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(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?

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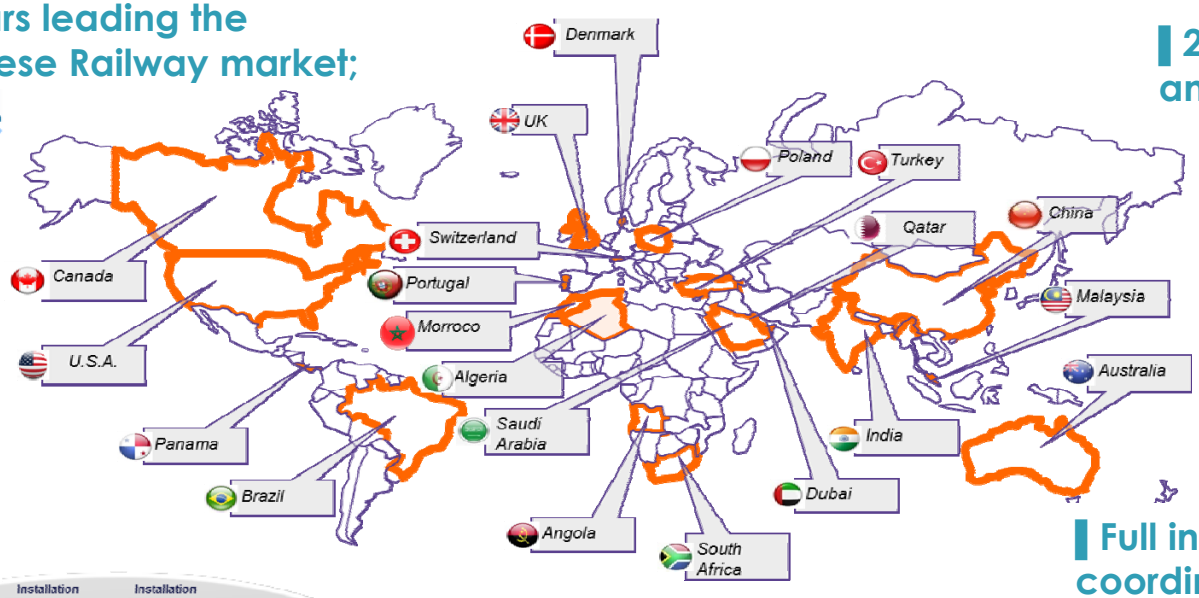
Thales (in Portugal)

What and who is Thales Portugal?

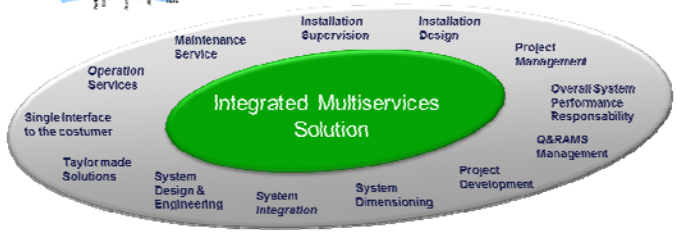
20 years leading the Portuguese Railway market;

Presence in 21 countries



25 Years experienced and skilled team;

Understanding the Transportation "world";



Delivers complex multivendor solutions;

Full integration and efficient coordination between Signaling and Telecommunications;

Linking technique with operational results;

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banedanmark
SBB
PKP
TCDD
ONCF
ANESRIF
UNDERGROUND
Development Commission of Makkah Al Mukarramah, Al Madinah Al Munawwarah and Al Mashaaer Al Muqadassah
ETS
Edmonton Transit System
stm
Infraestruturas de Portugal
RTA
METRO DE PANAMA
Mumbai Metro
Sydney Ferries
METRÔ DE SÃO PAULO
prasa
PASSENGER RAIL AGENCY OF SOUTH AFRICA
EMTU
namma metro
sydney METRO
L&T Metro Rail
Hyderabad

Metro&Rail Communications

Metro&Rail - The need for Telecommunications solutions:

- Operation Solutions.
- Security and Safety Solutions.
- Passenger Confort Solutions.

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Metro&Rail Communications

Metro&Rail - The need for Telecommunications solutions - Passenger Confort Solutions

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Thales Portugal – Our running projects

	Backbone	DTS	SDH	RADIO	BBRS/ WiFi	TEL	VRS	APIS/ PIDS	PAS	MCK	CCTV	ACIDS	FRS	POWER
GBT			X											
TRIS								X	X					
E65-APIS								X	X					
E65-CCTV											X			
ONCF				X		X	X					X	X	X
ROCADE	X	X	X	X		X		X	X	X	X	X		X
WCRP	X	X				X	X		X	X	X	X		
HMRP	X	X		X		X	X	X	X	X	X	X	X	
BMRC	X	X	X		X	X	X	X	X	X	X			
BS15								X	X	X				
JS15								X	X	X				
CS15								X	X	X				
MMOPL	X	X	X	X	X	X	X	X	X	X	X			X
Danshui								X	X					
NSR	X	X	X	X	X	X	X	X	X					
DOHA	X	X			X	X	X	X	X	X				
LUSAIL								X	X					
EDMONTON								X	X					
WVU								X	X					
PANAMA-L1								X	X					
PANAMA-L2								X	X					
VLT SANTOS	X	X		X	X	X	X	X	X	X	X			
SPL17	X	X				X	X	X	X	X	X			
SMNW								X	X		X	X		
ROC								X	X					
	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.

