(Algumas) Comunicações Móveis Ferroviárias

Diogo Cortez
1 de Junho, 2017
25as Palestras sobre Comunicações Móveis
Agenda

- Introduction – Thales Portugal in brief
- Mobile Communications – Metro/Rail needs
- Radio Communications – Thales Portugal Projects
  - GSM-R
  - BBRS
- And what about the Future?
Thales (in Portugal)

What and who is Thales Portugal?
- 20 years leading the Portuguese Railway market;
- Presence in 21 countries;
- 25 Years experienced and skilled team;
- Understanding the Transportation “world”;
- Full integration and efficient coordination between Signaling and Telecommunications;
- Delivers complex multivendor solutions;
- Linking technique with operational results;
Metro&Rail Communications

Metro&Rail - The need for Telecommunications solutions:

- Operation Solutions.
- Security and Safety Solutions.
- Passenger Comfort Solutions.
Metro&Rail Communications

Metro&Rail - The need for Telecommunications solutions - Passenger Comfort Solutions
## Thales Portugal – Our running projects

| Backbone   | DTS | SDH | RADIO | BBRS/WiFi | TEL | VRS | APIS/PIDS | PAS | MCK | CCTV | ACIDS | FRS | POWER |
|------------|-----|-----|-------|-----------|-----|-----|-----------|-----|-----|------|-------|-----|------|-------|
| GBT        |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| TRIS       |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| E65-APIS   |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| E65-CCTV   |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| ONCF       |     |     | X     |           |     |     |           |     |     |      |       |     |      |       |
| ROCADE     | X   | X   | X     |           |     |     |           |     |     |      |       |     |      |       |
| WCRP       |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| HMNP       |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| BMRC       | X   | X   | X     |           |     |     |           |     |     |      |       |     |      |       |
| BS15       |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| JS15       |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| CS315      |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| MMOPL      | X   | X   | X     | X         | X   |     | X         | X   |     |      |       |     |      |       |
| Danshui    |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| NSR        | X   | X   | X     | X         | X   |     | x         |     |     |      |       |     |      |       |
| DOHA       | X   | X   |       |           |     |     |           |     |     |      |       |     |      |       |
| LUSAIL     |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| EDMONTON   |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| WVU        |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| PANAMA-L1  |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| PANAMA-L2  |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| VLT SANTOS | X   | X   |       |           |     |     |           |     |     |      |       |     |      |       |
| SPL17      | X   | X   |       |           |     |     |           |     |     |      |       |     |      |       |
| SMNW       |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
| ROC        |     |     |       |           |     |     |           |     |     |      |       |     |      |       |
|            | 36% | 36% | 20%   | 24%       | 20% | 40% | 36%       | 84% | 88% | 44%  | 36%  | 20% | 8%   | 12%   |
Metro & Rail - GSM-R, TETRA & BBRS

GSM-R – in brief:

- GSM-R (GSM-Railway) is an international wireless communications standard for railway communications.
- The system is based on GSM and EIRENE – MORANE (Mobile Radio for Railways Networks in Europe) specifications, which guarantee performance at speeds up to 500 kmph, without any communication loss.
- It is used (mainly in Europe) to allow the communication between the train and Control Centre, for train shunting, and for communications between the train (and the train driver) and other Rail staff and devices.
- GSM-R is a secure platform for voice and data communication.
- It permits specific Rail communications modes, such as:
  - Group calls.
  - Broadcast calls.
  - Emergency calls (call pre-emption).
- GSM-R uses a specific frequency band. In Europe, the "standard" GSM-R band is:
  - Uplink: 873–880 MHz.
  - Downlink: 918–925 MHz.
Metro & Rail - GSM-R, TETRA & BBRS

TETRA (TErrestrial Trunked RAdio): Train-to-Ground radio (400 MHz band) – in brief:

