The GRAIL project: Galileo Localisation for the European Train Control System

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Galileo 6th Framework Programme
Structure

► The GRAIL Project:
  ► Context
  ► Consortium
  ► Objectives
  ► Status

► WP 3: Specification and Safety Analysis
  ► Enhances Odometry
  ► Support of Train Awakening and Cold Movement Detection
  ► Absolute Positioning
  ► Train Integrity Monitoring
  ► Safety Analysis

► Conclusion and Perspective
Context

**GRAIL: GNSS Introduction in the RAIL sector**

- **Project objective:**
  - Define applications as well as roadmap to support the introduction of GNSS in the Rail market
  - Specification and Test of applications to support ERTMS/ETCS.
- **Managed by the GJU/GSA**
- **Duration:**
  - From 1st-Sep-05 to 30st-May-08
- **Budget:** 6.627.191 Euro (estimated cost)
- **Co-financed by the GJU/GSA (50%)**
GRAIL Consortium
1. To achieve a **common specification** agreed by Users and Industry for the GNSS subsystem for the
   - Enhanced Odometry application
   - Enhanced ETCS applications (absolute positioning, train integrity, train awakening and cold movement detector)

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

3. To **study the complementary aspects**
   - economical issues
   - legal issues
   - development of GNSS local elements specific for railways
Current Status

► Achievements
  • Application Survey and Analysis. WP1.1
  • Service Enablers. WP1.2
  • Action Plan. WP1.3
  • Acceptance criteria and Safety Requirements - HAZOPs WP2
  • Legal and Regulatory analysis. WP7.2
  • Definition of a GNSS based **System Requirement Specification, Interface Specification**, and **Test Specification** for enhanced odometry, train awakening, absolute positioning and train integrity. WP3
  • Review of the specifications. WP3
  • Cost-benefit analysis WP7.1
  • Demonstration test plan. WP4
  • Migration strategies & User’s workshops. WP5
  • Local elements. WP6

► On-going activities
  • Safety analysis. WP3.4
  • Demonstration test activities. WP4
  • Legal and Regulatory recommendations. WP7.2
  • Dissemination and awareness. WP8
GNSS Subsystem Specifications

- System Requirement Specification (first draft)
  - Functional description
  - System architecture
  - Requirements at system level (functional, performance)

- ETCS-GNSS Interface specification (first draft)
  - Logical and Physical levels

- Test specification (first draft)
  - Functional and performance tests (in operation)
  - Test tools and reference test architecture (in operation)

- Safety requirements for the GNSS subsystem to allocate SIL to the different modules (on-going)
Enhanced Odometry - Functions

- **Measure position and speed** (along track)
  - To acquire the navigation data
  - To implement a real time data fusion in order to generate odometric information in a common format.
  - To prepare information to be sent in the appropriate format and timing.
  - Time stamping the data from GNSS receiver

- **Data processing and error estimation:**
  - Data fusion (sensor output elaboration, translation of coordinates, etc.)
  - Status determination: Diagnostic and self-test
  - Integrity monitoring of SIS (including Local effects)
  - Compute confidence interval
→ external to the ETCS on-board system
→ used as another sensor
→ independently management from the other sensors information
→ Data fusion from different sensors carried out in ETCS odometry function

The use of other sensors remains optional for the EVC suppliers
Train Awakening and CMD - Functions

Cold Movement Detection:
- Detection of **train movement** during **No Power** mode (based in the comparison of two absolute positions)
- **Validation of stored data**: During switch-on process, stored data, if any, are validated or not depending whether cold movement has been detected.

Train Awakening:
- Providing valid **RBC ID/telephone number** under request by ERTMS/ETCS on-board equipment (when in L2 and RBC ID/phone no. are unknown or invalid)
- Providing **valid position** under request by ERTMS/ETCS on-board equipment (when location variables are unknown or invalid). These include:
  - Identification of a reference point: It is a reference balise to be used as LRBG for the distance
  - Position of train: This information shall be provided as a distance along the track from LRBG and orientation of position of train with regard to orientation of LRBG
  - Orientation of train: Orientation of train with regard to orientation of LRBG
Train Awakening and CMD - Architecture

ETCS on board
- ODO
- Kernel
- BTM
- Euroradio

1 Relative position
- D_LRBG
- NID_LRBG
- Q_DLRBG
- Q_DIRLRBG

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

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

- List of reference points
- TA areas

Balise
RBC
Absolute Positioning - Functions

Approaches: position input to ETCS odometry and input to ETCS on board

Functions:

• **Compute train position**: in terms of travelled distance from the last LRBG or the last APRP and determine the confidence interval on the position corresponding to the required high integrity level.

• **Data translation in ETCS reference**: The positioning data obtained in the GNSS referential will be translated into a travelled distance from the LRBG or the last APRP.

• **Compute train speed**: two level of safety integrity have been defined for speed

• **Compute time**: This function takes SIS in input and provides the Universal Time Coordinated (UTC) in output.

• **Provide position information to ETCS**: sending position code to the ETCS on-board subsystem so that the odometry will make fusion.

• **Integrity Monitoring function**: of the SIS as well as the integrity of the UT itself.

• **Data base management**: monitors the integrity of the database internal to the UT.
Absolute Positioning - Architecture

UT

- GNSS Receiver
- GNSS Algorithm
- Balises database
- Integrity monitoring
- Track map

ETCS ONBOARD

- BTM
- Odometry
- EURO-RADIO

RBC Subsystem

- Track map
- Balises database

Database management

GNSS raw data

Balise_ID

APRP ID

High integrity Abs. Positioning (in ETCS references)
High integrity speed

GSM-R

Other sensors
Train Integrity - Functions

Functions:
• Train integrity assessment
  – Elaborate the TI status (TI ok, TI lost, TI unknown) and safe train length confidence interval
  – Displaying status and providing alarms to train staff (maintenance or info for the driver).
  – Computing and managing Juridical data
  – Providing train’s tail red light indication
• Train length confirmation at SoM

Inputs (ETCS subsystem to GNSS subsystem):
• Trigger to update TI info (if TI is event-driven) or parameters (cycle information,...) – [See output rate requirement] and configurable (TBC)
• Train length

Outputs (GNSS subsystem to ETCS subsystem):
• TI status (ok-train complete, lost-train not complete, Failure state/unknown, TI info unknown)
• Train length confidence interval (referred to the position of the rear of the train)
• Train length confirmation
• Info for the juridical recorder and for train staff
Train Integrity - Architecture

ETCS

GNSS subsystem (train integrity)

Front part

Rear part

SIS

TRAIN

(1)

(2)

Train front vehicle

Front train integrity assessment device

Train staff or Driver

Juridical recorder

ETCS

Radio communication

Train rear vehicle

End of train device

Mechanical interface
WP3.4 Safety Analysis Activities

According to CEN/CENELEC and UNISIG ERTMS/ETCS Subset 091

PHA Specification oriented

PHA content:
- Establish for the purpose of the analysis the boundaries of the application system and those to which it interfaces
- Establish the overall system structure, functions.
- Obtain the hazards from the earlier HAZOP and complementary analyses, e.g. FTA and FMEA
- Apply rational systematic and random probability targets
- Set out safety barriers and SILs
Conclusion and Perspective

► GRAIL is progressing well

► Both railway signalling (all UNISIG companies) and GNSS industry have proved a good co-operation towards a common interest.

► Main on-going activities:
  ► Test and Demonstration
  ► Finalisation of the Safety Analysis
  ► Digital map: Structure and Processes
Thank you!