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Metro & Rail - GSM-R, TETRA & BBRS

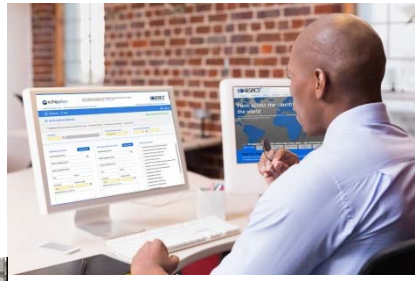
TETRA (TErrestrial Trunked RAdio): Train-to-Ground radio (400 MHz band) – in brief:

- 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.

Metro & Rail - GSM-R, TETRA & BBRS

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 surves 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.



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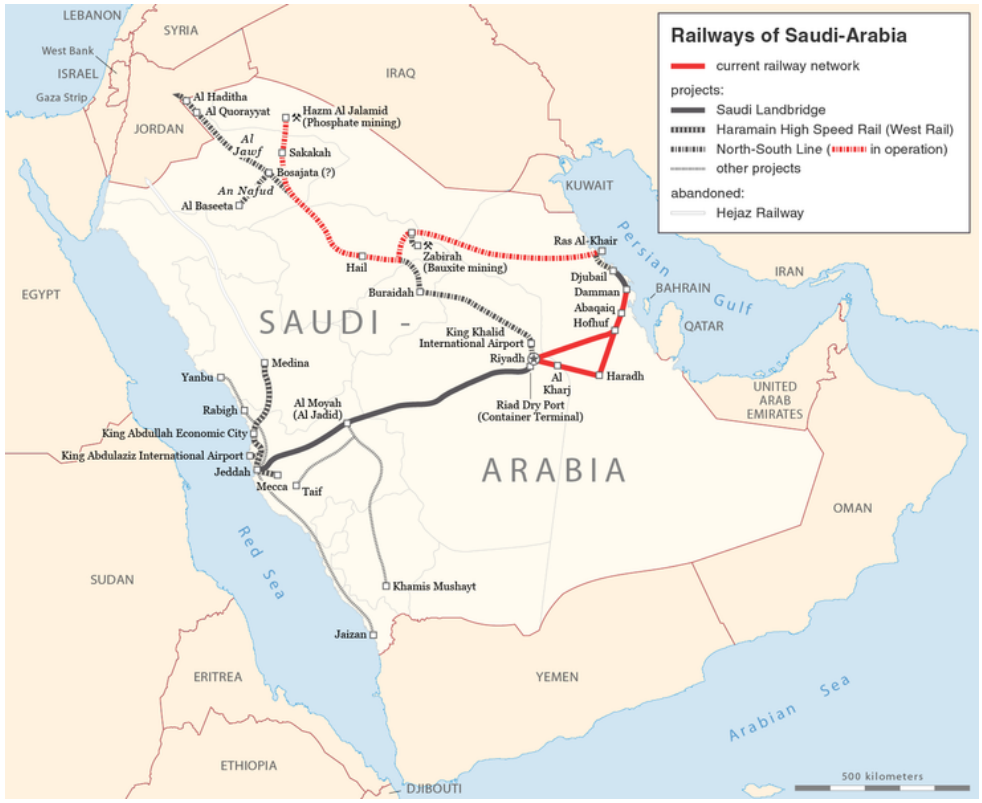
GSM-R – KSA NSR

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.*



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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.

