Requirements for the use of Galileo in Railway Applications

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Structure of the presentation

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- Classification of GNSS-based applications in railways
  - Information applications
  - Assistance application
  - Safety-relevant control applications
- Resulting requirements on GNSS
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  - technical requirements
  - operational requirements
- Conclusion and Perspective
Introduction

- GALILEO enables the on board localisation in real time of the trains.
- The topologic location and the precise time of the trains is a basic information for different railway applications like operations control or scheduling of trains.
- The new ERTMS/ETCS requires the train to know his own position.

ERTMS: European Rail Management System, ETCS: European Train Control System
# Introduction

## GALILEO Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Open Service</th>
<th>SOL Service</th>
<th>Public Regulated Service</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequencies</strong></td>
<td>Single</td>
<td>Dual</td>
<td>Triple</td>
</tr>
<tr>
<td><strong>Time Criticality</strong></td>
<td>-</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Regional Availability</strong></td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
</tr>
<tr>
<td><strong>Precision (95%)</strong></td>
<td>H: 15 m</td>
<td>H: 4 m</td>
<td>H: 4 m</td>
</tr>
<tr>
<td></td>
<td>V: 35 m</td>
<td>V: 8 m</td>
<td>V: 8 m</td>
</tr>
<tr>
<td><strong>Integrity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Alarm limit</strong></td>
<td>Not</td>
<td>H: 12 m</td>
<td>H: 556 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V: 20 m</td>
<td>V: 20 m</td>
</tr>
<tr>
<td><strong>Alarm time</strong></td>
<td>Available !</td>
<td>6 s</td>
<td>10 s</td>
</tr>
<tr>
<td><strong>Integrity risk</strong></td>
<td></td>
<td>1.5e-7/150s</td>
<td>1e-7/1h</td>
</tr>
<tr>
<td><strong>Continuity</strong></td>
<td>8e-6 pro 15 s</td>
<td>8e-6 pro 15 s</td>
<td>1e-4...1e-8 pro h</td>
</tr>
<tr>
<td><strong>Time Precision UTC/TAI</strong></td>
<td>Not defined</td>
<td>50 ns</td>
<td>50 ns</td>
</tr>
<tr>
<td><strong>Certification</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Availability</strong></td>
<td>99.5 %</td>
<td>99.8 %</td>
<td>99 – 99.9 %</td>
</tr>
</tbody>
</table>
Classification of GNSS-based applications in railways

3 Basic Classes:
- Information applications
- Assistance application
- Safety-relevant control systems
Classification of GNSS-based applications in railways – Information applications

Definition:
Applications used to acquire, collect or distribute information about dynamic or static status information of the railway system. They must not interfere with the safety relevant part of the system.

Examples:
- Goods tracking and tracing
- Railway vehicle identification systems
- Network use fees and toll collection
- Service fee collection
- Collection of geo-referenced environmental data
- Etc.
Classification of GNSS-based applications in railways – Assistance applications

**Definition:**

Applications used to assist a human being by performing the operation of the railway. They can perform safety-related tasks and interact with the safety-relevant part of the system, without being safety-critical by their own.

**Examples:**

- Advanced Alarm, Search and Rescue (ASAR)
- Support of overhauling whilst in motion in mixed operation
- Energy-optimal driving (locally or network-wide)
- Support of power-optimal driving by wireless intra-train communication
- Telemetry of dangerous goods
- Performance-optimal scheduling
- Etc.
Classification of GNSS-based applications in railways –
Safety-relevant applications

Definition:
Applications which are in charge to ensure safe operation of the railways with or without interaction with a human being. To reach the safety target a system with two independent measurement principles is needed.

Examples:
- Railway Operations Control
  - Train Separation
  - Speed and Distance Supervision
  - Route Supervision
  - Train integrity
- Support of time-optimal braking by wireless intra-train communication
- Automatic warning at platforms
- Etc.
Resulting requirements on GNSS

- The exact requirements are depending on a multitude of parameters:
  - Type of application
  - Operational characteristics
  - Safety case
  - Etc.

- Only a first estimation can be given here.

