GNSS for Train Control and Management Systems: Challenges and Opportunities for a Global Service

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Ansaldo STS

Ninth Meeting of the International Committee on Global Navigation Satellite Systems
Applications and Experts Seminar
Prague, Czech Republic
10 November 2014
Satellite-based solutions for Train Control Systems

Exploit new technologies
Ensure compatibility with signaling systems

Market driven

Making investments more attractive

Rail applications

Space technology

GNSS Assets
- Multii Constellation
- Wide Augmentation Networks
- Local Augmentation Networks

Train Control Needs
- Train positioning
- Track occupancy
- Train integrity

Reduce track-circuitry

GNSS & Rail
A Global challenge

USA

Ref: CRS Report for Congress

China

By 2020, over 30 thousand kilometer railway lines will be investigated and constructed. Then there will be more than 120 thousand kilometer railway line in China (including 45 thousand kilometer high-speed line).

Rapid develop & construction of railway
Integrate the satellite navigation and railway system to promote industrialized development.
Expand the function of satellite navigation system for economic and social values.
Collision alerting system for high-speed lines
Low-cost train control system for western China

Ref: BEIJING JIAO TONG UNIVERSITY

Europe

SHIFT²RAIL IP2 Advanced Traffic Management and Control System

UNISIG WG Satellite
European GNSS Agency

Next Generation Train Control - WP7

2012 2013 2022

Ref: NGTC

Stake-holder’s Roadmap
Specific applications

- heavy haul freight
- low traffic
- urban nodes

- lower operational costs
- increase capacity
- increase safety
The aim is to **reduce cost** of ETCS trackside by reducing the number of (real) balises in the track, which would also increase availability, reduce exposure to theft, vandalism etc. To minimize the impact on ETCS the concept of “virtual balises” was developed, in which a GNSS based positioning system shall confirm train position at defined reference points. This also allows handling of gaps in coverage, compared to a solution which requires permanent coverage.
GNSS Target Performance: ETCS Level 2

Approaching Dangerous point

Start of Mission

Normal operation

THR: 3e-8/1 h
CI ~ 14 m

THR: 1.4e-10/1 h
Cl ~ 3 m

THR: 3e-8/1 h
CI: 20 – 100 m

Ref. 3InSat project Safety case (Ales Filip, AZD)
Train Integrity

Virtual Track Circuit

Protection Level

~ 40-60% + capacity

Normal Probability Plot: case GF+RN, Train length L=2500 m

Radio Block Centre
Reference architecture

Wide Area Augmentation Networks

QoS

Radio Block Center (RBC)

TALS

Track Area Augmentation Network

RS 1  RS 2  ...  RS n

GPS  GLONASS  GALILEO  BEIDOU

Track

Area

Augmentation

Networks

QoS
“Dependability” is the capability of a system to deliver the correct service with an acceptable trust, specially in presence of faults, either due to internal or external causes.
Harsh railway environment

<table>
<thead>
<tr>
<th>Property</th>
<th>Characteristic</th>
<th>en-route</th>
<th>APV-I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>Horizontal Accuracy (99%)</td>
<td>3.7 km</td>
<td>16 m</td>
</tr>
<tr>
<td></td>
<td>Vertical Accuracy (99%)</td>
<td>N/A</td>
<td>6.4 m</td>
</tr>
<tr>
<td>Continuity</td>
<td>Continuity Risk</td>
<td>$10^{-5}$/h</td>
<td>$10^{-6}$/h</td>
</tr>
<tr>
<td>Availability</td>
<td></td>
<td>0.99 to 0.99999</td>
<td></td>
</tr>
<tr>
<td>Integrity</td>
<td>$3 \times 10^{-7}$/h</td>
<td>2 $\times 10^{-7}$/150 sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alarm Limit</td>
<td>1.85 - 7.4 km</td>
<td>40 m</td>
</tr>
<tr>
<td></td>
<td>Time to Alarm</td>
<td>10 sec - 5 min</td>
<td>6 sec</td>
</tr>
</tbody>
</table>

N/A: not available
The requirement is excerpted from the ICAO recommendations [13].

MOPs for Rail Applications?
Development & Test satellite technologies for rail signalling applications:
- Sat-com
- Geo-localization
http://artes-apps.esa.int/projects/3insat

Integrated Test-Bed
- EGNOS + Local Au-Networks
- Multi-bearer TLC
- Signalling

Joint Undertaking for innovation in rail sector
- IP-2: Innovative train control systems
http://www.shift2rail.org
ERSAT: Test Bed for Integrated Tests on field

- RBC
- TLC
- Mobile Access Router
  - TETRA
  - SATCOM
  - GSM-3G
- Train On-board system
- GNSS Localizer
- Track area station
- Rail TLC
- Track area Stations
- IP-based TLC
- L2 Virtual balise
- LDS
- Radio
- RBC & IXL
- Points
- 50 km
Conclusion

GNSS adoption for train control is a global challenge

- **Technology:**
  - Validation of GNSS technology developed for other applications
  - Dependability of GNSS parameters
  - QoS for interfacing Augmentation networks

- **Procedures:**
  - Adaptation of certifications released by other sectors (ie aviation)
  - Updating of existing reference norms

- **Contractual:**
  - Liability
  - Global coverage
Thank you for your attention