

GGSP: Geodetic Contribution to the Galileo System

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Introduction

The European Global Navigation Satellite System (GNSS) Galileo is going to be built up within the next years. A first test satellite (GIOVE-A) has been started at the end of last year (2005), the start of a second one is scheduled for September 2006. The In-Orbit-Validation (IOV) phase with a certain number of operative satellites is actually planned to begin at the end of 2008.

The Galileo Geodetic Service Provider (GGSP) is a project funded within the sixth framework programme (6th FP) for research and technological development of the European Union. The 6th FP was covering the time period 2002 – 2006. There was a total funding of 17500 Mio Euro. One of the primary seven main topics was “Aeronautics and Space” with a funding of 1075 Mio Euro. Within the thematic area “Space” there had been established the theme “Galileo – development of multisectoral systems, equipment, tools and user equipment” with a first Galileo call in 2003. The “Galileo 6th FP 2nd Call” was launched in June 2004. The funding was 66.9 million Euro for the whole call. There had been 17 topics in three different areas:

- Area 1: “User segment” with ten topics
- Area 2: “Mission definition and implementation” with five topics
- Area 3: “Innovation and international initiatives” with two topics

The deadlines for the delivery of the tenders were between late September and mid October 2004. In December 2005 there was a 3rd call for Galileo with a small number of additional projects.

The background of the call 2420 “Implementation of a Galileo Geodetic Service Provider Prototype” which was placed in area 2 was “(...) In order to benefit from this extensive level of existing expertise in the geodetic community, Galileo will refer to an external entity called the GGSP for a number of geodetic functions.” [SoW 2004]. This quotation shows the procedure of the Galileo consortium to pass well defined parts of the Galileo mission to external groups of experts. To be able to give a substantiated offer to this call a consortium of seven institutions has been established:

- Astronomical Institute of the University of Berne, Switzerland
- European Space Operations Centre, Darmstadt, Germany
- Federal Agency for Cartography and Geodesy, Frankfurt, Germany
- GeoForschungsZentrum Potsdam, Germany (lead)
- Institut Géographique National, Paris, France
- Natural Resources Canada, Ottawa, Canada
- University of Wuhan, China

The mains purposes of the GGSP prototype are

- the development of the Galileo Terrestrial Reference Frame (GTRF)

- the construction of the necessary interfaces between the various (Galileo-related and external) actors
- the establishment of a service with products and information for the potential users

After signing the contract with Galileo Joint Undertaking (GJU) the start of the project (“Kickoff”) was in July 2005.

Structures and interfaces

Figure 1 shows the external interfaces of the Geodetic Reference Service Provider (GRSP) – which is the name of this component within various Galileo documents – with some other actors which are important for the development of the GTRF. The Ground Mission Segment (GMS) is one part of the Galileo Core System (GCS). Other parts are the Space Segment and the Ground Control Segment. Among other duties the GMS is responsible for the development and maintenance of the Galileo Sensor Stations (GSS). The GMS will supply the GRSP mainly with GSS observations and meta data.

