
## GSM-R specific functions & features

### Railway Operation Aspects

<table>
<thead>
<tr>
<th>Functional Addressing</th>
<th>Allows a user or an application to be reached by means of a number which identifies the relevant function and not the physical terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation of Functional Numbers</td>
<td>Presents visual information about the call destination and origination via user to user signalling</td>
</tr>
<tr>
<td>Access Matrix</td>
<td>Provides access control within/among groups of users</td>
</tr>
<tr>
<td>Location Dependent Addressing</td>
<td>Provides the routing of mobile originated calls to the correct controller</td>
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### Telecommunication Services - Advanced speech call items (ASCI)

<table>
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<tr>
<th>eMLPP</th>
<th>enhanced Multi-Level Precedence and Preemption allowing resource preemption for priority calls</th>
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<tr>
<td>VBS</td>
<td>Voice Broadcast Services allowing groups of users to receive common information</td>
</tr>
<tr>
<td>VGCS</td>
<td>Voice Group Call Service allowing groups of users to make calls within/among the groups</td>
</tr>
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</table>

### Dedicated functions requiring reliability, speed and flexibility
**Enhanced Multi-Level Precedence and Pre-emption Service**

**eMLPP service** prevents network congestion while ensuring prioritized connection for emergency situations and specific users.

The eMLPP service consists of 2 parts:

- **Precedence** - assigns a priority level for call setup and call continuity in case of handover.

- **Pre-emption** - in the absence of idle resources, a call of higher level precedence can seize the resources being used for a call of lower precedence.

**eMLPP service applies to:**
- Point-to-point calls
- Voice Broadcast Service
- Voice Group Call Service
Voice Broadcast Service allows the distribution of speech originated by:

- a service subscriber
- a dispatcher

to all or a group of service subscribers located in a pre-defined geographical area

A standard full duplex channel is provided to the originator of VBS

A Simplex channel is provided to the receiving subscribers

One common simplex downlink per cell of the VBS Group Call Area is allocated for frequency efficiency
Voice Group Call Service

Voice Group Call Service allows a group of service subscribers in a pre-defined service area to have a speech conversation.

Voice Group Call Service includes all the functionalities in Voice Broadcast Service.

In addition, the originator can pass the full duplex channel to another subscriber.

Dispatchers involved in the group calls can talk at any moment, while service subscribers have to signal when they wish to talk.
Functional Addressing allows a user or an application to be reached by means of a number which identifies the relevant function and not the physical terminal.

The GSM features involved are:

- **USSD** for Registration, deregistration and interrogation of functional numbers
- **“Follow Me”** for call setup

Functional HLR manages the mapping of Functional Number to MSISDN.

Functional numbers presentation using the end-to-end supplementary service UUS1 (user-to-user signaling).
Location Dependent Addressing allows the routing of mobile originated calls to the correct controller by evaluating the mobile subscribers actual location at the time.

Location Dependent Addressing will initially be based on the Cell Specific Routing procedures - Short code triggered Mobile originated calls are routed based on Cell Of Origin, as defined by EIRENE and MORANE.

More accurate positioning of the train can be achieved by:
- External positional device
- IN based Location Dependent Addressing
**Access Matrix**

<table>
<thead>
<tr>
<th></th>
<th>Train Controller</th>
<th>Leading Driver</th>
<th>Other Drivers</th>
<th>Operations Support</th>
<th>Train Prep &amp; Supervision Systems</th>
<th>Customer Support Systems</th>
<th>Ticketing</th>
</tr>
</thead>
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<tr>
<td>Train Controller</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leading Driver</td>
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<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Drivers</td>
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<td>X</td>
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- Each GSM-R functional call is screened to determine if a connection between the originator's function and the terminator's function is allowed according to the defined Access Matrix.
- For each originating function, the Access Matrix defines the terminating functions which allow connection.
- The originator Class Of Registration is stored in the HLRm function.
- The terminator's Class of Registration (and function) is derived from the Railway Subscriber Number dialed digits.
• Nortel Overview
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• Vendor’s Solution
Infrastructure of the network

- OSS
- OMC-S
- OMC-R
- LAN
- Data Network
- Other EIRENE system
- ATC Centers
- Dispatcher centers
- ServiceBuilder IN
- SCP
- SCE
- VMS
- EIR
- SMS
- VLR
- GCR
- AUC
- HLR
- MSC
- BSC
- BTS
- PSTN/PLMN/Data Network/ISDN
- General purpose Radio
- Operational Radio
- CAB RADIO
- PABX
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- PABX
**BSS impact**

