Sentinel-3A Flight Dynamics LEOP operational experience

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Sentinel-3A is an Earth observation satellite and part of the Copernicus program of the European Commission. It was launched on February 16th, 2016 at 17:57 UTC from Plesetsk, Russia by a Rockot launcher. The satellite carries instruments to perform diverse measurements of the oceans and land, including the topography of the sea surface, fire detection and forest cover mapping.

During the phases of Launch and Early Operations Phase (LEOP) and commissioning, the satellite was operated from ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany. After six months of operations it was handed over to EUMETSAT, from where the satellite is operated now in its routine phase. This paper discusses the most relevant events during the three days long LEOP and the beginning of the commissioning phase from a Flight Dynamics (FD) perspective including the cooperation with Flight Control Team (FCT) and the spacecraft manufacturer team present at ESOC during this critical period. Although the launcher vehicle achieved an almost nominal injection and the first activities of the LEOP were carried out within the nominal timeline, there were several unexpected events.

The first anomaly happened with the switching on of the Star Trackers at Mission Elapsed Time 08:30 hours: the FD Attitude Monitoring Team reported that the attitude estimation from those units showed a disagreement of 50 to 150 degrees (depending on the Star Tracker head) with respect to the Coarse Sun Sensor and Magnetometer measurements. With such a high deviation the Star Tracker Unit was considered unsafe, preventing the satellite to be commanded to Normal Operation Mode. After investigation by the expert teams, the problem was tracked down to a wrong interpretation of the meaning of the alignments that were loaded into the Star Trackers database. Once the correct alignments were identified, it was necessary to perform an analysis of the new values before uploading them to the satellite. The paper details the events that were triggered by this problem, from the discovery by FD, over the findings of the manufacturers to the performed analysis by FD and the on-board fix by FCT, all within a few hours. The LEOP timeline suffered a delay, but after the problem was solved the transition to Normal Operational Mode was performed and it was possible to do the remaining steps of the LEOP in a shorter time span than planned for a successful on-time end of LEOP operations.

The FD activities performed during the first days of commissioning centred on the execution of manoeuvres for torque estimation. This led to new unexpected results: although the performance of thruster set 1 was considered satisfactory, for the thruster set 2 higher torques than expected were observed on two spacecraft axes, depending on the thruster pair used. Suspecting that plume impingement could be the explanation to the observed high torques, it was decided to execute further test manoeuvres at different orbital positions, where the incidence of the plume on the solar array would be different. This new set of test manoeuvres confirmed plume impingement as the most likely cause. As a result, new constraints were introduced on the maximum delta-v achievable with thruster set 2. The paper presents the data and the main conclusions from the findings.

Another relevant event was observed during the second week after launch: a decreasing and even negative value was estimated for the drag coefficient as part of the orbit determination. This effect was beneficial for the orbit control, leveraging the need for control manoeuvres. The reason for this was believed to be out-gassing of some component of the spacecraft during this period. The paper briefly discusses the observed behaviour.

In addition to the particularities of the LEOP and commissioning, this paper gives a general outline of the FD operations during these phases.