METOP-A DE-ORBITING USING VERY LARGE IN-PLANE MANEUVERS

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The Metop spacecraft are Earth observation satellites flying on a low Earth, sun-synchronous circular orbit. Although built prior to current international regulations on space debris, and therefore not designed to comply with them, it is EUMETSAT's desire and policy to perform their disposal targeting an uncontrolled re-entry within 25 years from their end of operations, as long as this is possible with this platform. The required de-orbiting operations need to be carried out taking into account different constraints imposed by the satellite platform and the ground infrastructures, and within as short a period of time as possible, in order to minimize interferences with the operations of the rest of the Metop satellites in orbit.

In view of the good health of the Metop-A satellite, launched in October 2006 from Baikonur, current plans are to continue operating it until the end of the commissioning of Metop-C, in the first half of 2019. However, the strategy and operational procedures for the de-orbiting are already being defined and fine-tuned, so that end-of-life operations can be carried out at any point in time in case there is a risk of Metop-A becoming not operable.

As part of those end-of-life operations, in-plane maneuvers are required to lower both the apogee (to free the operational Metop orbit) and the perigee (to achieve the target re-entry conditions). These maneuvers are grouped in two different phases. The first one will free the operational orbit by lowering the apogee, place the perigee at a convenient argument of latitude and lower it as much as possible (though not beyond the altitude defined as the minimum one allowed by the manufacturer plus some margin for the following maneuver phase), ensuring at the same time that there is still some fuel on-board for the second maneuver phase, during which full passivation of the propulsive system will be carried out.

Given the fuel level left on board at the end of the first maneuver phase, any of the burns during the second one can be the last one. Consequently, all these possible final thrusts will have to be performed under close monitoring from ground, and will therefore be programmed to start at the beginning of combined visibilities of Metop-A from the EUMETSAT ground station in Svalbard and from either the Fairbanks ground station (NOAA) or the Villafranca ground station (ESA). Thus, once the symptoms of fuel depletion are observed there will be enough time for commanding the final switch-off of the satellite during that pass.

Being the ground stations used for the final end-of-life operations located at high northern latitudes, the most convenient location of the perigee in order to extend as much as possible the duration of those passes is close to the South Pole. Coincidentally, this is also the location that results in the lowest re-entry time, and therefore it will be the one targeted during the first maneuver phase.

The initial strategy for the Metop-A de-orbiting operations included the execution of standard double-burn in-plane maneuvers. A first set of maneuvers, with separation between burns of half an orbit, would achieve the lowering of both perigee and apogee below the Metop operational orbit, maintaining the eccentricity. Following maneuvers would consist of burns separated by a complete orbital period, initially to set the perigee at the desired argument of latitude, then to bring the perigee down to the target altitude, and finally to lower the apogee until reaching the level of estimated on-board fuel that marks the start of the passivation phase.

However, analysis of the operations required for this strategy has shown that the execution of large, double in-plane maneuvers implies significant implementation problems, most significantly for the update of the antenna pointing information between burns of the same maneuver. Discussions with the spacecraft manufacturer have shown that the possibility of executing larger maneuvers (up to a duration of 2300 seconds) can be exploited. Following this, it has been analyzed whether execution of very large, single in-plane maneuvers during the whole de-orbiting phase can bring the spacecraft to acceptable conditions in terms of re-entry time expected after the finalization of the end-of-life operations, without affecting other variables like the overall duration of the end-of-life operations.

This paper will present how this strategy, thought to be quite innovative, can cope with the constraints imposed on the Metop-A de-orbiting, and this in two different fuel conditions: considering that the last inclination maneuvers will be the ones executed in Fall 2015, already part of the baseline operations; and taking into account the effects of a further inclination maneuver in Fall 2016, which execution is still under discussion. It will moreover be shown how, within this strategy, there are still margins for reducing the duration of the de-orbiting operations or for further reducing the final orbit altitude and, with it, the time to re-entry.