GSM-R – KSA NSR

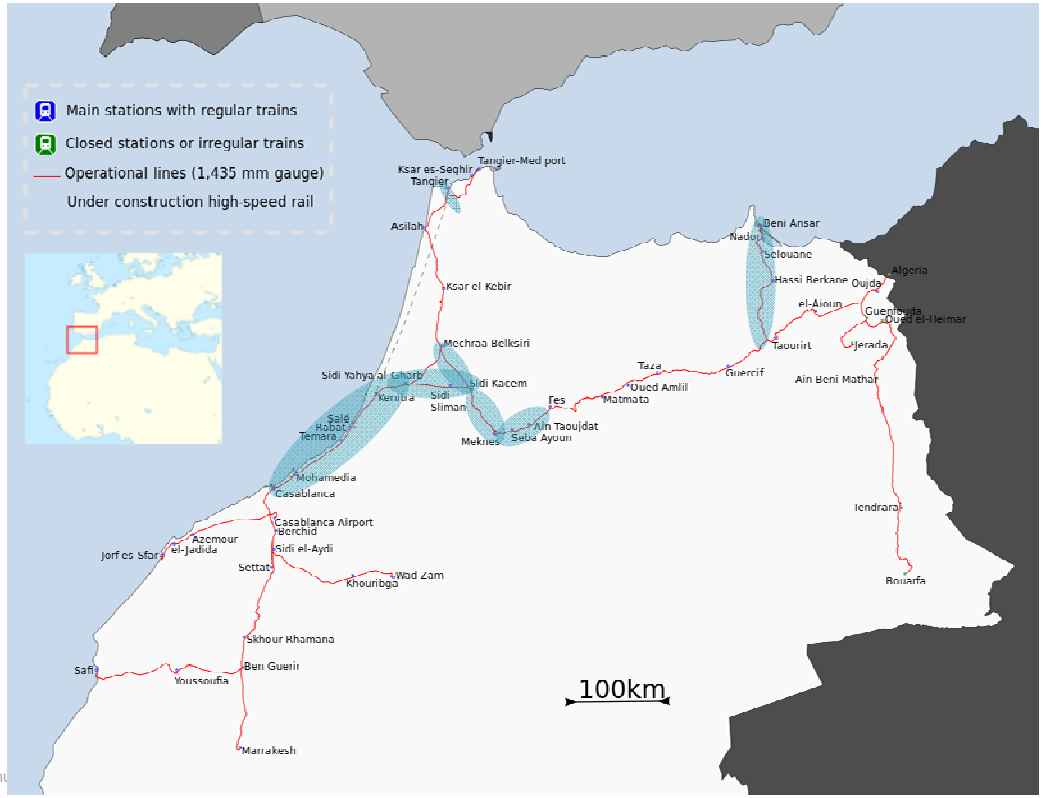
Main difficulties

- 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 may obstacles (and some times moving obstacles).
  - Large plain and very dry areas, creating the conditions for signal propagation to long distances increasing the possibility of interferences.
- Distancies: 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).

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

Main Requirements

- Design, Supply, Installation, Configuration, Tests & Commissioning of the ONCF GSM-R network for the existing Conventional Main Lines and for the High Speed Line Casa/Tanger-Kenitra.



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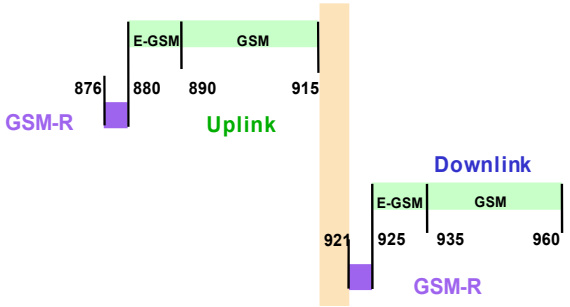
GSM-R – ONCF - High Speed Line & Conventional Main Lines

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-Fés (~80 trains per
- GSM-R Band – specific for
  - 889 – 893 MHz uplink
  - 934 – 938 MHz downlink

Type de ligne	Longueur [km]	Communications
Lignes classiques	1 738	Voix et data
LGV	185	Voix, data et ETCS L2
Total réseau	1 923	

Lignes	Longueur [km]	Voie unique	Double voie	Vitesse Maximale [km/h]
				220
			x	350
			x	220
			x	220
			x	220
				220
				220



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

Main Requirements

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

Canal	Fréquence uplink (MHz)	Fréquence downlink (MHz)	Espagne (Zones frontalières)	Maroc	
1016	888,4	933,4	Orange (UMTS 900)	INWI (GSM)	
1017	888,6	933,6			
1018	888,8	933,8			
1019	889,0	934,0		Garde GSM	
1020	889,2	934,2	Orange (GSM)	ONCF	
1021	889,4	934,4			
1022	889,6	934,6			TCH
1023	889,8	934,8			ONCF (Zones frontalières)
1024	890,0	935,0			
1	890,2	935,2			
2	890,4	935,4			
3	890,6	935,6			
4	890,8	935,8			
5	891,0	936,0			
6	891,2	936,2			
7	891,4	936,4			
8	891,6	936,6			TCH
9	891,8	936,8	Telefonica (GSM)		
10	892,0	937,0			
11	892,2	937,2			
12	892,4	937,4			
13	892,6	937,6			
14	892,8	937,8			
15	893,0	938,0		Garde GSM	

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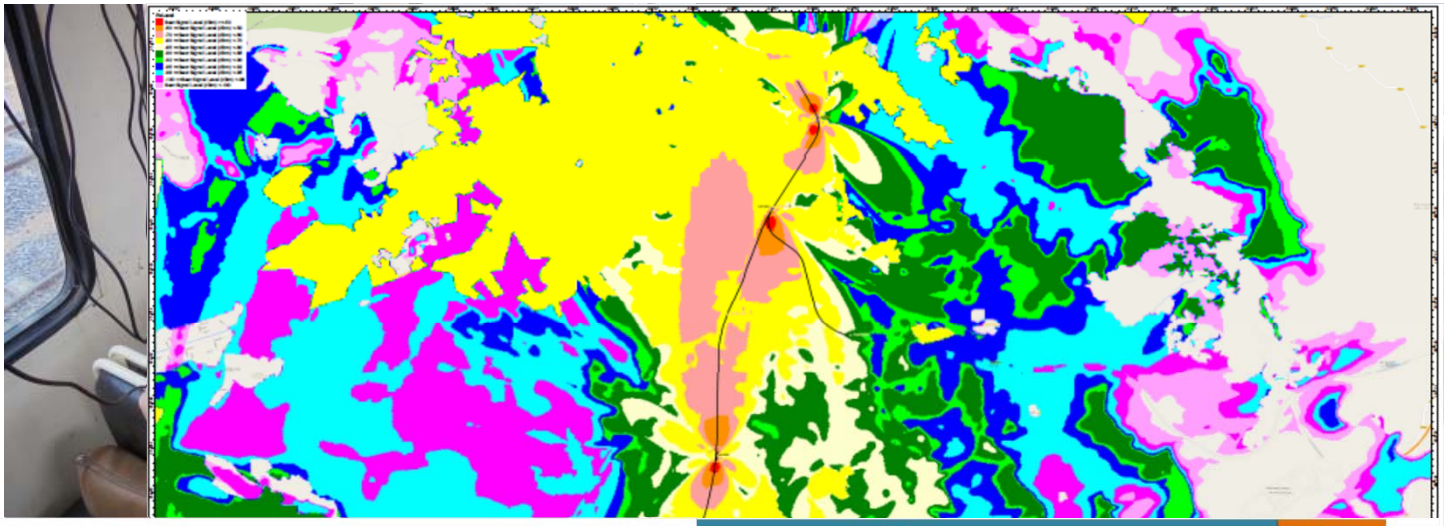
GSM-R – ONCF - High Speed Line & Conventional Main Lines

