DE-ORBITATION STUDIES AND OPERATIONS FOR SPIRALE GTO SATELLITES

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Keywords: *Geostationary Transfer Orbit, GTO, de-orbitation, orbital resonance, micro-satellites, debris*

ABSTRACT

Introduction

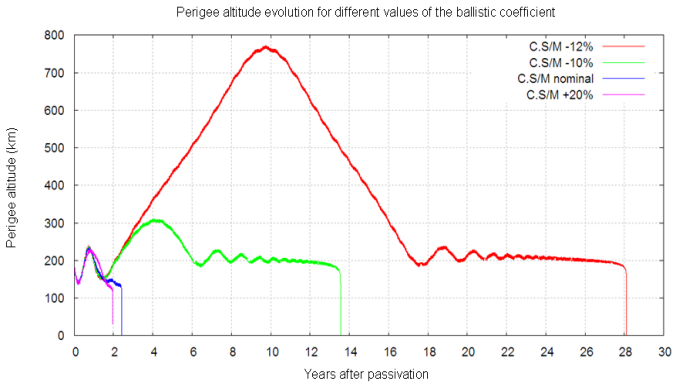
SPIRALE was a demonstrator operated by Astrium Satellites for the French DoD (DGA). Its mission was to collect infrared images of the Earth for the design of an Early Warning system. It consisted of two micro-satellites launched on February 12 2009 as secondary payload by an Ariane-5 ECA launcher on a GTO orbit, together with two GEO commercial telecommunication satellites. The two spacecrafts, based on the CNES Myriade micro-satellite platform, shared the same orbit (perigee at 600 km, apogee near geosynchronous orbit), SPIRALE-B following SPIRALE-A with a 30 minute time delay.

The propellant tank contained 4.7 kg of propellant, enough to achieve perigee rising, station-keeping activities and de-orbitation operations.

Mission analysis

After more than 20 months of operations, the mission of the demonstrator was over. It was time to de-orbit. In the context of the French Space Act (French extension of the end-of-life IADC recommendations), the aim was to perform orbital maneuvers in order to ensure that the two spacecrafts will fall on Earth in less than 25 years with a probability of at least 50 %. The maneuvers consisted in deltaVs performed at the apogee in order to lower the perigee altitude. Then air drag at each perigee pass naturally leads to a decrease of the apogee altitude and thus of the semi-major axis of the orbit.

The difficulty was to estimate the re-entry time: huge variations in re-entry time estimation could be caused by small variations in the orbital propagation hypotheses. In particular higher air drag effects could lead to longer fall duration, that is not common sense. This is due to a *Sun-synchronous resonance* effect caused by Sun gravity and specific to elliptic orbits. On SPIRALE orbits, the perigee altitude may deviate up to +600 km from its nominal mean value.



Operations

The initial maneuver plan intended to alternate the deltaV between SPIRALE-A and SPIRALE-B (two maneuvers for each) in order to maintain a limited separation between the two spacecrafts. But last minute constraints did not allow the operational team to follow the nominal schedule. First the main ground station was requested for the ATV2 operations, and second the SPIRALE-B mission has been slightly extended just before the start of the operations. Thus SPIRALE-A was fully operated and passivated before SPIRALE-B, leading to a crossing of the spacecrafts due to the difference in their orbital periods. But separation between the two orbits was ensured up to a minimum distance of 70 km at time of closest approach.

The last maneuver for each satellite has been performed up to full propellant depletion, in order to minimize the residual pressure in the tanks. The propellant mass available for de-orbitation maneuvers was a little bit larger than the estimation for both satellites, and the final perigee altitude was below 230 km for a targeted altitude of 250 km.

Concerning the French Space Act constraints, as expected there was no risk of collision with human-manned LEO spacecraft because the orbital plane of the ISS was favorably oriented with respect to the SPIRALE perigee positions. Furthermore thanks to the natural decrease of the apogee altitude the GEO restricted zone was cleared in less than one month. Re-entry was ensured in less than 25 years with a probability better than 90%.

Further activities

In the frame of the SPIRALE project, it is interesting to follow the evolution of the orbital parameters in order to potentially observe the Sun-synchronous resonance. However after spacecraft passivation, orbit determination cannot be performed any more by usual active methods. One year and a half after the end of the operations, and thanks to the JSpOC public catalog of TLE, we have access to the cumulative orbital bulletins of both satellites and a snapshot of the orbital situation can be performed.