Determination of Global Geodetic Parameters using the Galileo Satellite System

Since the Global Positioning System (GPS) reached the full operational capability in 1994, the number of global navigation satellite system (GNSS) applications has been steadily increasing. Nowadays GPS is an indispensable component in many elements of everyday life and in research allowing for: (1) precise positioning in geodesy, (2) surveying and supporting engineering activities, (3) car, maritime, and aircraft navigation, (4) geospatial information systems (GIS), (5) synchronization and transfer of time; (6) determination of precise orbits of low-orbiting satellites such as GRACE, GOCE, Jason-2; (7) verification of effects of special and general relativity; (8) geodynamic studies of deformation of the Earth's crust and movements of tectonic plates.

In 2010, the Russian global navigation system GLONASS achieved full operational capability after placing 24 satellites in the Earth’s orbit. The currently being developed by the European Union and the European Space Agency (ESA), the only non-military (civil) navigation system Galileo consists of 22 satellites orbiting the Earth: four In-Orbit Validation satellites (IOV) and eighteen FOC satellites (Full Operational Capability). The Galileo system achieved partial operational capability in December 2016, and it is assumed to be fully operational by 2018. The Galileo system is intended to perform the same tasks as the GPS system and, in addition, will support services dedicated to authorized users.

The goal of the project is to improve the processing algorithms of observation modeling of Galileo data and orbit determination and using the enhanced algorithms to determine the global geodetic parameters, such as: Earth rotation parameters (pole coordinates and length-of-day excess), coordinates of Earth's center of mass (geocenter coordinates), multi-GNSS station coordinates, as well as global scale of the terrestrial reference frame. The project will explore and refine the fundamental research products that can be obtained from precise satellite observations of the Galileo system.

Galileo satellites broadcast signals at frequencies than less affected by the observation noise than the GPS signal, making Galileo code measurements about three times more accurate. A low noise level of code observation allows for combinations of code and phase observations on a single frequency, thus eliminating the first order ionospheric delay. All Galileo satellites, in contrast to GPS, are equipped with retroreflectors for laser measurements, enabling reliable and independent assessment of the orbit quality. Galileo satellites also have high-quality atomic clocks (hydrogen masers and rubidium clocks), however, due to emergencies, some satellites have to rely on redundant clocks.

The Determination of some global geodetic parameters, such as the geocenter coordinates or Earth’s oblateness term, have been unsuccessful so far when employing GPS and GLONASS observations, due to substantial dragonitic orbital errors caused by the unmodelled part of the impact of solar radiation pressure and correlations between orbital parameters and global geodetic parameters. The project will attempt to determine the global geodetic parameters using Galileo observations and the combinations of Galileo data with other GNSS observations. The Galileo satellite system integrates two space geodetic techniques: laser (SLR) and microwave (GNSS). Therefore the integration of both techniques is possible onboard Galileo, which was impossible with GPS due to the lack of retroreflectors onboard all satellites. In addition, the Galileo system suffers from systematic errors that are different than those of GPS, due to the different altitudes and revolution periods of the satellites. The integration of GPS+Galileo observations will allow for the identification and distinction between the geodynamical signal from the orbital errors in the time series of global geodetic parameters, e.g., in pole coordinates, length-of-day variations, and geocenter coordinates. All of these will contribute to a better understanding of geodynamic processes and phenomena that occur in the system Earth and may be monitored by geodetic parameters.