Engineering Design

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

Installation & T&C

- Static Tests.
- Dynamic Tests.



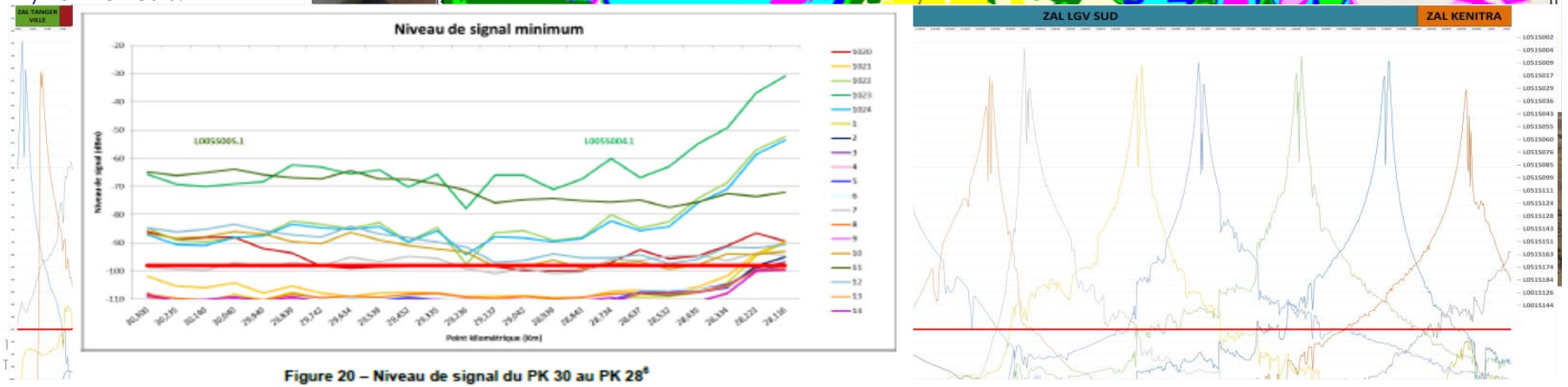
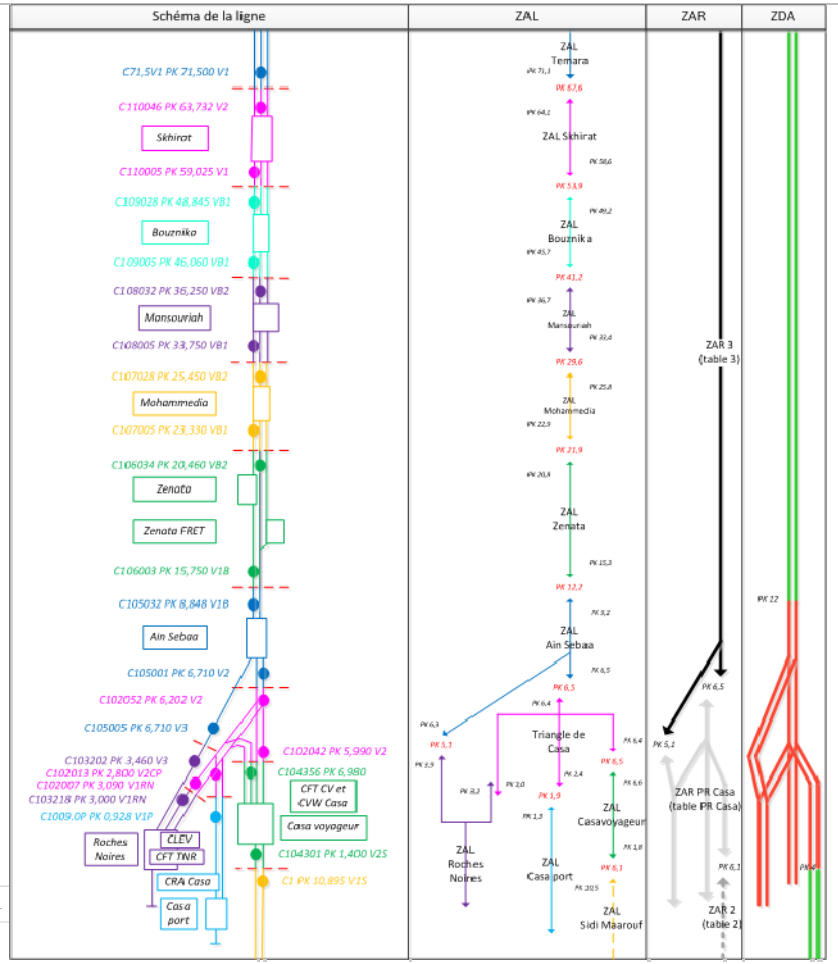


