RFI experience for the application of satellite technologies to ERTMS signalling system

Massimiliano Ciaffi
Technical Department
Standard CCS

Berlin, September 19th 2017
The Italian Rail Network

Lines classification related to the traffic development

~ 1000 km  High Speed Network
Command Control System: ERTMS/ETCS L2
Train spacing with radio block

~ 950 km  Metropolitan Traffic Lines
Command Control System: CTC, SCC, SCC-M
Train spacing with short block sections (High Capacity)

~ 2.900 km  Fast Lines
Command Control System: CTC, SCC
Train spacing with SCMT

~ 3.900 km  Middle performances + Freight lines
Command Control System: CTCeV, SCC
Train spacing with block sections: SSC, SCMT

~ 7.950 km  Subsidiary + Low Traffic Lines
Command Control System: CTC
Train spacing with block sections: SSC

Economic Sustainability
The ERTMS L2 Satellite / L3 Regional project is one of the steps of the renewal technology program of regional lines aimed at:

**REDUCING** the operating costs (OPEX) of the "Regional" lines with the aim of making them more economically sustainable.
## What is the context?

- Secondary medium / low traffic lines
- Normally simple track
- Normally not electrified or electrified 3 kV
- «Multistation» operating rules without attend PP
- Automatic Train Supervision
How to achieve the goal?

- **Eliminate:**
  - Class B protection systems
  - Light signals
  - Train detection systems (track circuits, axel counter) both online and station

- **INTRODUCTION (in scalable configuration):**
  - IXL functions according to ACCM logic with non-attend PPs
  - SDT functions through ERTMS (L3)
  - The adoption of a GSM-R or public radio system/ Satcom
  - The Supervision and Automation function of the trains
  - The function of "virtual balises" through the use of satellite technology
  - OBU ETCS «Regional» with simplifications that can reduce costs with interoperability
Satellite Application Development Plan

**2012 – 2020**

- **2012**: Satellite Application Development Program
- **2013 – 2014**: GNSS Signalling Demonstrator
- **2015 – 2016**: ERTMS Application
- **2017 – 2018**: Commissioning
- **2019 – 2020**: First Pilot Line By 2020

- **Regional & Local lines** renewal at **lower costs**, with **higher capacity** and ensuring the **highest safety level of ERTMS**

- **ERSAT EAV + GGSC**
- **ERTMS-ETCS Test Site**

**Commissioning**

**Pinerolo – Sangone**

- **First Pilot Line By 2020**

**DB4RAIL**

- **Antispoofing and Antijamming technology**
RFI partner of ESA 3INSAT Project

Objective: to develop, test and validate in a real set up a new satellite-based platform suitable for a Train Control and Management System meeting the SIL4 safety requirements and compatible with the ERTMS standard.

- Location Determination System (LDS) including Au-Network
- Integrated TLC solution based on SatCom, 3G/4G, TETRA to realize a link between the on board train control system interfaces (e.g European Vital Computer EVC) and the ground based infrastructure (e.g the Radio Block Centre RBC)

Double track line
Mitigation of such a kind of hazard has been primarily investigated for military applications.

Intentional interferences affecting the received GNSS Signals, represent a major

Availability of low cost wideband SDR transceivers designed for the mass market of LAN (e.g. IEEE 802.11 ac) and mobile communications (LTE advanced)
Trial Site Architecture and Configuration for Demonstration

- **Centralized Traffic Control**
- **RBC Monitor**
- **RS Diagnostic Monitor**
- **Satellite Radio Communication Network**
- **Signalling & Augmentation Data**
- **Railway Line: Cagliari – S. Gavino**
  (about 50 Km long)
  *Virtual Balise Only*

**Locations:**
- **Samassi**
- **Decimomannu**
- **RSs & Servers**
  (EGNOS / GALILEO)
- **TAN - CC**
- **RBC&IXL TALS & CTC**
- **RFI SDH**
Field Test Results - Position

The expected value of GNSS **Position Average Accuracy** per train run is less than +/- 3 meters.

