ERTMS FOR HIGH DENSITY IN URBAN NODES

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Contents

• RFI’s outlook
• Architecture’s description
• Functionalities and challenges
• Conclusions
ERTMS Applications in Italy - RFI’s Portfolio

High Speed Network
Level 2 (Baseline 2) Without fallback

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

10 years in Operation and always in Evolution

2016 UpGrading 230d Ro Nal
2016 Treviglio - Brescia
2018 Roma - Firenze
2020 Brescia - Verona

In realization
2018: HD Roma and Milano Node (headway 3’)
Virtual Section by Train Integrity Detection

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

Pilot Line in Sardinia
2017 ERSAT merging two EU project (Galileo and ERTMS) for Interoperable Virtual Balise concept
HD Rome node - Development programme

Stage 1
Stage 2
Stage 3
HD Milan node - Development programme

1- Milano Garibaldi - Bivio Mirabello - Milano Greco Pirelli

2- Milano Garibaldi - Bivio Mirabello - Milano Lambrate
HD CCS: ETCS + GSM-R + IXL + ETML

HD CCS (High Density Command, Control & Signalling) should be optimized in all component subsystems to boost network capacity in urban nodes:

- ETCS L2 and IXL have to be integrated with a dedicated logic both for line and station (emi-route concept). Application conditions, parameters and variables have to be properly configured.

- GSM-R network should be performed to increase QoS and capacity in term of traffic channels/trains. A migration to packet switching communication (IP or LTE) have to be planned in a second phase.

- Traffic Management Layer: improved management of traffic scheduling introducing «sailing speed» for driver (ATS – Automatic Train Supervision).
HD ERTMS: Principles

- ERTMS L2 System for High Density with the new emi-route logic of IXL will be overlapped on part of line and routes of the existing national signalling system specified by the Implementation Planning, assuring the no intrusiveness over it.

- HD ERTMS will be overlapped on electronic IXL (ACC or ACCM). In specific cases ERTMS L2 will be overlapped without HD functionality in order to guarantee the harmonization of driver’s operations.

- HD ERTMS operational regime will be envisaged with specialized equipped train batteries but promiscuous traffic however should be considered.

- Dynamic HD ERTMS L2/STM transitions and viceversa have to be configured in specific points of the lines to manage degraded situations or faults of ERTMS L2 trackside subsystem. HD ERTMS equipped train should be allowed to run with national signalling system anyway.
HD ERTMS in urban nodes: new functionalities

- New ETCS BL3 Braking curve optimized by the right safety margins transmitted by trackside subsystem.
- Static speed profile (SSP) managed from the starting of switching point instead of from the signal (marker board).
- Definition of Radio block section (SBR) length should be optimized for line and station to maximize the capacity.
- Release speed calculated by onboard subsystem and management of overlap length (also "virtual overlap") inside of following SBR.
- IXL and RBC timer should be configured to allow the release of route elements locked in the overlap and to increase release speed value.
- A subsidiary aspect of light signals for using HD SBR with a new dedicated announcing and acknowledgment logic between RBC and IXL subsystem.
- Emi-routes management only for ERTMS equipped trains dedicated for high density functionalities.
- GSM-R network strengthening by using GPRS functions both on trackside and onboard.
- SBR clearing function by odometric mechanism as well as Level 3.
ERTMS L2 overlapped to Class B system

For RFC Corridor....  .....and High Density (HD) in Urban Nodes

Existing GSM-R BTS

SCMT Train

RBC

ETCS Train

Packet 44 (SCMT Data)

ETCS L2 Telegram

Existing Class B (SCMT) use same Eurobalises and Encoder
HD ERTMS overlapped to Class B: application

ATO/ATS

Transitions/interconnections

RBC

HD ERTMS area

No HD ERTMS area

HD ERTMS area

Collegamento Terra - Treno

Treno

ERTMS area

«Traditional» Electronic Block

«Advanced» Electronic Block

«Advanced» Electronic Block

ACC/ACCM: Electronic Interlocking

ACEI: Relay Interlocking

SCC/CTC

RBC-IXL Interface

Line/station-IXL Interface
IXL Subsystem: new functions for HD ERTMS

Main innovations introduced for HD ERTMS application in urban node are:

- management of *HD ERTMS routes* (emi-routes) in stations and *HD ERTMS sections* in line;
- management of the «virtual overlap»;
- optimized management of degraded scenarios both in stations and line.

*Railway concept of «zona d’uscita» in station and in line are still valid and will be extended to HD ERTMS signals too.*
HD ERTMS routes and sections: definition

Lineside HD ERTMS radio block sections (SBR):
- Realized by means of Eurobalise positioning without electromechanical joint. The exit from HD SBR is managed using Position Report sent by onboard and «train integrity» functionality.
- Introducing of «Virtual Overlap» concept.
- Lineside HD ERTMS will be applied principally over new innovative technology block sections.