Figure 20 – Niveau de signal du PK 30 au PK 28[4]

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

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 Melila).
- 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

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BBRS Projects – Main Requiremens

BBRS Main Requirements – Montreal Metro; Bangalore Metro; Mumbai Metro; Makkah Metro, and Doha Metro:

Project	Bandwidth			Frequency Band [MHz]
	UpLink	DownLink	Total	
Montreal Metro (Tunnel) – 2010	12Mbps		12Mbps	5.885 – 5.905 Ch 177 & Ch 181
Montreal Metro (Station) – 2010	12Mbps	8Mbps	20Mbps	5.885 – 5.905 Ch 177 & Ch 181
BMRC - Bangalore Metro – 2008	10Mbps		10Mbps	5.850 – 5.950 Ch: 165 – 167
MMOPL - Mumbai Metro – 2007	4Mbps	4Mbps	8Mbps	5.850 – 5.950 Ch: 165
MMMP-SL – Makkah Metro - 2010	6Mbps		6Mbps	
Doha Metro - 2015	6.5Mbps	13.5Mbps	20Mbps	

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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

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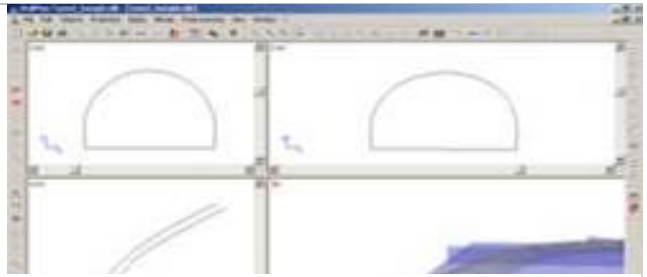
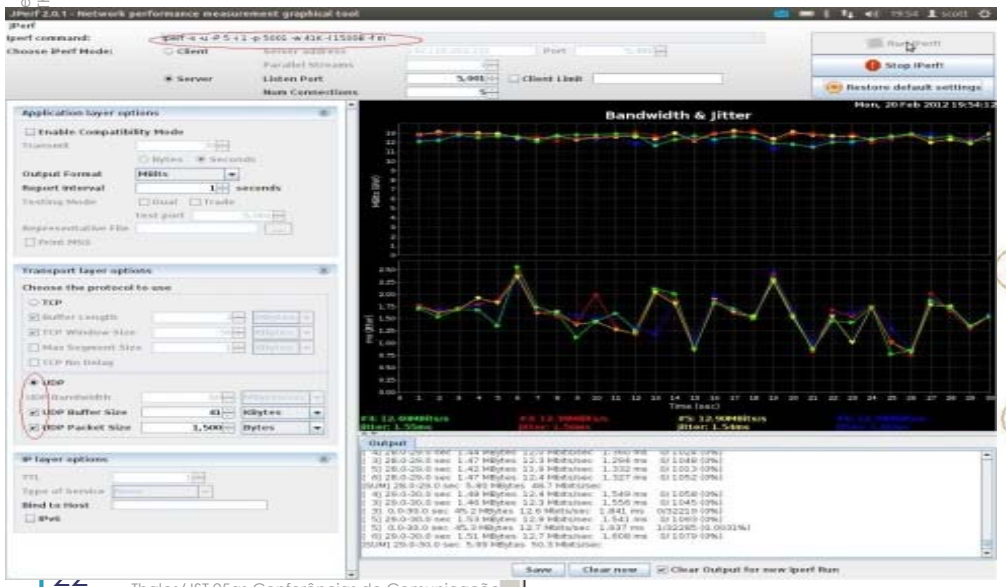
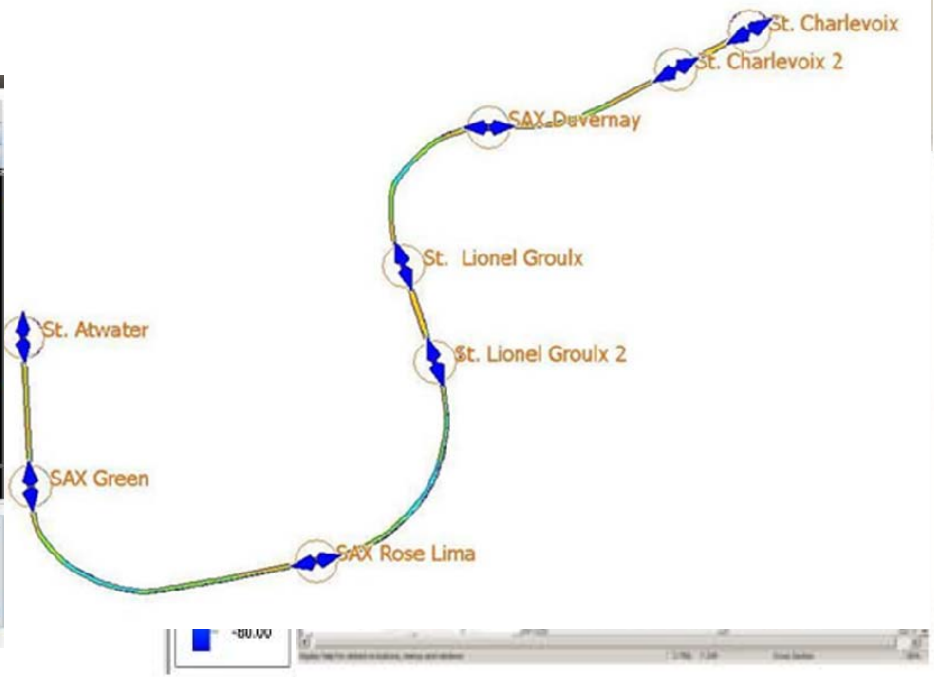
BBRS – Radio Planning

