The Galileo Test Range

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Abstract. The GTR (Galileo Test Range) project is an initiative of Regione Lazio in the frame of its support to technical research and innovation in satellite navigation. Its main target is the development of a laboratory for the test and analysis of the Galileo signals, the support for development, test and certification of user terminals (GPS, EGNOS, Galileo) and of applications in different user domains.

The Phase A of the project started on July 2005.

The project is coordinated by a Consortium Agreement (C.A) composed by Telespazio, Alcatel Alenia Space Italia and Finmeccanica under the supervisory of FILAS S.p.A. the regional Financial Investment Agency dedicated to the support of innovation.

In the phase A, the C.A. has the responsibility of developing an infrastructure able to acquire and process signals coming from a constellation of pseudolites, from GPS, from EGNOS and from GSTB V2 satellites and able to support the testing of applications demanding high accuracy positioning providing augmentation to the users in the covered area.

Actually the proposal of constituting a center of excellence for satellite navigation follows the strategy of growth of industrial and technological capabilities in the frame of an industrial development policy pursued by Regione Lazio.

1 The GTR Center – Overview

The Galileo Test Range (GTR) project is an initiative of Regione Lazio in the frame of its support to technical research and innovation in satellite navigation. It is born with the scope of supporting the following high level missions:

- Characterization of the Galileo signal: the GTR aims to support the activity of analysing the performance of the Galileo navigation system, through the analysis of signal measurements in an environment suitably characterized and controlled. For this purpose, the GTR shall be able to gather raw navigation data within an experimental area and to process them in its analysis laboratories. Such objective is limited, as far as Phase A is concerned, to the characterization of the signal GTSB-V2, as it is propedeutical to the final scope of characterizing the Galileo signal, this latter assigned to the Final Phase of the Programme. This Centre will support the certification of the Galileo receivers the GTR must represent a suitable Test Bed for Galileo terminals, besides the GPS and EGNOS, placing the own navigation infrastructures and all the necessary hardware and software support instruments at disposal.

- Realization and Distribution of Services: The GTR, with the know-how and the experience gathered in the first operative phase of the project, must be set as a base for the realization of the Services to be distributed to the end users both public bodies, companies and privates. The support for the certification of applications, at a system level and at user terminal level, the possibility of providing universities and research centres with laboratories and testing areas, the continuous monitoring of the Galileo constellation are the basis of the GTR offer. Moreover the GTR aims to support the definition and the development of new High-Tech applications in the various user domains, for the utilization of the services offered by Galileo once operative.

  The development of the GTR is foreseen in three phases, in order to match the capabilities of the system with the development plan of Galileo:
  - Phase A = Definition and Start up: implementation of the initial system, based on the generation on ground of navigation signals (GPS-like) using pseudolite technology and based on the analysis and use of signals in space coming from GPS and EGNOS.
  - Phase B1 = Preparation to the development and deployment of Galileo system: implementation of the GTR in a configuration able to generate Galileo-like signals with ground equipment and to receive real signals coming from GSTB V2.
  - Phase B2 = Full deployment and initialisation of the GTR: implementation of the GTR final configuration, not only able to generate Galileo–like signals, but also to receive and process real signals coming from Galileo IOV satellites.

The Phase A of the project started on July 2005.

The project is coordinated by a Consortium Agreement (C.A) composed by Telespazio, Alcatel Alenia Space Italia and Finmeccanica with the FILAS S.p.A., the regional Financial Investment Agency dedicated to the support of innovation, as customer.

2 The Objectives of Phase A

In the phase A, the C.A. has the responsibility of developing an infrastructure able to acquire and process signals coming from 4 pseudolites, from GPS, from EGNOS and from the GSTB V2 experimental satellite and able to support the testing of applications demanding high accuracy positioning providing augmentation to the users in the covered area.