- Initially was mainly used for Voice Communications between the Train Driver and the OCC Controllers and/or for Shunting functions.
- With the development of data communication dedicated to remote control and maintenance of vehicles, TETRA was also used for data transmission.
- Main advantages:
  - The frequency band used gives longer range, which in turn permits very high levels of geographic coverage with a smaller number of transmitters.
  - During a voice call, the communications are not interrupted when moving to another network site: This is a unique feature, which dPMR networks typically provide, that allows a number of fall-back modes such as the ability for a base station to process local calls.
  - ’Mission critical’ networks can be built with TETRA where all aspects are fail-safe and multiple-redundant.
  - In the absence of a network, mobile/portables devices can use ‘direct mode’ whereby they share channels directly (walkie-talkie mode).
  - Gateway mode - where a single mobile with connection to the network can act as a relay for other nearby mobiles that are out of range of the infrastructure.
  - TETRA also provides a point-to-point function that traditional analogue emergency services radio systems did not provide. This enables users to have a one-to-one trunked ‘radio’ link between sets without the need for the direct involvement of a control room operator/dispatcher.
  - Unlike cellular technologies, which connect one subscriber to one other subscriber (one-to-one), TETRA is built to do one-to-one, one-to-many and many-to-many. These operational modes are directly relevant to Mobile Rail Communications.
- Some limitations:
  - Very limited bandwidth (up to 7.2 kbps per timeslot, in the case of point-to-point connections).
  - UHF spectrum is now overloaded and the trend is to go in the upper frequency band in order to increase the number of available communication channels.
BBRS (Broad Band Radio System) – in brief:

- Allow high bitrate data transmission between the Rolling Stock and the Way-side (Stations, Depot, OCC/BCC).
- This serves the need of systems asking for real time information, like:
  - CCTV – video transmission (Train ↔ OCC),
  - Public Address,
  - Passenger Information,
  - Help Points,
  - Train Management Systems,
  - Train Maintenance Systems,
  - High bitrate data access for Passengers.
- The way-side radio equipment (APs) permits radio coverage along the track.
- The on-board equipment establishes permanent connections to the OCC.
- WiFi technology (802.11n 2x2) is used.
- Handover setup is based on RSSI, bandwidth, packet loss, etc.
KSA NSR: The North South Railway (NSR) Project – GSM-R Solution - Main requirements:

- Total track Chainage: 2,400 km.
- Telecommunication Works Comprising Design, Procurement, Installation Testing and Commissioning of all elements related to the signalling and telecommunication systems for the Saudi railway (SAR) project in the KSA.
- GSM-R radio: fully compliant to all of the requirements classified as Mandatory in the EIRENE Function Requirements Specification and System Requirements Specifications.
- GSM-R radio solution: shall support European Train Control System Level 2 communications as laid down in the EIRENE specifications.
- Coverage levels shall be designed for train mobiles.
- The radio system shall be capable of handling all train traffic that is predicted. This includes:
  - All voice communications between train drivers and the Operation Control Centre;
  - All voice communications between staff with hand-portable radios;
  - All data communications (circuit switched) between the train data radio and the radio block controller (RBC) for ETCS Level 2.
- The passenger lines may be upgraded in the future so that speeds up to 250 kmph are achievable. The radio system shall be able to operate fully at this speed.
- As per EIRENE SRS 16 (clause 3.2.3) - Coverage probability of 95% based on a coverage level between -95 dBm and -92 dBm on lines with ETCS levels 2/3 for speeds above 220km/h and lower than or equal to 280km/h.
GSM-R – KSA NSR

Engineering Design

- Conceptual & Detailed Design
  - 175 BTS.
  - UIC Band:
    - 876 – 880 MHz uplink
    - 921 – 925 MHz downlink
  - Average distance between BTSs:
    - @ Dunes 7-8 km;
    - @ Flat areas 13 km;
    - No urban zones.
- Survey, Radio Planning & Coverage design (Atoll)
- Interface Design.
- Installation Design.

Installation & T&C

- Static Tests.
- Dynamic Tests.
Main difficulties

- GSM-R frequency sharing with another existing Rail Operator in the Kingdom.
- Local geography: Sand dunes, large plain and dry areas:
  - Dunes are zones with high relief, creating many obstacles (and sometimes moving obstacles).
  - Large plain and very dry areas, creating the conditions for signal propagation to long distances increasing the possibility of interferences.
- Distances: even with site camps along the Railway line, long distances to the sites for Set-up and Testing.
- Very harsh climatic conditions (for people and equipment).
Main Requirements

GSM-R – ONCF - High Speed Line & Conventional Main Lines

Main Requirements

- Comply with EIRENE Interoperability standards, to assure smooth integration of future devices.

- High Speed Line:
  - GSM-R network shall permit train communications up to 350 kmph.
  - Voice and Data applications for ETCS L2.
  - Double coverage.

- Conventional Main Lines: Design to allow single coverage.

- Support current traffic density:
  - Casa-Kenitra (~140 trains per day).
  - Kenitra-Fès (~80 trains per day).