- Globally the requirements can be grouped in:
  Functional requirements as:
  - Precision
  - Performance
  - Signal-Integrity
  - Data Format

  Non-Functional requirements as:
  - Safety
  - Reliability
  - Availability
  - Maintainability
  - Costs
### Resulting requirements on GNSS – Examples for Information applications

<table>
<thead>
<tr>
<th>Generic information application</th>
<th>Goods tracking and tracing</th>
<th>Railway vehicle identification systems</th>
<th>Network use fees and toll collection</th>
<th>Service fee collection</th>
<th>Alarm, Search and Rescue</th>
<th>Collection of geo-referenced environmental data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Precision</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>100m-1km</td>
<td>100m</td>
<td>100m</td>
<td>1km</td>
<td>1km</td>
<td>100m</td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Z</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>track selectivity</td>
<td>no (yes)</td>
<td>no (yes)</td>
<td>yes</td>
<td>no (yes)</td>
<td>no (yes)</td>
<td>no</td>
</tr>
<tr>
<td>Performance</td>
<td>low - medium</td>
<td>low</td>
<td>low - medium</td>
<td>low</td>
<td>low</td>
<td>medium</td>
</tr>
<tr>
<td><strong>RAMS</strong></td>
<td></td>
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<tr>
<td>Safety</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Reliability</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>low</td>
</tr>
<tr>
<td>Availability</td>
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<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>low</td>
</tr>
<tr>
<td>Cost</td>
<td>low</td>
<td>low-medium</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>low</td>
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### Resulting requirements on GNSS – Examples for Assistance applications

<table>
<thead>
<tr>
<th>RAMS</th>
<th>Safety</th>
<th>Reliability</th>
<th>Availability</th>
<th>Maintainability</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>-</td>
<td>10-100 m</td>
<td>10m</td>
<td>10-100 m</td>
<td>10m</td>
</tr>
<tr>
<td>Y</td>
<td>-</td>
<td>10-100 m</td>
<td>10m</td>
<td>10-100 m</td>
<td>100m</td>
</tr>
<tr>
<td>Z</td>
<td>-</td>
<td>10-100 m</td>
<td>10m</td>
<td>100m</td>
<td>100m</td>
</tr>
<tr>
<td>track selectivity</td>
<td>yes (no)</td>
<td>yes</td>
<td>yes (no)</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Performance</td>
<td>medium - high</td>
<td>high</td>
<td>high</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td></td>
<td>SIL 1-2</td>
<td>?</td>
<td>SIL 2</td>
<td>SIL 2</td>
<td>SIL 2</td>
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<tr>
<td></td>
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<td>medium</td>
<td>medium</td>
<td>medium</td>
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<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>?</td>
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<tr>
<td></td>
<td>low-medium</td>
<td>?</td>
<td>low</td>
<td>medium</td>
<td>low</td>
</tr>
</tbody>
</table>

**Precision**

- X: 10-100 m
- Y: 10-100 m
- Z: 10-100 m

**Track selectivity**

- yes (no)

**Performance**

- medium - high
- high
- high
- medium
- high
- medium

**Safety**

- SIL 1-2
- SIL 2
- SIL 2
- SIL 2
- SIL 2

**Reliability**

- medium
- medium
- medium
- medium
- high

**Availability**

- medium
- high
- medium
- medium
- high

**Maintainability**

- medium
- medium
- medium
- medium
- medium

**Cost**

- low-medium
- low
- medium
- medium
- low-medium
### Resulting requirements on GNSS –
#### Examples for Safety-relevant applications

<table>
<thead>
<tr>
<th>Precision</th>
<th>Generic safety-critical application</th>
<th>ERTMS/ETCS</th>
<th>Railway Operations Control</th>
<th>Train Separation</th>
<th>Speed and Distance Supervision</th>
<th>Route Supervision</th>
<th>Train integrity</th>
<th>Support of time-optimal braking</th>
<th>Automatic warning at platforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>10-100 m</td>
<td>10-100 m</td>
<td>10-100 m</td>
<td>100m</td>
<td>10-100 m</td>
<td>100m</td>
<td>10m</td>
<td>10m</td>
<td>100m</td>
</tr>
<tr>
<td>Y</td>
<td>(1m)</td>
<td>1m</td>
<td>1m</td>
<td>1m</td>
<td>1m</td>
<td>1m</td>
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<tr>
<td>track selectivity</td>
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<td>yes</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
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<td>Performance</td>
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<tr>
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<td>SIL 4</td>
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<tr>
<td>Availability</td>
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<tr>
<td>Maintainability</td>
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<td>high</td>
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<td>high</td>
<td>high</td>
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</tr>
<tr>
<td>Cost</td>
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<td>high</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
</tr>
</tbody>
</table>
Conclusion and Perspective

Conclusion

• GNSS can help the railways to become more competitive.
• The different possible applications can be grouped in information, assistance and safety-critical applications.
• Information applications can use GALILEO as the only source of localisation.
• Safety-relevant applications will need a second independent source of localisation.

Perspective

• The certification of GNSS must show the applicable level of safety.
• GALILEO will enable a lot of new or improved applications for railways.
Thank you for your attention!

Questions?