During Phase A, the GTR will achieve a basic configuration, called “start-up” and its main objectives are:

To provide a preliminary validation of the whole set of pseudolites implemented from this first stage, eventually in combination with the reception of the satellite GSTB-V2 that is already in orbit from the beginning of 2006, waiting for the Galileo signal.

To carry out analysis and experimentation on the GPS, EGNOS and GSTB-V2 signals (the latter at least for the frequency in the L1 band) that bring to the evaluation of their navigation performance, through the suitable acquisition, filing and processing of the gathered data.

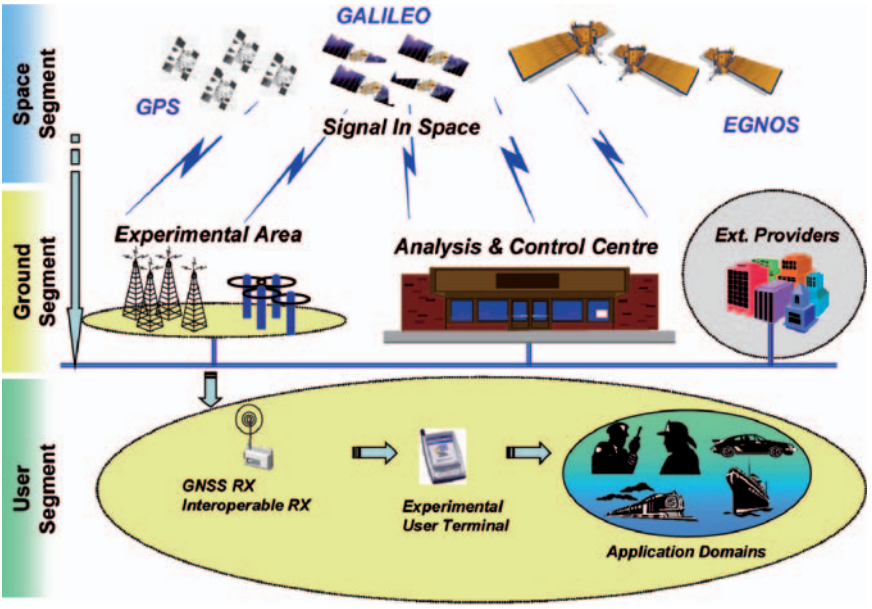

Fig. 1. GTR final high level architecture.

The characterization of the environment, by means of the use of an appropriate meteo station foreseen in the GTR architecture.

The physical realization of a local time reference, through the development and implementation of a time laboratory within the GTR.

The implementation of local "augmentation" of the navigation performance for the development of applications prototypes based on the use of navigation GPS + EGNOS signals.

The Phase A architecture has been designed taking into account the mentioned technical requirements and it is composed by the following macro segments (Fig. 1):

- The Space Segment: it is not part of the GTR system. Nevertheless the GTR is structured in order to allow the reception and the evaluation of the signals coming from the GPS, GSTB-V2, EGNOS and Galileo satellites.
- The Analysis & Control Centre
- The Experimental Area (that contains the Test Area)
- The User Segment.

3 The Analysis & Control Center

The characterization of the Galileo signal, with the consequent evaluation of the navigation performance in relation to its more prominent design aspects, such as the modulation and coding scheme it adopts, cannot leave out of consideration special calculation infrastructures. From the above follows the identification of a certain