Radio Network Planning

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



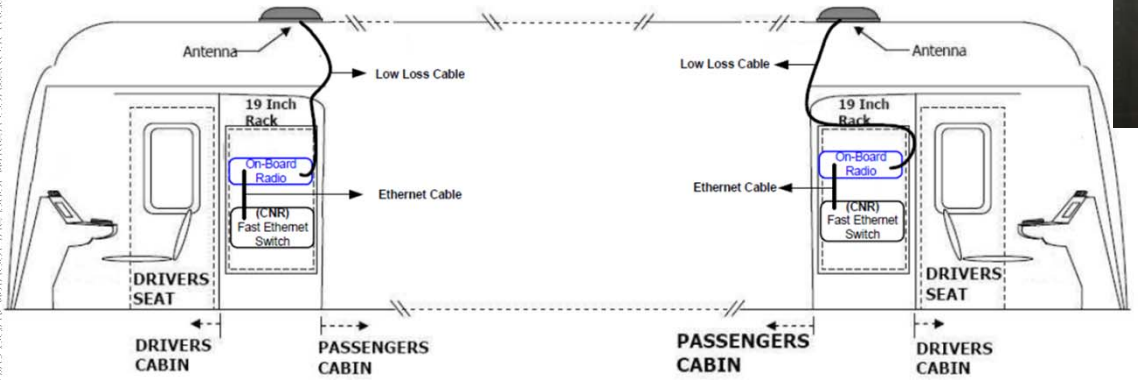




BBRS – System Architecture and Equipment

BBRS – System Architecture and Equipment

On-board Equipment



BBRS – System Architecture and 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.

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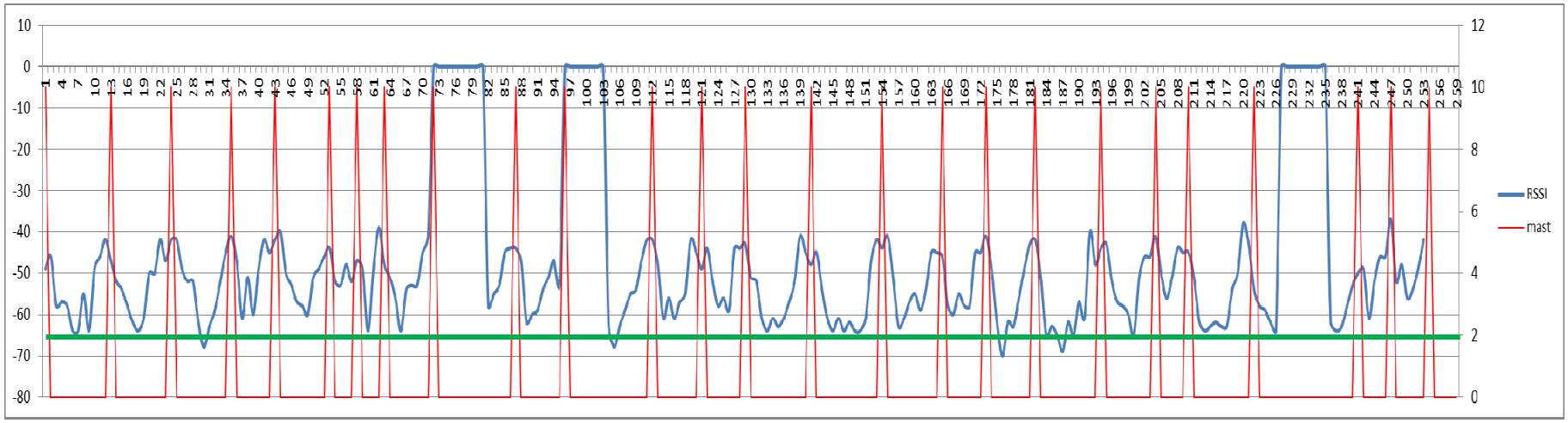
BBRS – System Tests