- GSM-R Band – specific for
  - 889 – 893 MHz uplink
  - 934 – 938 MHz downlink

<table>
<thead>
<tr>
<th>Type de ligne</th>
<th>Longueur [km]</th>
<th>Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignes classiques</td>
<td>1 738</td>
<td>Voix et data</td>
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<tr>
<td>LGV</td>
<td>185</td>
<td>Voix, data et ETCS L2</td>
</tr>
<tr>
<td>Total réseau</td>
<td>1 923</td>
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<thead>
<tr>
<th>Lignes</th>
<th>Longueur [km]</th>
<th>Voie unique</th>
<th>Double voie</th>
<th>Vitesse Maximale [km/h]</th>
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<td>Kénitra / Tanger LGV</td>
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<td>Tanger-Tanger Med</td>
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<tr>
<td>S Yahia / Belksiri</td>
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<td>890</td>
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<tr>
<td>915</td>
<td>960</td>
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</table>

Thales/ST 25as Conferências de Comunicações Móveis
## Main Requirements

- **20 Channels:**
  - **889 – 893 MHz uplink**
  - **934 – 938 MHz downlink**

<table>
<thead>
<tr>
<th>Canal</th>
<th>Fréquence uplink (MHz)</th>
<th>Fréquence downlink (MHz)</th>
<th>Espagne (Zones frontalières)</th>
<th>Maroc</th>
</tr>
</thead>
<tbody>
<tr>
<td>1016</td>
<td>888,4</td>
<td>933,4</td>
<td>Orange (UMTS 900)</td>
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<td>15</td>
<td>893,0</td>
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</tr>
</tbody>
</table>

**Countries:**
- Spain (Frontier Zones)
- Morocco (Frontier Zones)
- ONCF (Frontier Zones)
- INWI (GSM)
- Garde GSM
- Orange (UMTS 900)
- Orange (GSM)
- Telefonica (GSM)
- TCH
- Garde GSM

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GSM-R – ONCF - High Speed Line & Conventional Main Lines

**Engineering Design**
- Conceptual & Detailed Design.
- Survey, Radio Planning (Atoll).
- Interface Design.
- Installation Design.

**Installation & T&C**
- Static Tests.
- Dynamic Tests.
Main difficulties

- GSM-R frequency band not fully allocated to GSM-R application, implying local GSM operators to switch their frequency band usage after ANRT higher decision.
- Interferences with Other Operators (in particular, close to Spanish cities, Ceuta and Melilla).
- Operational Plan asking for very demanding transition areas between Train Controllers, without taking into account the geographical conditions.
BBRS – Projects

**Makkah Metro Meca (Saudi Arabia)**
- 20 kms - 9 stations
- 60 way-side radios
- 20 trains
- 100% Elevated

**Mumbai Metro (India)**
- 12 kms - 10 stations
- 32 way-side radios
- 12 trains
- 100% Elevated and 2 metallic bridges

**Bangalore Metro (India)**
- 50 kms - 65 stations
- 250 way-side radios
- 35 trains
- 90% Elevated + 10% Underground

**Montreal Metro (Canada)**
- 72 kms - 70 stations
- 270 way-side radios
- 55 trains
- 100% Underground
# BBRS Projects – Main Requirements

<table>
<thead>
<tr>
<th>Project</th>
<th>Bandwidth</th>
<th>Frequency Band [MHz]</th>
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<tbody>
<tr>
<td></td>
<td>UpLink</td>
<td>DownLink</td>
</tr>
<tr>
<td>Montreal Metro (Tunnel) – 2010</td>
<td>12Mbps</td>
<td></td>
</tr>
<tr>
<td>Montreal Metro (Station) – 2010</td>
<td>12Mbps</td>
<td>8Mbps</td>
</tr>
<tr>
<td>MMOPL - Mumbai Metro – 2007</td>
<td>4Mbps</td>
<td>4Mbps</td>
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<tr>
<td>MMMP-SL – Makkah Metro - 2010</td>
<td>6Mbps</td>
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</tr>
<tr>
<td>Doha Metro - 2015</td>
<td>6.5Mbps</td>
<td>13.5Mbps</td>
</tr>
</tbody>
</table>
BBRS – Main Requirements - General

