Satellite based train control systems for local and regional lines

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Roadmap

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The Italian Rail Network

Infrastructure specialization

Goals
Lines classification related to traffic development
(time horizon 2013)

High Speed Network
- Command Control System: ERTMS/ETCS
- Train spacing with radio block
- (6%) 993 km

Metropolitan traffic lines
- Command Control System: CTC, SCC, SCC-M
- Train spacing with short block sections (high capacity)
- (10%) 1.600 km

Fast lines
- Command Control System: CTC, SCC
- Train spacing with SCMT
- (18%) 2.920 km

Middle performances + freight lines
- Command Control System: CTC, SCC
- Train spacing with block sections: SSC, SCMT
- (22%) 3.710 km

Subsidiary + low traffic lines
- Command Control System: CTC
- Train spacing with block sections: SSC
- (44%) 7.457 km

Economic Sustainability

RFI
RETE FERROVIARIA ITALIANA
GRUPPO FERROVIE DELLO STATO
HS Italian network : ERTMS Feedback

- In commercial operation since 2005 (10th Happy Birthday Roma Napoli)

- 750 KMs equipped by ERTMS/ETCS level 2 without fall back at 300km/h and trials up to 350km/h

- In construction other 500km of ERTMS high speed lines

- 2.3.0D (ETCS) trackside system compliant

- Very good feedback availability

- 200 ETCS trains per day

- 3' potential headway
ERTMS in Italy: Obligation and Opportunities

ERTMS (ETCS+ GSM-R)

High Speed Network
Level 2 (Baseline 2) Without fallback

In realization
2018: HD Rome and Milan Node (headway 2’30sec)

High Density Urban Nodes
Level 2 /Level 3 (Baseline 3) Overlapped to National CCS

Freight & Passenger Tent-T Corridors
Level 1/Level 2 (Baseline 3) Overlapped to National CCS

Low density Lines
Level 2 /Level 3 (Baseline 3) Satellite & Public Bearer

In realization
2015 Pilot Line Corr D
2016: Ranzo Luino, Domo Iselle
2017: Domo Novara
2018: Milano Chiasso
2020 Novara –Villa Opicina; Fortezza Verona; Milano Genova

10 years In Operation and always in Evolution
2016 UpGrading 230d Ro Na
2016 Treviglio Brescia
2018 Roma Firenze
2020 Brescia - Verona

ERSAT PROGRAM merging two EU project (Galileo and ERTMS) for Interoperable Virtual Balise concept

Virtual Section by Train Integrity Detection
RFI Needs

1. Reduction of investment costs (CAPEX) and maintenance costs (Opex) for the simplification of the technological infrastructure;

2. Guarantee a standard level of the European rail safety (SIL4);

3. Improved safety and capacity of transport networks through the application of **moving block** on secondary lines

4. Modernise signalling system at lower costs to ensure the sustainability

5. Ensure the interoperability of the fleet

6. All the update and transmission functions for digital map have to be executed automatically without train driver intervention or verification during the normal operation.
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 Detection 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)
3inSAT - The Sardinia Test Site

- Total length: ~ 300 km (Cagliari-Olbia)
- Double track
- Satellite localization system at SIL-4 level
- Multi-bearer TLC network
- Augmentation network
- Test Procedures validation
- Independent assessment by a NoBo (Italcertifer)
3InSat Architecture
Demo test on the Sardinia Trial Site

- GNSS Antenna
- Virtual Balise Reader
- Virtual Balise
- ERTMS/ETCS (EVC, Odometry, Radio Mng)
- TALS & RBC Functions
- Peripheral Post I/F
- IXL Functions
- Radio
- Radio I/F
- Communication Network
- DMI
- Reference Station
- Communication Network
- Existing CTC
Demonstration Field Tests

✓ Phase 1 (Satellite Assets Only)
  ➢ Travelled Distance **2000 kms** (1300 kms with 2G/3G, 700 kms with Satcom)
  ➢ Period: **May – July 2015**

✓ Phase 2 (ERTMS Integrated with the GNSS based Location Determination System)
  ➢ Travelled Distance **4500 kms** (3000 kms with TETRA, 1200 kms with 2G/3G, and 300 with Satcom)
  ➢ Period: **July – December 2015**
The expected value of the Average GNSS Position Accuracy per train run is less than +/-3 meters.

Std Dev is always less than 4 meters (except two cases).
3InSat – Results

Demonstration Field Tests

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

Examples of Measures

Std Dev roughly always less than 2 meters
GNSS Protection Level

• % of epochs for which the GNSS subsystem does not provide a solution: **NEGLIGIBLE**

• % of epochs for which the GNSS subsystem is potentially intrusive (Protection Level > Application Threshold): **NEGLIGIBLE**

• % of epochs for which the GNSS Subsystem is in MI/HMI: **NEGLIGIBLE. Events automatically filtered at ERTMS level**
ERTMS Signaling KPIs

- Expected Delivered vs. Planned Virtual Balises per train run (expected greater than 95%): **PASSED** except two cases (ONE missed in one train run and two missed in another train run)
- Correct Sequence of Provided Virtual Balises per train run (expected no error): **ALWAYS**
- Virtual Balise Groups detected inside the Expectation Window per train run (expected greater than >95%): **PASSED**
- 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): **ALWAYS**
RFI partner of ERSAT EAV Project

RFI-DB Netz - ASSTRA accounting for large number of European local lines
ERSAT EAV: Main General Objectives

- To improve the **sustainability and growth of the regional and local railway lines**, guaranteeing the safety:
  - minimizing the costs for railway signalling infrastructure, without sacrificing the safety;
  - safeguarding the European efforts for standardization of signalling systems (ERTMS);
  - promoting the adoption of the GNSS technology into the ERTMS for improving the competitiveness of European railway industry.

- The **utilization of EGNOS and Galileo Services**, as foreseen in the ERTMS MoU signed in 2012 by the railways stake-holders:
  - Exploiting and adapting the enabling GNSS key technologies;
  - Complementing the existing GNSS technology and operational services for railways application, fulfilling user requirements (SIL-4).
User Requirements - PHA

Team is composed by RFI, Ansaldo STS, Radiolabs, Sogei and Telespazio.

Output : Final Report for Railway Risk Management

Next step: Request of certification to ANSF with NoBo assessment
Conclusions

- GNSS & new telecom solutions (cellular-satcom) are being validated for ERTMS platform
  - World’s first SIL-4 satellite localization system
  - IP multi-bearer TLC solutions do not require dedicated infrastructures
  - Reduction of investment costs (CAPEX) and maintenance costs (Opex) for the simplification of the technological infrastructure;
  - Modernisation signalling system at lower costs to ensure the sustainability of secondary lines
  - Fleet interoperability & ERTMS deployment on regional lines
  - Harmonization of user requirement for different scenario (e.g. Europe, Russia, USA and Australia)

- A roadmap with key stakeholders is a priority for the adoption of satellite systems
  - Rail sector: world’s leader with ERTMS
  - GNSS-EGNOS: for SIL-4 rail applications
  - Satellite TLC: optimised solutions for rail signalling applications

A common strategy