Satellite for Rail
(Satellite Communications and Global Navigation Satellite Systems)

ETSI Workshop – Managing Rail Mobile Communications Evolution
2-3rd November 2016

Michele Castorina, Christian Wullems
ESA-TIAA-HO-2016-0992
Presentation Overview

- What we do (our programmes, Space4Rail)
- Thematic areas
  - SATCOM
    - What we have done
    - ESA & EUAR
    - SatCom for railways
    - Plan of activities – towards 2021
  - GNSS
    - High-level virtual balise concept
    - ESA’s role in NGTC and support to community
    - What we have done in GNSS
    - Plan of activities – towards 2021
Space4Rail is an ESA initiative to support the railway community by raising awareness of the added value that space-based assets can bring to railway applications.

The initiative identifies ESA funding programmes that can support potential opportunities for the exploitation of space-based assets such as telecommunication, navigation and earth observation satellites to meet today’s challenges and needs in railway operations.

The ESA programmes included in the Space4Rail initiative are

- Advanced Research in Telecommunications Systems (ARTES)
- General Support Technology Programme (GSTP)
- Technology Research Programme (TRP)
- General Studies Programme (GSP)
Thematic Areas

**Broadband to passengers**
- Opportunities: On board internet and entertainment in case of lack of terrestrial coverage in rural areas complemented by terrestrial networks
- Activities: Broadband to Trains, SAET, INDRA, EOMST,

**Signalling**
- Opportunities: Low cost signalling using GNSS and SatCom through virtual balises and carrier independent telecommunications solutions, innovative solutions at level crossing.
- Activities: 3InSat, SBSRailS, SatCom Rail, EMUSER, INLU, RailSafe, LeCross, Saferail

**Railway Infrastructure monitoring**
- Opportunities: railways stability and subsidence analysis, landslides and rock fall prevention
- Activities: MATIST, LIVE LAND

**Tracking**
- Opportunities: railway asset monitoring for safety and operational effectiveness
- Activities: SAMOLOSA, IRISS
SATELLITE TELECOMMUNICATIONS FOR RAIL
ESA Activities Supporting Satcom for railways

A demo project testing of IP-based multi-bearer communications (3/4G, TETRA, SATCOM) for ETCS data

A study to identify and evaluate the most promising satellite communication solutions candidates to meet the requirements complementing existing terrestrial communication networks

A study to determine the technical feasibility and economic viability of “satellite add-ons” GNSS+SATCOM (voice+data)
ESA and EUAR

- ESA is cooperating with European Agency for Railways (EUAR) since 2012
- ESA is involved in the EUAR study (led by INDRA/ALG) on the Study on feasibility of SatCom for railway communication; EUAR is involved in the ESA studies
- ESA and EUAR share a mutual interest to investigate the use of space-based technologies and applications, in particular related to the SatCom and SatNav areas and complementing terrestrial railway infrastructures.
- ESA and EUAR will collaborate to harmonize Space4Rail activities with those undertaken in the framework of the program on evolution on railway radio communication
Space for safe skies
ESA’s Iris Programme of satellite communication for ATM

What is Iris?

• A validated satellite-based communication system for air traffic management, fulfilling the requirements for the future Air Traffic Management communication infrastructure

• A technology to provide safe and cyber-secure air-to-ground services, portable to other Transport Domains (e.g. train management systems)

• A tool to support operational and business application developments

• In coordination with SESAR JU
IRIS for Railway

- IRIS looks to be a promising solution also for railway:
  - SATCOM used as complementary solution to the terrestrial component in multilink configuration
  - High capacity
  - Wide and homogeneous coverage
  - Modular for regional and global system deployment
  - Higher safety standards
  - Higher performance requirements: i.e. availability, integrity, latency
• In the context of Space4Rail and in coordination with EUAR, ESA will launch a study to identify how to use IRIS solution for railway applications, and will support development of space and ground segment technologies
• A coordination with Shift2Rail (as done in the past with SESAR) is desirable
• A shared roadmap should be identified with the key stakeholders
GLOBAL NAVIGATION SATELLITE SYSTEMS FOR RAIL
Satellite-based functions (including use of GNSS for virtual balise detection) have been identified as **key new capabilities of the next evolution** of the European Rail Traffic Management System (ERTMS).

European Railway Agency, ERTMS Control Command and Railway Communication Conference (CCRCC) in Lille, 22nd September 2015
ESA Activities Supporting Virtual Balise Concept

**Integrated Signalling System**
- 2 GNSS reference stations
- Vital Safety Server implementing RBC and Track-area LDS functions (installed in Cagliari control centre)
- Train equipped with ERTMS EVC and LDS on-board (shadow mode)

**Feasibility study**
- determine the technical feasibility and economic viability of “satellite add-ons”
- (SATNAV and SATCOM with terrestrial comms)

ESA was part of satellite experts group providing support to NGTC WP7
Virtual Balise Concept

Virtual Balise Concept

- Reduction / Replacement of physical Eurobalises with virtual balises
- Use of GNSS for virtual balise detection
- Reduce cost of ETCS trackside
- Reduce exposure to theft, vandalism, etc.
- Minimise impact on existing ETCS architecture
Virtual Balise Detection using GNSS

ETCS Eurobalise Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>THR for failure of balise group detection (ETCS on-board)</td>
<td>1.0E-7 dangerous failures / hour</td>
</tr>
<tr>
<td>THR for failure of a balise group being detectable (trackside)</td>
<td>1.0E-9 dangerous failures / hour (individual balise unavailability &lt; 2E-5 / hour)</td>
</tr>
<tr>
<td>THR for cross-talk of balise group (on-board and trackside)</td>
<td>1.0E-9 dangerous failures / hour</td>
</tr>
<tr>
<td>Balise detection accuracy for vital purposes</td>
<td>Within ±1m</td>
</tr>
</tbody>
</table>

Simplified version of concept proposed in NGTC WP7
GNSS Challenges (Local Environment)

AIRBUS Beluga (10) (SBAS/EGNOS CMC)

DLR Aeronautical channel

DLR Land mobile car channel (LMC)

Airframe multipath budget

Multipath observed in railway environment
**GNSS Challenges (Intentional Interference)**

1. **Resilience in the presence of...**
   a. **Jamming**
      i. Unavailability caused by GPS jammers
         1) E.g. in vehicles parallel to the railway line
   
   b. **Spoofing**
      i. Need to understand risk and possible attack scenarios
Telecoms to Support New ETCS Capabilities

Will GSM-R evolution satisfy bandwidth requirements for Virtual Balise concept (and other “game-changing” capabilities)?

a. NGTC functional architecture
   i. Aims to minimise changes to ETCS and use existing EURORADIO channel (where practicable)

b. GNSS augmentation information
   i. Limited availability from SIS
   ii. Latency is critical

c. Virtual balise information
   i. Several options:
   ii. Upload of track DB for RBC area
   iii. Provided progressively with MA (update of on-board database)

NGTC functional architecture (physical architecture is not defined)
1. GSA Map of Activities
   a. For telecoms?

2. ESA Technology Support Activities in GNSS
   a. Tools and technology-enablers to support development and certification of virtual balise detection using GNSS in ETCS

3. First intended ITT on EMITS for GNSS Simulation Testbed
   a. Link on space4rail.esa.int
Questions?

Michele Castorina (michele.castorina@esa.int)
Christian Wullems (christian.wullems@esa.int)