- **Train Speed**: up to 250 kmph
- **Bandwidth**
  - Typical: 70 Mbps
  - Up to: 125 Mbps
- **Handovers (way-side nodes & Meshs)**
  - Up to 100ms
- **Way-side nodes coverage**
  - Typically no more than 300m
- **Technology**
  - WiFi Technology based on 802.11n 2x2
- **Security**
  - Data encryption
  - Access control
- **Frequency band**
  - WiFi Standard – Unlicensed:
    - 2.4 GHz (2.405-2.495GHz)
    - 5 GHz (5.150-5.825GHz)
  - WiFi Non-Standard - Unlicensed
    - 5.825 – 5.875 GHz
  - WiFi Non-Standard - Licensed
    - 5.9 GHz (5.875 – 5.925 GHz)
- **Redundancy**
  - On-board train radios (one on each cab)
  - Way-side radios
  - OCC Controllers
- **Management**
  - Real-time equipment monitoring
BBRS – Radio Planning

Radio Network Planning

- Track (viaduct and/or tunnel) survey
- System dimensioning (location, power, …), based on track alignment and line architecture
BBRS – System Architecture and Equipment
BBRS – System Architecture and Equipment

On-board Equipment
OCC Equipment

- Nas redes de dados é necessário a introdução de controladores centrais para o sistema BBRS.
- Estes equipamentos são responsáveis por encaminhar o tráfego proveniente de pontos de acesso para o destino correcto.
- Consoante a solução e o número total de rádios na via, pode ser necessário instalar mais ou menos controladores.
BBRS – System Tests

System Tests – RSSI, Bandwidth, Packet loss

> Mumbai Metro
BBRS – System Tests

System Tests – RSSI, Bandwidth, Packet loss

Montreal Metro

Passage 1, Mesh 105
System Management Application – monitors and controls all system devices
BBRS – Main difficulties

Frequency band
- Un-licensed vs. Licensed frequency band
- Frequency band usage in highly populated urban areas

Specific firmware development
- Handover
- Linear Mobility

On-board antenna
- Antenna Model (omni vs. directional)
- Location (e.g., interface with Rolling Stock; electrical distance to other on-board antennas)

RF coverage on metallic bridges
And what about the Future? Thinking about…

How are we going to live in the mid-term future?

**Urbanization**

Urban population by country in 2010 and 2050

**Urban Population**

- > 75%
- 50%-75%
- 25%-50%
- < 25%

- World population will be about 9.5 billions.
- 75% of the world’s population will live in cities.
- The number of Mega-cities will increase, and will provide shelter for more than 100 Million people each.
- 50% of the World’s population will have moved into the middle class.
And what about the Future? Thinking about…

How are we going to live in the mid-term future?

➢ In 2050 (as per International Transport Forum):

- People Mobility: expected to increase more than 300%.
  - Huge increase in terms of service expectation and quality demanding:
    » Data Services availability all the way.
    » Effective Security Services and Control.
    » Time information accuracy.
    » Timely delivery.

- Freight Transportation: expected to increase more than 250%
  - Huge increase in terms of Traffic Control needs, mainly in Mega-Cities.
And what about the Future? Thinking about…

And what about Metro/Rail Transportation?

- Must serve the increasing needs (and concentration also) of People Mobility and Freight Transportation:
  - People comfort.
  - Operational needs (e.g., traffic control, security, safety).

People Mobility

- “Rail” services must focus on the entire journey → Door-to-Door.

& Freight Transportation

- “Rail” services must improve transit times, and reduce transportation costs.
And what about the Future? Thinking about...

People Mobility & Freight Transportation – “Rail” Services

- A few possibilities – leading to an increase in terms of data from/to the Trains:
  - More driverless trains.
  - Improve accuracy of passenger’s information.
  - Increase passengers security without adding time to the journey.
  - Real time monitoring of the entire infrastructure: Rolling Stock, Electrical Systems, Signalling, Telecoms, Fair Collection, …
  - Support Predictive Maintenance.
  - Data Service for Passengers.
  - …
“Rail” Radio Communication – what can we guess?

People Mobility
“Rail” Radio Communication – what can we guess?

Freight Transportation
“Rail” Radio Communication – what can we guess?

**Expectations & Facts…**

- Traffic increase.
- Different environments (Mega-cities/New Architectures).
- Security threats.
- Climate changes.
- New transportation systems.

leading to...

**Challenges**

- Spectrum usage and sharing.
- Additional security measures.
- New error-prediction and correction techniques.
- Higher bitrates.
Obrigado
Thank You
Danhya Vaad
Merci bien
Shukraan
Tak
Dziękuję
Dankie