Lessons learned from initial Sentinel-3A manoeuvre operations

Daniel Aguilar Taboada[1*], Pier Luigi Righetti[1], Rami Houdroge[1]
[1]*EUMETSAT, Germany*
Daniel.AguilarTaboada@eumetsat.int

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Sentinel-3A, first of the Sentinel-3 fleet of the European Commission's Copernicus programme, was launched from Plesetsk Cosmodrome on a Rockot launcher on 16 February 2016. It measures Earth's oceans, land, ice and atmosphere in order to monitor and understand large-scale global dynamics. It provides essential information in near-real time for ocean and weather forecasting.

Sentinel-3 satellites fly around the Earth on a Sun-synchronous orbit with a repeat cycle of 27 days and cycle length of 385 orbits with an orbit control requirements of ±1 km with respect to the reference ground track. One out-of-plane station keeping manoeuvre is needed every three or four months and an in-plane station keeping manoeuvre is needed every two to eight weeks depending on the level of solar activity. For these station keeping manoeuvres, Sentinel-3 satellites are equipped with two sets of four 1N monopropellant hydrazine thrusters.

Several deviations have been observed for the manoeuvres performed up to date. The durations of these manoeuvres were consistently longer than predicted (a) and the pulse distributions among the four thrusters of a given set were not as expected (b). These deviations caused reduced performances in POD solution due mainly to delta-V centroid displacement and relatively urgent need of in-plane manoeuvre as different pulse distribution induced misalignment in main thrust direction. Furthermore, by comparison with independent methods, a recurrent overestimation of propellant consumption was observed (c).

In order to solve issue (c), a propellant flow rate calibration factor was successfully implemented in the ground segment and is used for current and future manoeuvres. In order to mitigate issues (a) and (b), a manoeuvre duration factor and a thrust direction calibration factor were also implemented. In addition, sensitivity analyses on some manufacturer spacecraft database parameters were performed in order to identify the root cause of issues (a) and (b). Figure 1 shows the prediction errors for the manoeuvre duration and distribution of pulses as a function of the displacement of the satellite's centre-of-mass along Y_{sc} and Z_{sc}, perpendicular to the main thrust direction. By adjusting the satellite's centre-of-mass, the manoeuvre duration and main thrust direction predictions can be significantly improved.

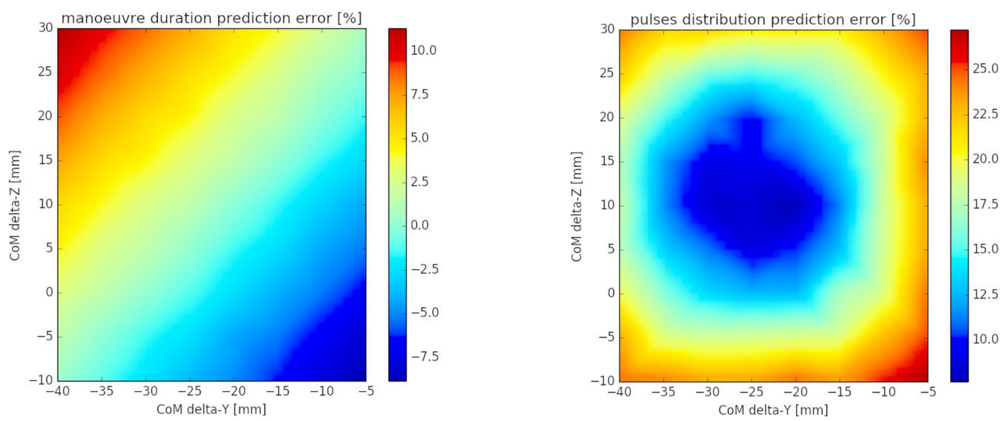

Fig. 1. Manoeuvre duration and pulses distribution prediction errors as function of the satellite's centre-of-mass displacement for the out-of-plane manoeuvre performed on 31 August 2016