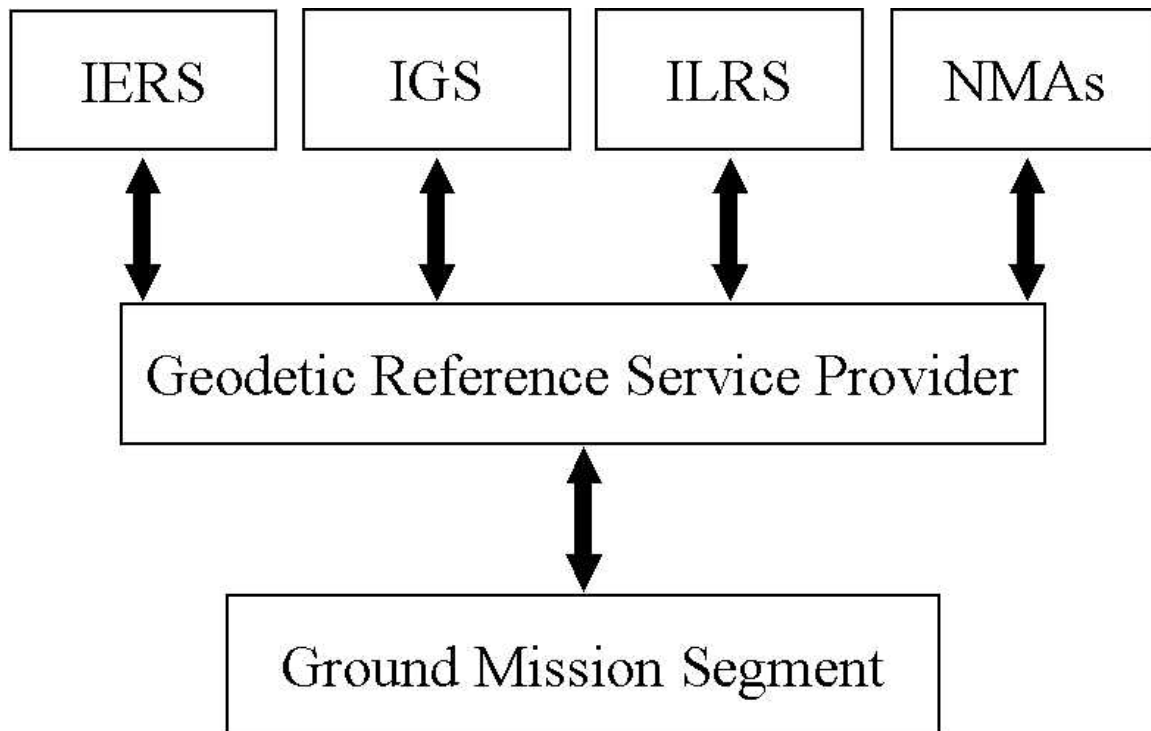


Figure 1: External interfaces of the Geodetic Reference Service Provider (GRSP)

On the other hand, the GRSP is responsible for providing the GMS with, e.g.

- GSS coordinates and velocities
- Earth physical model
- predicted and estimated Earth Orientation Parameters
- Transformation matrices and procedures
- Solar flux parameters

Beside these major constituents there are the connections to the various geodetic services. The International Earth Rotation and Reference Systems Service (IERS) is responsible for the ITRF realization which is needed by the GRSP because of the alignment requirement: “The relative accuracy (compatibility) between the GSS coordinates and the coordinates of the ITRF reference stations shall be 3 cm (2 sigma)” [SoW 2004]. From the International GNSS Service (IGS) the GRSP will get observations and meta data of additional GPS stations as far as necessary. The International Laser Ranging Service (ILRS) will provide Satellite Laser Ranging (SLR) data for independent validation of the Galileo satellite orbits. On the other hand, the ILRS will be supplied with information about predictions or maneuvers. In both cases, the GRSP will only pass the data through. In a later stage, the GRSP will provide the National Mapping Agencies (NMAs) with information about transformation parameters between the GTRF and national coordinate systems.

The refined proposal for the implementation of the GGSP prototype resulted in a noticeable number of work packages (WP). The WP structure shows nine main topics:

- WP100: Project Management
- WP200: Consolidation of GGSP
- WP300: S/W extensions, adaptations and tests
- WP400: Initial realization of GTRF
- WP500: Maintenance of GTRF until completion of IOV
- WP600: Validation
- WP700: Recommendation for operation of permanent GGSP
- WP800: Galileo in the geodetic world
- WP900: Data, product and information management

WP200 which had to be finalized first at the Critical Design Review (CDR) includes the definitions for the other actions. The work packages within WP200 are covering the following items:

