One year of Galileo IOV orbit and clock determination

Peter Steigenberger (1), Stefan Hackel (2), Urs Hugentobler (1), and Oliver Montenbruck (2)

(1) Technische Universität München, Institut für Astronomische und Physikalische Geodäsie, München, Germany (steigenberger@bv.tum.de), (2) Deutsches Zentrum für Luft- und Raumfahrt, German Space Operations Center, Oberpfaffenhofen, Germany

With activation of the fourth Galileo satellite, the Galileo In-Orbit Validation (IOV) phase was achieved in December 2012. The Galileo IOV constellation consists of Proto Flight Model (PFM) and Flight Model 2 (FM2) launched in October 2011 and FM3 and FM4 launched in October 2012. Although the satellites are transmitting navigation signals on all designated frequencies, transmission of the navigation message has not yet started. However, the availability of an orbit product is a prerequisite for most user applications.

To support early applications of Galileo, IOV orbit and clock parameters are estimated from observations of the Cooperative Network for GNSS Observation (CONGO) and the Multi-GNSS Experiment (MGEX) of the International GNSS Service (IGS). The quality of these GNSS-only orbits as evaluated by internal consistency tests and Satellite Laser Ranging (SLR) residuals is in general on the one decimeter level. However, the orbits suffer from systematic errors depending on the elevation of the Sun above the orbital plane. These errors show up, e.g., as a bump in the Allan deviation of the estimated clock parameters at the orbital frequency.

We started with the Galileo orbit and clock determination in January 2012 and 2013 for PFM/FM2 and FM3/FM4, respectively. The time period of more than one year for PFM/FM2 allows for a proper analysis of the systematic errors. The impact of including SLR observations for a combined GNSS+SLR orbit determination, namely a reduction of the systematic errors, is demonstrated. Finally, the performance of the different clocks on board the IOV satellites (Rubidium clocks and Hydrogen masers) is evaluated and compared with other state-of-the-art GNSS satellite clocks.