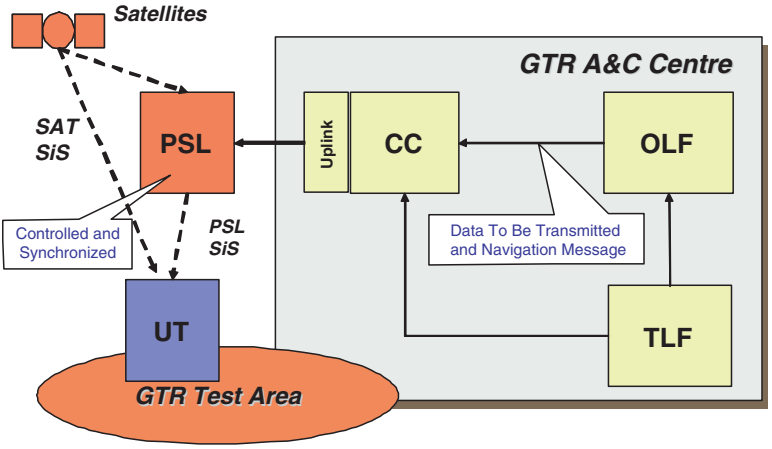

Fig. 2. Synchronization concept.

number of laboratories (for the generation of the time, the computation and analysis of orbitography and integrity) that the GTR requires in its configuration to be able to process and file the navigation data gathered with suitable Galileo receivers (available on site).

The Analysis & Control Center, the heart of the GTR, is composed by a Control Centre, Processing Facilities and Specialised Laboratories, and it is sited in the Tecnopolo Area (in the East of Rome).

It includes the structures dedicated to the processing of the navigation data produced in the experimental area. It includes the Signal Generator (SGF), that provides a controlled environment for User Terminal Qualification Tests (Fig.2).

The Analysis & Control Center includes moreover the Time Laboratory Facility (TLF), used to provide a reference time scale to the GTR system. This laboratory is composed by a group of high stability atomic clocks (one H-Maser and four Caesium atomic clocks) operating in a controlled environment. This guarantees a high stability both at short term and at medium/long term; the GTR-ST time scale is moreover steered to the TAI by means of GPS System Time.

The Integrity (ILF) and Orbitography (OLF) Laboratory facilities provide the support for the implementation of the integrity and navigation algorithms both on the GPS and Galileo constellation and on the pseudolite constellation.

Two types of processing chains are implemented in the GTR:

- Real time Processing for orbit determination and time synchronization, with the aim to provide the synchronization to all the elements composing the testing area and provided by part of the OLF.
- Real time integrity determination, with the aim to monitor the quality of the signals generated in the testing area and to rise alarm flags if system errors exceed certain thresholds, provided by part of the ILF.

Finally the Control Center contains the infrastructures for the monitoring and control of all the GTR elements besides the filing center of all the data produced by it.

Moreover the general purpose GTR-Laboratory has all the instruments necessary to support more innovative studies and activities, such as analysis, modelling and compensation of errors affecting GPS and Galileo measurements, development of Galileo Receivers technology, development of prototype applications and certification (with focus on the applications certification).

4 The Analysis & Control Center

Two main areas (See Fig. 3) can be identified in the ground segment:

- The ***Experimental Area***: for the support to the Galileo receivers certification, an experimental area, in east of Rome, has been identified, where it is possible to perform the relevant tests, taking into account the most typical environmental conditions that cannot be reproduced in an extremely good way in a laboratory.
- The ***Test Area***: that is the area covered by the Pseudolite Signals and where it is then possible to conduct Tests in a fully controlled (also in terms of Signals) environment. The Test Area is a subset of the Experimental Area. At the same time special test campaigns are foreseen for the testing of the prototypes of applications and relevant added value services in portions of the experimental area that