- **RBS to be adapted to support**
  - GSM-R frequencies
  - ASCI feature

- **BSC to be adapted to support ASCI features**:
  - Group call management
  - New channels management
High Speed impacts

High Speed affects signal quality

Vendor’s antidistortion algorithm enhances received signal quality

RxQual follows signal strength

500 km/h

RXQUAL

BER

Legend
- 1 Antenna
- corr. = 1 (sep=01wl)
- corr. = .9 (sep=3wl)
- corr. = .6 (sep=1wl)
- corr. = .2 (sep=9wl)
- corr. = .2 (sep=20wl)

Poor & saturated RxQual

Eb/N0

High Speed affects signal quality

Vendor’s antidistortion algorithm enhances received signal quality
Handling of fast mobility within GSM-R networks:
Early Hand-Over Decision Algorithm
**NSS impact**

- Group call management
- Maximum priority per subscriber (HLR)
- New element: Group Call Register (GCR)
  - Contains information on group calls: group ID, a list of dispatchers, Group Call Area (GCA), priority associated to a broadcast call, etc.

**IN based solution to support**

- Functional Adressing
- Location Dependant Adressing
- Access Matrix
- Other IN services: VPN, Welcome to this Area, Location Inquiry (for location dependent information alert)
GSM-R Terminals

Cab Radio

- Track-to-Train radio, ATC, Data
- Redundant ATC access (2 ETCS Interfaces)
- Support of 2 cabs (driver positions)
- Driver can use Handheld when leaving cab

Handsets

- General purpose radio
- Operational Radio
- Shunting

Trackside terminals

Using GALA terminals as trackside emergency phones

Integration of Railway specific features
Can use the public GSM network as a fall-back
**Cab Radio System (Planned)**

- Track-to-Train radio, ATC, Data Communication (Remote Train Diag.)
- Redundant ATC access (2 ETCS Interfaces)
- Support of 2 cabs (driver positions) for driver MMI
- MMI based on MORANE/EIRENE guidelines
- Driver can use Handheld (HH) when leaving cab for train inspection
- Compatibility with existing equipment (On-Board cabling,..)
<table>
<thead>
<tr>
<th>MSC Capacity</th>
<th>BSC Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Processing and management of group calls</td>
<td>3 Group call management</td>
</tr>
<tr>
<td>3 Priority level management</td>
<td>3 Load depends on Group Call Area size</td>
</tr>
<tr>
<td>3 High percentage of IN calls</td>
<td></td>
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</tbody>
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<tr>
<th>New Call Profile</th>
<th>Air Interface</th>
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<tbody>
<tr>
<td>3 Long Group calls (shunting) and ATC</td>
<td>3 Group calls : 1 TCH per cell per call</td>
</tr>
<tr>
<td>3 High percentage of data and IN calls</td>
<td>3 NCH : impact on AGCH and PCH capability</td>
</tr>
<tr>
<td>3 Mobility</td>
<td>3 Data calls</td>
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<td>3 Group Calls</td>
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</table>
Future markets in Europe

- Germany: 30,000 km
- France: 13,000 km
- Spain: 5,000 km
- Italy: 2,000 km
- Austria: 2,000 km
- Sweden: 7,000 km
- Benelux: 3,000 km
- Switzerland: 1,000 km
## Mapping of applications to functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Service/Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train Controller calling train driver</td>
<td>Functional addressing, eMLPP</td>
</tr>
<tr>
<td>Controller informing group of train or users in its area</td>
<td>Functional addressing, eMLPP Voice Broadcast service</td>
</tr>
<tr>
<td>Train driver calling train controller</td>
<td>Location dependent addressing eMLPP</td>
</tr>
<tr>
<td>Driver communicating with other on-train drivers</td>
<td>Multi-party call, eMLPP on-board wired system</td>
</tr>
<tr>
<td>Preparation of shunting</td>
<td>Voice Group Call Service, eMLPP (low priority)</td>
</tr>
<tr>
<td>Conducting shunting movement</td>
<td>Voice Group Call Service, eMLPP (high priority) link assurance signal</td>
</tr>
<tr>
<td>Emergency call (general, shunting,..)</td>
<td>eMLPP with fast call setup, Voice Group Call Service</td>
</tr>
<tr>
<td>High priority call; no resources available in BSS</td>
<td>eMLPP- Resource pre-emption</td>
</tr>
</tbody>
</table>