HD ERTMS routes in station:
- HD ERTMS routes have a smaller extension than traditional ones. Setting of HD ERTMS routes included in the main traditional route trigger all the functionalities of the main route.
- HD Route setting are triggered by means the same command available for main traditional route.
- Setting of first HD ERTMS route lock the final point of main traditional route that verify all conflicting routes.
- HD ERTMS in station will be applied principally over electronic apparatus.
Lineside management of HD functionality
In station, ETCS train can occupy HD ERTMS routes also in case of not equipped train ahead (without train integrity function), by means of traditional track circuits.
HD ERTMS: Railway functional scenarios

- Train 2 ETCS or SCMT
  - SBR x occupied
  - “Virtual SBR” 1, 2 e 3 “not relevant”
  - SBR x free
  - “Virtual SBR” 1, 2 e 3 “not relevant”
  - Train 2 SCMT
    - SBR x free
    - “Virtual SBR” 1 e 2 free but not available for Train 2 SCMT
  - Train 2 ETCS
    - SBR x free
    - “Virtual SBR” 1 free and available for Train 2 ETCS
  - Train 4 ETCS
    - SBR x occupied
    - “Virtual SBR” 1 free and available for Train 4 ETCS
- Train 1 SCMT
  - SBR x+1 free
  - “Virtual SBR” 2 e 3 occupied
- Train 1 ETCS
  - SBR x+1 free
  - “Virtual SBR” 3 occupied
- “Virtual SBR” 1 free and available for Train 4 ETCS
- “Virtual SBR” 2 e 3 occupied
Virtual overlap concept

To permit a train to approach one HD ERTMS route or end-section signal in advance with a suitable release speed an overlap from EoA should be defined. It will be referred to «virtual overlap» because it will be configured only in RBC database and not «physically identified» on track.

This solution let’s save cost of trackside installation!

Introducing virtual overlap concept, equipped trains can entry in HD section or route with following rules:

- a release speed null (=0) in case of virtual overlap occupied but a minimum area of 20 m. (in line) or 50 m. (in station) are free, in according to current Italian national rules (RCF) and NSA guidelines;
- a release speed not null (≠0) in case of virtual overlap free.
Physical and virtual overlap

Without release speed

Physical overlap free (50m)
Virtual overlap free

Physical overlap occupied
Management of degraded scenario

Station

Line
Train Integrity: a possible solution

<table>
<thead>
<tr>
<th>Name</th>
<th>Qualifier for train integrity status</th>
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</thead>
<tbody>
<tr>
<td>Description</td>
<td>Qualifier, identifying the train integrity information available. The related safe train length information is given by L_TRAINT.</td>
</tr>
<tr>
<td>Length of variable</td>
<td>Minimum Value</td>
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<tr>
<td>2 bits</td>
<td></td>
</tr>
<tr>
<td>Special/Reserved Values</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
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</table>
Train Integrity management in ERTMS Level 2

ETCS Train 2

Min safe rear end
Position report

ETCS Train 1

Position report

ETCS Train 2

Min safe rear end
Position report

ETCS Train 1

Position report

ETCS Train 2

Position report

Min safe rear end
BL3 Braking model: IM design right safety margin

Improve capacity:

- Rolling stock correction factors for Gamma trains – split of responsibility RU/IM.
- Different margins between high speed passenger train and cargo train.
- A real cross border operation could be possible without losing capacity! (no table installed on board).
HD Requirements to ETCS Onboard subsystem

HD ERTMS have to guarantee the high density headway only for chain of trains with this minimum characteristics (Gamma Trains):

- Max lenght 200 m;
- time delay for breaking system application < 4.5 s;
- 140 % Weigth Breaking (PMF);
- 1,0 m/s² average deceleration for EB in the speed range 0-100 km/h;
- 0,9 the parameter of “rolling stock correction factors”.

The trains using HD ERTMS functionalities must be equipped with EVC BL3 R2 and:

- release speed calculated by onboard unit;
- the “ETCS smart sleeping” functionality (without the breaking of the train in case of losing connection with tail EVC);
- management of Position Report (Q_lenght parameter) to RBC to check the safe tail of the ETCS train;
- Cab Radio for GPRS and MT with Professional Filter against interferences.
BL3 Braking Model: case study for HD ERTMS

- «Safe» pneumatic brake
- Gradient null (flat line)
- No degraded adhesion (no wet track)
- Target speed monitoring without SBI (Service Brake Intervention)
- Odometric errors space-offset according to specification
- HD section length = 350 m
- EoA – SL (Supervised Location) = 50 m or 100 m
- Release speed calculated by EVC
- Train characteristics:
  - «Light» passengers train featured as «gamma train»
  - Interfaced traction cutting off
  - Lunghezza fino a 200 m (tempo equivalente 3,5 s circa)
  - Braking performance assimilable to weight breaking of 140 % or more
- Rolling stock correction factors Krst = 0,9 (*)
- Other protection factors null
**Conclusions: results of simulation**

<table>
<thead>
<tr>
<th>N° of sections</th>
<th>MA length</th>
<th>EoA–SL distance (overlap)</th>
<th>Nominal Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>350 m</td>
<td>≥ 50 m</td>
<td>30 km/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 100 m</td>
<td>40 km/h</td>
</tr>
<tr>
<td>2</td>
<td>700 m</td>
<td>≥ 50 m</td>
<td>85 km/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 100 m</td>
<td>90 km/h</td>
</tr>
<tr>
<td>3</td>
<td>1050 m</td>
<td>≥ 50 m</td>
<td>120 km/h</td>
</tr>
</tbody>
</table>

HD ERTMS raise up the average speed of route entering!
Images from the International Sustainability Institute

Here are 200 people in 177 cars
without cars
on bikes

Images of downtown Seattle’s 2nd Avenue

From the International Sustainability Institute’s Commuter Toolkit poster
on 3 buses
More than 1 light rail train

HD ERTMS: Improve train path!
Thank you
for your attention