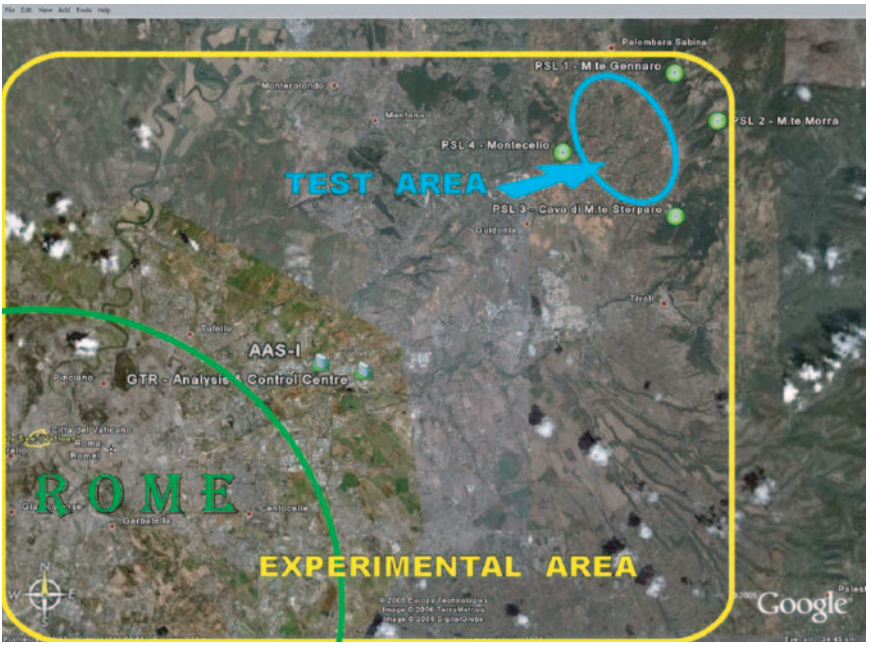

Fig. 3. GTR experimental & test areas.

contains the infrastructures representative of the concerned users domain, such as parts of roads, railways, sections of urban environment and others.

The Experimental Area is mainly characterized by the following elements:

- A constellation of pseudolites (PSL) that broadcast navigation signals representative of the GPS and/or Galileo System (only GPS in phase A) to the users present in the area,. They are synchronized by the GTR-OLF with respect to the reference time scale of the GTR (GTR-ST), generated by the Time Laboratory (TLF), also part of the Analysis & Control Center.
  The Sensor Station (SS): the navigation signals generated both from the ground network of pseudolites and from the satellites in orbit, are also processed by two monitoring stations one sited in the test area and the other co-located into the TLF. The two SS gather the observables useful for the estimation of the synchronization parameters of the pseudolites to be sent to the users. The synchronization algorithm is based on the well known Common View technique, processing the measurements acquired by the two sensor stations and computing the clock biases of the different elements.
- The Differential Reference Stations (DRS): the experimental area will include infrastructures of augmentation for the implementation of applications prototypes: besides the pseudolites, two Differential Reference Stations will be installed. The two DRS are collecting raw data that are then archived in the Control Centre as RINEX files, but they are also distributing corrections in real time through the NTRIP protocol (message types 1, 3, 16, 20 and 21), so that users can have access to high accuracy positioning service directly through internet.

5 The User Segment

The user segment includes the following elements:

- GPS/EGNOS Receivers: necessary for the evaluation of the user position calculated with the GPS system, as a reference for the tests carried out with other receivers.
- GSTB-V2 Receivers: used for the reception of the GSTB-V2 signal, that will be representative of the final Galileo signal. In combination with the processing of the signals transmitted by the pseudolites (transmitting GPS Signals), it allows a first evaluation of performance at user level, obtainable with the Galileo signals.

6 Conclusions

The Regione Lazio represents an area of absolute international relevance in the aerospace sector. With 5 billion € turnover, more than 30,000 employees and 250 prominent sized companies the region is characterised by strong technical capabilities, high quality productivity and broad diversification in national and international projects.

Actually the proposal of constituting an international center of excellence for satellite navigation follows the strategy of growth of industrial and technological capabilities in the frame of an industrial development policy pursued by Regione Lazio.

In particular, SMEs that wish to step into the new business of satellite navigation, have been particularly addressed during the development of the project, supporting the C.A. in the research and development activities concerning the set up of the GTR.

Moreover the role of 10 public research centers, 5 Universities (La Sapienza, Tor Vergata and La Terza, Cassino, Viterbo) and 4 aerospace engineering faculties in the Lazio region is of paramount importance in the entire framework since they participate proactively both to the definition and to the development of the Galileo Test Range.