Manoeuvre Optimization in the Galileo L7 Orbit Acquisition

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Keyword : Galileo L7, Orbit Determination, Manoeuvre Optimization, Y-bias

Galileo is a global navigation satellite system (GNSS) currently being deployed by the European Union. One of the aims of the Galileo project is to provide a high-precision positioning system that is interoperable with GPS and Glonass. The fully deployed Galileo system will consist of 24 operational satellites positioned in a Medium Earth Orbit (MEO), divided in three equally spaced orbital planes, at an inclination of 56 degrees with respect to the Earth equator. Up to October of 2016, the Galileo constellation has twelve operational satellites.

The seventh launch (called L7), in which the GSAT0210 and GSAT0211 satellites were launched from Kourou in a Soyuz launcher, took place on the 24th of May of 2016. The Launch and Early Operations (LEOP) and the subsequent manoeuvre campaign to acquire the target orbital slots were conducted from the European Space Operations Centre (ESOC) in Darmstadt, by a joint team from ESOC and Centre national d'études spatiales (CNES). After a manoeuvre campaign comprising 18 manoeuvres, the target orbital slots were declared to be successfully acquired for both satellites on the 5th of July of 2016.

In the launches up to and including L7, Galileo satellites were launched in pairs. The Galileo acquisition operations are divided into four phases: drift start, drift phase, drift stop, and fine positioning, comprising in total up to 50 days of operations. During the drift start phase three manoeuvres are executed to correct the drift of the spacecraft, while in the drift stop phase three manoeuvres stop the drift. The other orbital elements should be corrected as well by these six manoeuvres. The requirements on the orbital elements are strict, with the semi-major axis in particular having to be acquired within 5 meters of the target, in order to guarantee that at most one corrective manoeuvre is necessary in the spacecraft’s operational lifetime. In order to successfully achieve these precise targets, up to eight fine positioning manoeuvres are planned for correcting the remaining error after the drift stop phase. The manoeuvres in the fine positioning phase might be as small as 0.1 millimetres per second.

In the preparation of the launch one of the main roles of the Flight Dynamics orbit and manoeuvre team is to design the manoeuvre strategy. This consists in selecting the manoeuvre slots for the drift start, drift stop, and fine positioning phases. These have to be selected based on station visibility, orbital correction capabilities, spacecraft on-board constraints, but are also conditioned by operational constraints. Furthermore a different plan has to be performed for each launch date, due to differing phasing with respect to the target orbital slots. In this paper the tools and decisions to tackle the acquisition problem are described.

The actual L7 launch and performed acquisition manoeuvres are described as well in the paper. In particular, the orbit determination close to the acquisition (based on two-way range radiometric data) poses an interesting challenge for the orbit team, in particular due to the presence of a Y-bias which has to be modelled and determined. Due to the specific circumstances of this launch, there was a longer orbit determination arc without manoeuvres than what is usually available for Galileo launches. This allowed for a more in-depth analysis of the acquisition and of the Y-bias, which is described in the paper.

The activity described is carried out under a contract managed by ESA on behalf of and funded by the European Union. The views expressed herein can in no way be construed as reflecting the official opinion of the European Union and/or of the European Space Agency.