System Tests – RSSI, Bandwidth, Packet loss

- Mumbai Metro



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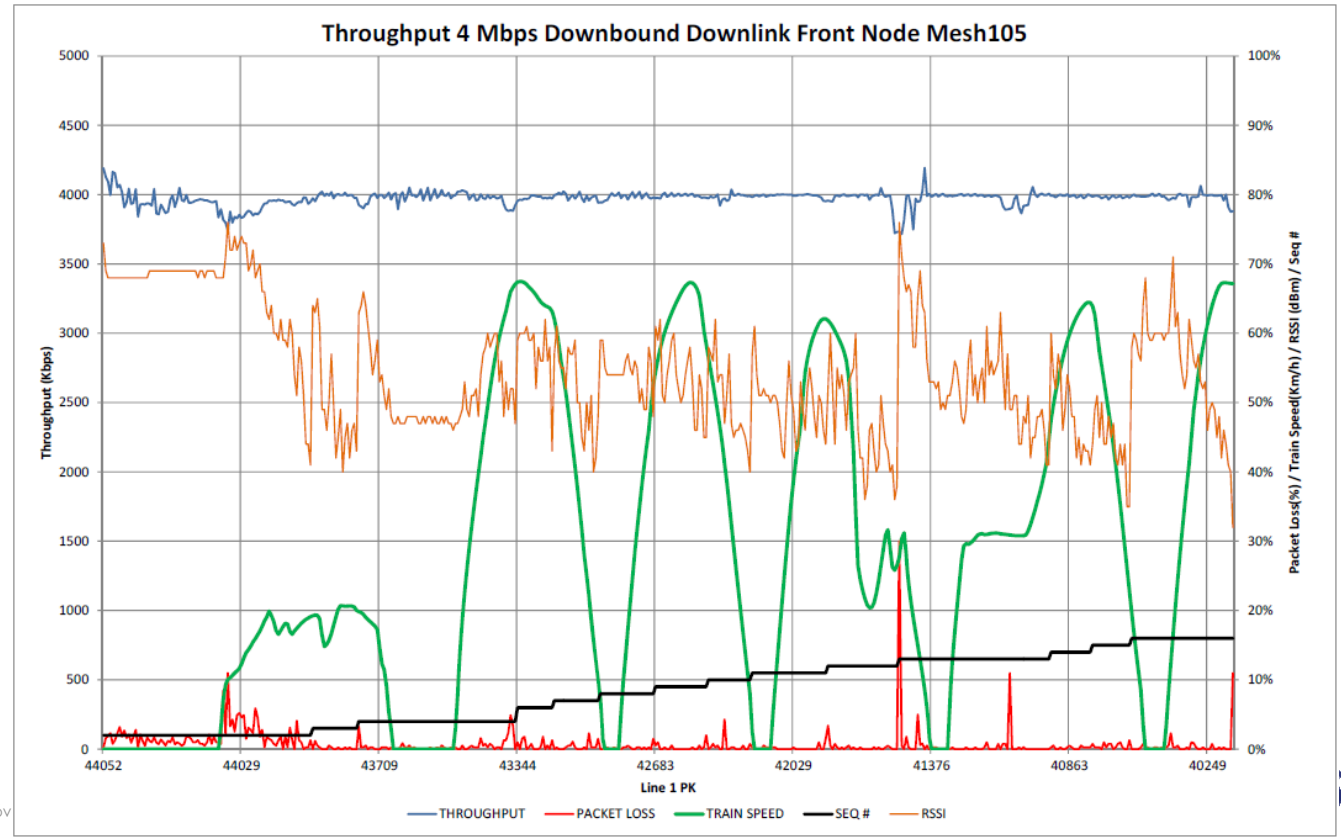
BBRS – System Tests

