Metop long term free-dynamics attitude analysis, for improved re-entry prediction

Stefano Pessina[1*], Pierluigi Righetti[1], João Branco[2], Victor Moreno Villa[3],Thomas Vincent Peters[3]
[1] EUMETSAT, Darmstadt, Germany, [2] GMV, Lisbon, Portugal, [3] GMV, Madrid, Spain
Stefano.Pessina@eumetsat.int

Keyword : LEO, End-of-Life, Attitude Dynamics, Re-entry

Metop-A is an EUMETSAT meteorological satellite flying in near polar sun-synchronous orbit since 2006. After 10 years of operations, controlling his orbital plan orientation, it executed its last out-of-plane manoeuvre on August 2016. Metop-A will now continue to provide operational data, but will start to drift out of the nominal orbit plane: the Local Time of Ascending node (LTAN) will change from the value of 21:30, lowering progressively to 19:40 in early 2022. The solar array will be kept rotating, to maximise the sun exposure, in this mission-extension phase.
Metop-A has enough propellant to be eventually de-orbited in line with international debris mitigation guidelines. These target a re-entry of the satellite within 25 years after the end of its operational lifetime.

Starting from a nearly circular operational orbit with 817 km radius, the current strategy foresees a progressive perigee lowering above the South pole (target is to reach 550km perigee height) that will be lowered further in case of still available propellant reserves. At the end of the manoeuvres, the spacecraft will be passivated: the air density rises exponentially as altitude reduces, so the successive apogee lowering is naturally obtained by aerodynamic drag, with the apogee height lowering progressively till a circular decay orbit is reached. It is to be noted that in this phase the perigee position will rotate continuously with respect to the Earth, with a full 360 deg rotation roughly every 4 months. In addition, the Mean Local Time of the Ascending Node (MLTAN) will also change progressively, spanning all values between 00:00 and 24:00.
After the deactivation, the spacecraft attitude will evolve in free dynamics, with the solar array lock in fixed position.

The long term (>25 years) orbit re-entry propagation are usually performed assuming a random thumbing, decoupling the attitude dynamics, and using a mean area for the perturbation depending on external surfaces. Due to its mass properties, especially at higher altitude in the initial part of the decay, Metop can have a stable attitude configuration, due to the predominant effect of the gravity gradient with respect to air drag.
The knowledge of the attitude evolution around eventual temporally stable configuration allows the definition of variable mean cross-section area for decay analysis, and therefore an improved re-entry prediction

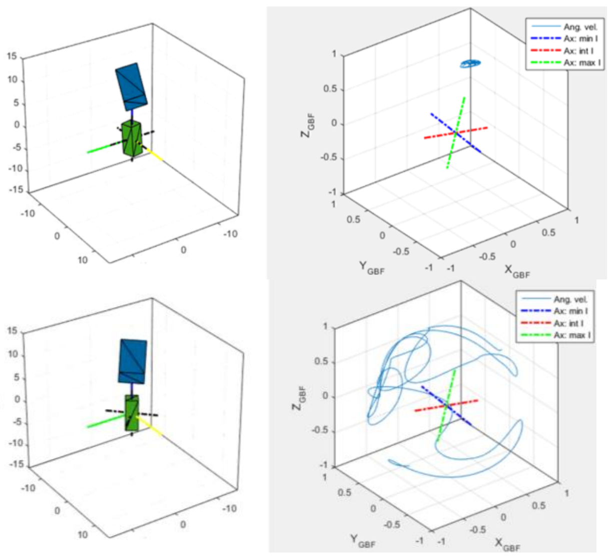

Fig. 1. Free-dynamics attitude evolution in time, for a stable (top) and unstable (bottom) configurations

A dedicated accurate attitude dynamics simulator (based on ECSS standard models) has been used by the EUMETSAT flight dynamics team to perform a sensitivity analysis of the stability, based on initial spacecraft attitude, lock position of the solar array with respect to satellite body, orbital altitude, solar activity, orbital plane orientation with respect the Sun.
This paper will report on the modelling assumptions, assumed simulation inputs, stability results and subsequent characterisation of the mean cross-section area in support to re-entry long term propagation and end-of-life strategy selection.