10,000 km of field test

Std Dev is less than 4 meters (GPS)

About 2 m with Galileo
Field Test Results - Speed

The expected value of GNSS Speed Average Accuracy per train run is less than +/-5 km/h

Std Dev is less than 2 km/h

10,000 km of field test
# Field Test Results – Control Command System

## ERTMS Signalling KPIs

<table>
<thead>
<tr>
<th>KPI</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Delivered vs. Planned Virtual Balises per train run (expected greater than 95%)</td>
<td>✔ PASSED except two cases (one for two different train runs)</td>
</tr>
<tr>
<td>Correct Sequence of Provided Virtual Balises per train run (expected no error)</td>
<td>✔ PASSED (at 100%)</td>
</tr>
<tr>
<td>Virtual Balise Groups detected inside the Expectation Window per train run (expected greater than 95%)</td>
<td>✔ PASSED</td>
</tr>
<tr>
<td>Train Position Confidence Interval (the actual safe front end, based on the Ground Truth, must be never outside the train confidence interval for every measured distance from the applicable LRBGs)</td>
<td>✔ PASSED</td>
</tr>
</tbody>
</table>

22,000 virtual balises generated
Economic Sustainability

The main benefits of the new solution are two:

→ the **reduced need of physical balises**, which generates savings in the associated capex and opex

→ **avoided investments in additional GSM-R infrastructure**, which also generates savings in capex and related maintenance opex

An application of a Cost-Benefit Analysis to compare the convenience of GNSS-based ERTMS vs traditional ERTMS at the European level

(source: Bocconi University)
PILOT LINE MONCALIERI SANGONE - PINEROLO

Total length 30 km:
- Single track, 1 train each 30 minutes
- Line is electrified 3KVcc
- Vmax 135 Km/h
- Operators Trenitalia\Mercitalia
- Mixed passengers/freight traffic
- 17 automated Level crossings
- No tunnels, only bridges for autoroutes
- Passengers trains:
  - TAF
  - JAZZ
- Freight trains:
  - E633 MERCITALIA
  - E652 MERCITALIA
Pinerolo – Sangone Plan

12/10/2017
Train Identification, it will be fitted by technology on board and Reference Station

08/06/2018
Activation ACCM Pinerolo – Candiolo

03/12/2017
ACC Activation Pinerolo-Piscina

29/11/2020
ERTMS L2 system activation with GNSS system Local Augmentation + Public Tlc

21/11/2021
ERTMS system activation with GNSS system EGNOS Augmentation + Public Tlc

29/11/2022
ERTMS L3 implementation with satellite localization + Public Tlc

25/09/2023
ERTMS L3 activation with satellite localization + Public Tlc

GALILEO + GPS
Activities to support the certification process

GNSS and public TLC networks are external components to the ERTMS standard.

GNSS Adoption and Public Communications are required the definition of interfaces / Service levels between service providers and the «core» ERTMS.

- Evaluate the impacts on the safety and availability of the ERTMS with 'External' services to the ERTMS ecosystem

  - Augmentation System
  - Virtual Balise reader
  - RBC Interface - Augmentation Network
  - Multi-bearer telecom

- The Safety Case must be set up with the service levels required by the operators of the service.

Support and involvement of experienced ASI, ESA and GSA are required.

Space and ANSF / EUAR for Railway.
User Requirements - PHA

RFI has activated the certification process for using GNSS & Public telecom as primary communication means in the ERTMS platform

Sept. 2015
Preliminary Hazard Analysis

CE 402/2013 Regulation

User Requirements

June 2016
First formal process in Europe to validate/certify GNSS and Public telecom with ERTMS (NoBo)

Request to put in service the system

RFI

Coordinator of technical committee & Responsible for Authorization

Request to ANSF: RFI

Team of outside experts: Ansaldo STS, Radiolabs, Sogei, Telespazio
ERSAT exploits the potential benefits of **GALILEO & ERTMS** to innovate ERTMS with newest technologies impacting the «vehicle automation» landscape....and synergy with **driver-less cars innovation** as valuable resource → **ANAS-RFI**, first opportunity on cross-technology fertilization between two sectors with mutual benefits on rail know how and new technologies being *mass-developed* for intelligent vehicles & roads.
Conclusions

- The **Virtual Balise Concept** is now a reality. The Sardinia Trial Site demonstrated that the proposed ERTMS based on the satellite LDS correctly works.

- The performance of a radio communication based on Public Packed Switching and/or SatCom networks looks suitable for ERTMS L2/L3 in regional lines.

- Barriers against onboard local feared events (e.g. multipath, radio frequency interference) must be implemented.

- Additional analysis is required on Augmentation Systems (e.g. EGNOS).

- Standardisation within ERTMS legal framework is necessary to guarantee interoperability and cost reduction.

SAT technology + Euroradio over public bearer + ERTMS L2/L3 appear as a feasible way for achieving a safe and sustainable (for Total Cost of Ownership - TCO) railway (at least in the regional low traffic domain) provided that benefit are equally shared among IM and RUs.
Thanks for your attention

m.ciaffi@rfi.it