Sentinel-1A Reference Orbit Acquisition Manoeuvre Campaign

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Keywords: *Copernicus, Earth Observation, GMES, Reference Acquisition, LEO, Sentinels*

EXTENDED ABSTRACT

Sentinel-1 is a 2 satellite radar imaging mission, part of the European Copernicus Programme. The first satellite of the constellation, Sentinel-1A, was launched on the 3rd of April of 2014 by a Soyuz rocket from Europe's Spaceport in the French Guiana. Flight Dynamics, as part of the Mission Control Team, supported the LEOP operations from the European Space Operations Centre (ESOC) in Darmstadt (Germany) and the subsequent acquisition of the reference orbit.

Like in many other Earth Observation missions, the orbit control of Sentinel-1A is based on a reference orbit. This reference orbit is a sun-synchronous dusk-dawn orbit, with a 12-day ground-track repeat cycle after 175 orbits and a Mean Solar Local Time of the Ascending Node (MSLTAN) of 18:00h.
The orbit control is achieved through the execution of in-plane and out-of-plane manoeuvres, performed by thrusters mounted respectively in the velocity, anti-velocity, and out-of-plane directions. With this configuration of thrusters no slewing is necessary for manoeuvring.

The FD team at ESOC was in charge of designing the manoeuvring campaign to acquire the reference ground-track. The campaign was to be started after a 3 day LEOP.
The design of the manoeuvre campaign was driven by:

- A maximum Delta-V of 13 cm/s per manoeuvre, corresponding to a maximum on-time of 300 seconds for the 1 Newton thrusters at beginning of life;
- The execution of a maximum of one manoeuvre per orbital revolution, to ensure the recovery of the attitude control system between manoeuvres;
- The allocation of a sufficiently large calibration arc between manoeuvre groups, in order to have a proper characterization of the propulsion system and allow for the screening of conjunction risks by the Space Debris Office at ESOC before the implementation of subsequent manoeuvres;
- Manning constraints, conducting operations to the maximum extent possible within working hours;
- The reference orbit could be acquired at any of the 175 nodes.

During the launch campaign tools were developed to analyse the acquisition strategy for different expected injection conditions. This analysis also yielded the expected duration of the campaign.

The satellite was injected in a non-nominal semi-major axis, 8 kilometres below the reference altitude. Additionally the behavior of the propulsion system was not as expected. This was observed during the execution of the first manoeuvre during LEOP, where higher torques than expected were observed (see "Sentinel-1A Flight Dynamics LEOP Operational Experience" extended abstract, M.A. Martin Serrano et al., submitted to the 25th ISSFD). As a consequence the manoeuvre strategy designed before launch had to be revisited. The first impact was a delay in the start of the manoeuvre campaign, during which test manoeuvres were executed in order to investigate the observed anomalous behaviour. The final recommendation from the spacecraft manufacturer was to reduce the maximum on-time of the thrusters used for in-plane manoeuvres to 30 seconds.
The final manoeuvre campaign was then divided in two phases:

- Phase 1: 4 km orbit rise. The objective of this phase was to reduce the drift with respect to the reference orbit;
- Phase 2: Acquisition of a selected reference node and correction of the inclination.

The reference orbit acquisition was successfully concluded in the beginning of August, 4 months after the start of the LEOP and after the execution of more than 400 manoeuvres.

This paper presents a brief overview of the preparatory work made by Flight Dynamics during the launch campaign to plan the acquisition of Sentinel-1A's reference orbit. More extensively, it will address the redesign of the manoeuvre acquisition strategy after launch, providing details of the planning and operational implementation of the manoeuvre campaign.