System Tests – RSSI, Bandwidth, Packet loss

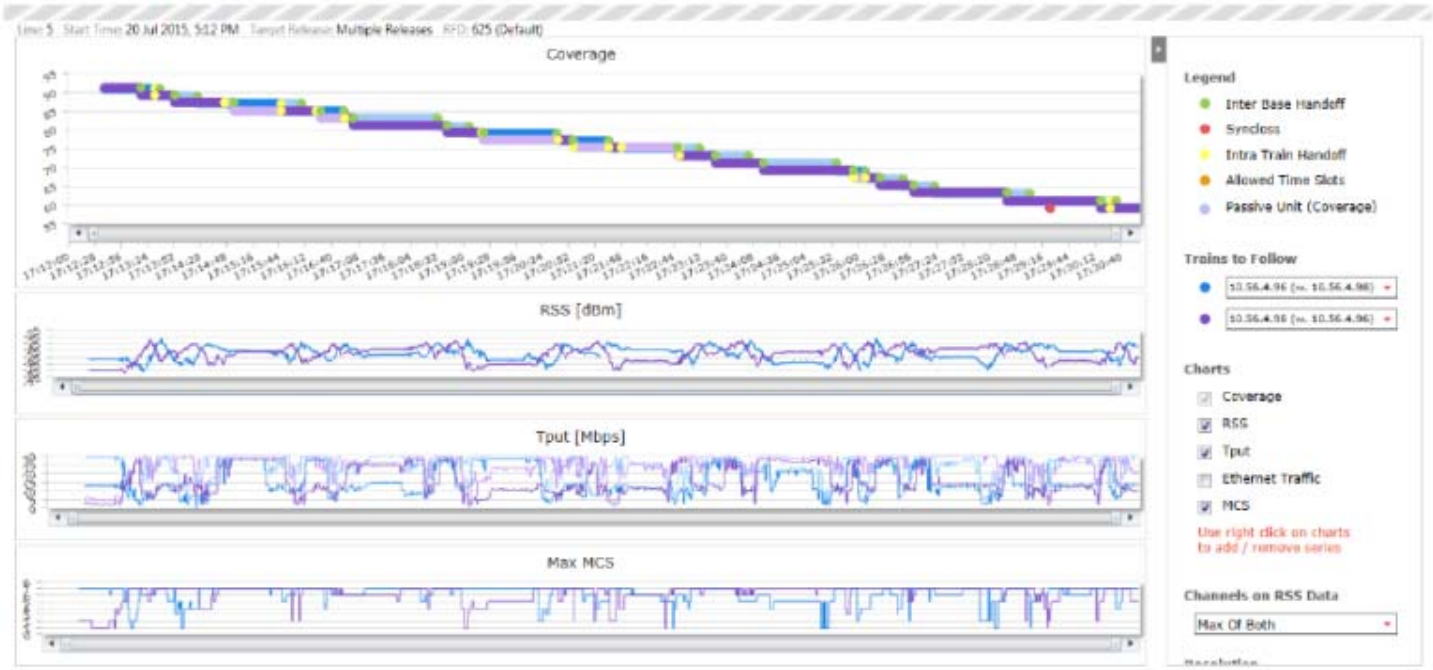
- Montreal Metro

Passage 1, Mesh 105



BBRS – System Management

System Management Application – monitors and controls all system devices



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BBRS – Main difficulties

Frequency band

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

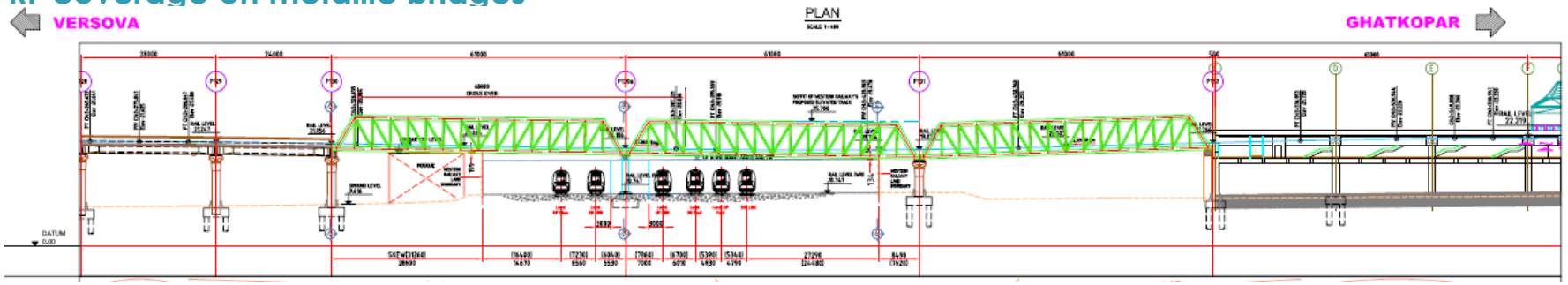
Specific firmware development

- 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

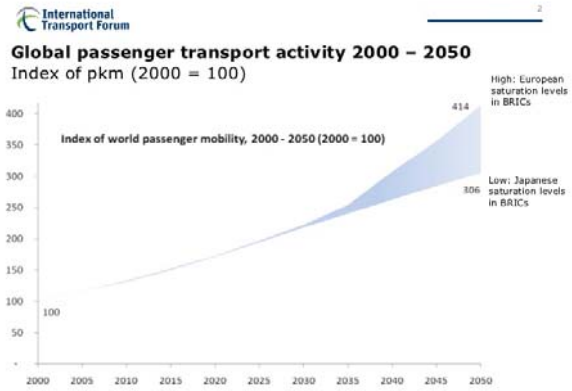
Urban Population

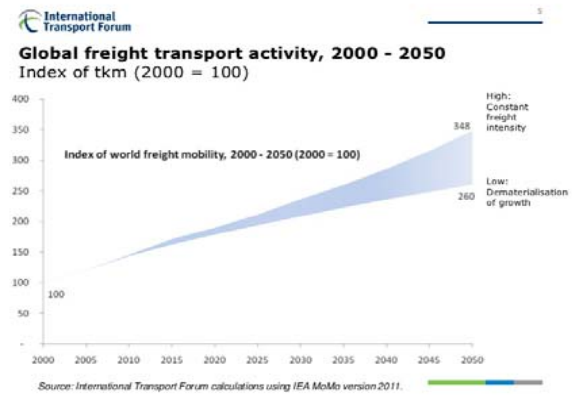
- > 75%
- 50%-75%
- 25%-50%
- < 25%

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 confort.
  - 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.

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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.
  - ➔ …

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“Rail” Radio Communication – what can we guess?

People Mobility

“Rail” Radio Communication – what can we guess?

Freight Transportation

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“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.

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Obrigado

Thank You

Danhya Vaad

Merci bien

Shukraan

Tak

Dziękuję

Dankie

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