GRAIL: GNSS in the rail domain
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Galileo 6th Framework Programme
Project objective: to support the introduction of GNSS in the Rail market, with a special emphasis on ERTMS/ETCS.

Co-financed by the GSA (50%)

Duration: started sep-05, to finish end of may-08
Project Objectives

1. **To achieve a common specification for the GNSS subsystem for the**
   - Enhanced Odometry application
   - Enhanced ETCS applications (absolute positioning)

2. **To develop and test a prototype of the GNSS subsystem for the Enhanced Odometry and the Enhanced ETCS applications**
   - Tests in a real ERTMS/ETCS line
   - Tests in a lab environment

3. **To study the complementary aspects**
   - economic issues
   - legal issues
   - development of GNSS local elements specific for railways consistent with the objectives 1 and 2
Selected applications

► Enhanced Odometry
► Train Awakening / Cold Movement Detection
► Absolute Positioning
► Train Integrity
Enhanced Odometry - Architecture

OPTION 1:
- current ETCS odometry performances:
  ± (5 + 5%)s
- simple UT: basically providing speed information
- no change in the ETCS specifications
- cost reduction (TBD)
- Increased availability

OPTION 2 (Enhanced ETCS odometry):
- increased performances for the UT:
  ± (5 + 2%)s
- more complex UT (current WP3 specifications): providing additional information apart from speed
- UT external to the ETCS on-board system (PROFIBUS) → change in the ETCS specifications
Train Awakening and CMD - Architecture

UT
- Coordinates translation
- Other Sensors
- GNSS receiver
- LE UT

ETCS on board
- ODO
- Kernel
- BTM
- Euroradio

1 Relative position
- D_LRBG
- NID_LRBG
- Q_DLRLRBG
- Q_DIRLRBG

2 Position info
- Doppler Radar, tacho and other odometric signals

RBC
- Balise

- List of reference points
- TA areas
Absolute Positioning - Architecture

UT

- GNSS Receiver
- GNSS Algorithm
- Balise database
- Integrity monitoring
- Track map
- Database management
- GNSS raw data
- APRP ID
- High integrity Abs. Positioning (in ETCS referential)
- High integrity speed

ETCS ONBOARD

- BTM
- Odometry
- EURORADIO

Other sensors

RBC Subsystem

- Track map
- Balises database

GSM-R
Train Integrity – Functions / Architecture

Functions:
- **Train integrity** assessment
- **Train length confirmation** at Start of Mission

Diagram:
- Front train integrity assessment device
- End of train device
- Mechanical interface
- Radio communication
- ETCS
- Juridical recorder
- Train staff or Driver
**Digital Map specifications**

**GRAIL Digital Map**: a data base providing location infrastructure data required for train operation with ETCS and GNSS technology

<table>
<thead>
<tr>
<th>General Functional requirements:</th>
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<tbody>
<tr>
<td>Layer 0 Reference frame (e.g. WGS 84)</td>
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<tr>
<td>Layer 1 Track description (nodes &amp; track sections &amp; tracks)</td>
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<tr>
<td>Layer 2 Elements of the track (balises and reference points, TA areas, RBC areas, tunnels, etc.)</td>
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<thead>
<tr>
<th>Specific Functional requirements:</th>
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<tbody>
<tr>
<td><strong>AP</strong> (layer 2):</td>
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<tr>
<td>• Balise Data Set</td>
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<tr>
<td>• AP Reference Point Data Set</td>
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<tr>
<td><strong>TA</strong> (layer 2)</td>
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<tr>
<td>• List of RBC’s ID, phone n°s &amp; RBC’s areas</td>
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<tr>
<td>• List of areas where TA is allowed</td>
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<tr>
<td>• Reference points</td>
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<tr>
<th>General Performance requirements:</th>
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<tr>
<td>• Node location accuracy: &lt; 1m</td>
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<tr>
<td>• Track section geometric length: so that the error between the modeled track and the actual track is &lt; 1m.</td>
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<th>Specific Performance requirements:</th>
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<tr>
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<tr>
<td>Position accuracy</td>
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<tr>
<td>&lt; 1m</td>
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<tr>
<th>Track section length</th>
<th>APRP</th>
<th>TA</th>
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<tr>
<td>&lt; 0.2%</td>
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GRAIL Demostration: Lab tests

GNSS / IMU simulation introduced in CEDEX environment
GRAIL Demostration: Lab tests

Laboratory Demonstration in CEDEX Lab

Conclusions

A reference simulation environment for GNSS application to ERTMS has been defined and implemented

- Execution Technical Instructions for the defined tests

- GNSS simulation integrated successfully in ERTMS certification environment

- Defined test has been successfully executed, showing the applicability of proposed enhanced functionalities to present ERTMS standard
GRAIL Demonstration: Onsite tests

Test Train: GNSS equipment
Test Train: ERTMS equipment

Ansaldo OBU installed onboard  
BTM and synchronization IF
GRAIL Demostration: Onsite tests

A view of the test train: TALGO BT
 UT FEATURES

- UT Normal operation. In cab signalling with GNSS odometry
- UT Calibration operations
- Diagnosis and self-tests

ENHANCED ODOMETRY

- Communication and Synchronization with OBU
- In cab signalling with GNSS odometry. Normal operation
- In cab signalling with GNSS odometry. Failure/absence of signal from GNSS
- In cab signalling with GNSS odometry. Failure/absence of other Odometry sources

TRADITIONAL ODOMETRY DISCONNECTED AT OBU SOFTWARE LEVEL
Some results: Absolute position Reference Points

- APRP database elaborated during demonstration campaign.
  - During several trips UT collected position data and time-stamped it with CTODL/OBU time
  - Simultaneously, OBU was recording time when balises groups were passed
  - Offline comparison of both records was used to established Database
  - RBC was not modify for GRAIL demonstration, hence APRP had to be made of all balises in the trip. Demonstration database with 88 balises

- For APRP demonstration. Balise antenna was disconnected from BTM. OBU was receiving reference position information only from UT

- All database length was succesfully covered in ERTMS Level 2 and Full supervision mode. Some APRP were lost and others detected off of the expectation window but not enough losses to provoke brake intervention in ERTMS implementation of a commercial line
Conclusions

• Current results
  – Agreed specifications for selected applications
  – Agreed performance requirements
  – CBA final iteration
  – Regulatory recommendations
  – Safety requirements under discussion
  – Laboratory and Safety Analysis

• Formal delivery of results by the end of June ’08

• GRAIL is an important step ahead in the use of GNSS in the ERTMS/ETCS environment.

For further information: www.grail-project.com