- Definition of a TRS
Concepts and terminology related to the definition of a Terrestrial Reference System (TRS) and its realization by a Terrestrial Reference Frame (TRF)
- Review of related work in Galileo
Compilation of the external and internal requirements for the GGSP prototype, derived from all relevant external information
- External interfaces
GGSP prototype interfaces with all relevant external entities covering both, data flow and formats
- Review and selection of parameters and models
Standards (e.g. IERS conventions), models (e.g. motion of stations) and parameters (e.g. system transformation) to be adopted for the GGSP
- GGSP prototype design
Design of the GGSP prototype for practical implementation both on the system level for the overall architecture and on the detailed level for each facility (see below)
- Initial GTRF realization
Concept of the initial GTRF realization under consideration of the different phases of the Galileo mission
- Validation plan for initial GTRF realization
Setup of the plan for validation of the GGSP prototype and the initial GTRF realisation
- GTRF maintenance until completion of IOV
Plan and mechanism for the maintenance of the GTRF throughout the IOV phase

The main units of the GGSP which are defined in the prototype design are:

- Data Collection & Control Facility
Collecting all data and third party products required by GMS and GGSP to realize the GTRF including basic quality checks
- Processing Facility
Processing the necessary raw GSS and GPS data and generating required products
- Combination Facility
Combining station coordinates from SINEX files and orbit products
- Validation Facility
Validating the GTRF and monitoring the GTRF in the operational phase
- Archiving & Dissemination Facility
Archiving the data as well as the external and the GGSP products

GTRF realization

The main requirement for the GTRF realization and maintenance is the close alignment to the ITRF within 3 cm (2 sigma). The GTRF realization will primarily base on the observation data sampled at the GSS. For the operation of a GSS there exists a huge number of requirements concerning e.g. the operation of the station throughout the whole lifetime of the Galileo system, the reliability of the data and the resources of the station and others more. It is intended that each GSS is equipped with two stations GSS-A and GSS-B.

The design of the network of the GSS is not finalized yet. It is planned to have about 18 stations for the IOV phase. Later on, about 22 stations will be added until Full Operational Capability (FOC). For the initial GTRF realization it can be assumed that there will be available GPS observations only. It is planned to use IGS stations in the neighborhood of the proposed GSS if they are not built up so far. Moreover, it is necessary to fill up the network with additional IGS stations to get a global coverage and homogeneous station distribution, to connect the GTRF to ITRF and to keep the alignment requirement. For future GTRF releases the GSS will replace the IGS stations in the analysis step by step as soon as they are installed. Additionally, co-location of some of the GNSS stations with SLR stations capable to track Medium Earth Orbiters (MEO) will be considered for the design of the network.

Conclusions and outlook

The GGSP consortium is a team of seven institutions with experts and expertise in the fields of GNSS applications, the analysis of GNSS data and the definition and realization of global reference frames.

The GGSP consortium will initialize (realize), validate and maintain the Galileo Terrestrial Reference Frame (GTRF) in close connection to the International Terrestrial Reference Frame (ITRF).

Further more, the GGSP will establish the prototype of a service with various products for the potential users, e.g. station coordinates, precise satellite orbits and clocks.

At least, considering the importance of having Galileo data at an early stage available the GGSP consortium is calling attention to his partners to this point.

The time schedule of the GGSP prototype is closely connected to the overall Galileo time table. T₁, the Kickoff of the Galileo CDE₁ phase, was in December 2004. The start of the GSS implementation is planned for spring 2007. At that time an early prototype test will be started which will be used to validate the GGSP internal architecture. The GSS pre-operational phase is planned to start in the second half of 2008. At that point the final GGSP prototype tests will be performed including the relevant external interfaces. The IOV phase with the GGSP prototype acting on a routine basis in the real Galileo scenario is planned to cover the period first half of 2009.

References

[SoW 2004] – Implementation of Galileo Geodesy Service Provider Prototype – Statement of Work,
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