Mission Analysis for MSG-3&4 considering combined LEOP/Station-Keeping costs and In-Orbit storage

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ABSTRACT

EUMETSAT is an independent intergovernmental organisation created in 1986 to establish, maintain and exploit European systems of operational meteorological satellites. It currently operates a system of meteorological satellites, monitoring the atmosphere and ocean and land surfaces which deliver weather and climate-related satellite data, images and products – 24 hours a day, 365 days a year. The current generation of satellites, providing Earth Full-Disk and Rapid-Scan services from geosynchronous (GEO), is the Meteosat Second Generation (MSG). The programme foresees 4 satellites of this kind, 3 of them are operational: MSG-1 launched in 2002, MSG-2 in 2005 and MSG-3 in 2012. MSG-4 will be launched in 2015, completing the programme, before the third generation (MTG) will take over the service. MSG-4, as a difference from the other spacecrafts, will be initially stored in orbit. For all of them, the insertion to GEO is done starting from a standard Geosynchronous Transfer Orbit (GTO) after an Ariane-5 dual-spacecraft launch. The spacecrafts are spin-stabilised.

The Mission Analysis for these missions is based on different sequential tasks:

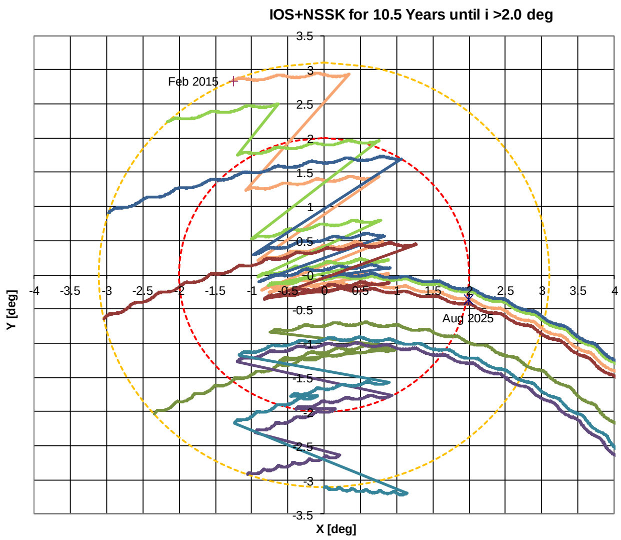
a) design of the LEOP sequence for in-plane manoeuvres for GTO circularisation using a restartable propellant system, according to various constraints (e.g. double ground station coverage, time to reach the target longitude slot)
b) analysis of backup strategies in case of missed major manoeuvres
c) selection of orbital node rotation inclination change for optimal propellant consumption
d) launch windows definition to respect the spacecraft limits (Sun-Aspect-Angle, eclipses)
e) accurate definition of the LEOP timeline of Flight Dynamics (FD) operations, including spin maintenance, attitude manoeuvres and special operations (instrument covers ejection)

Apart for c) all tasks above are based for all spacecrafts on well-established principles for GEO insertion, as from dedicated analysis done for the whole MSG program. Related to task c), novel concepts have been studied for MSG-3 and MSG-4 and they will be presented in this paper.

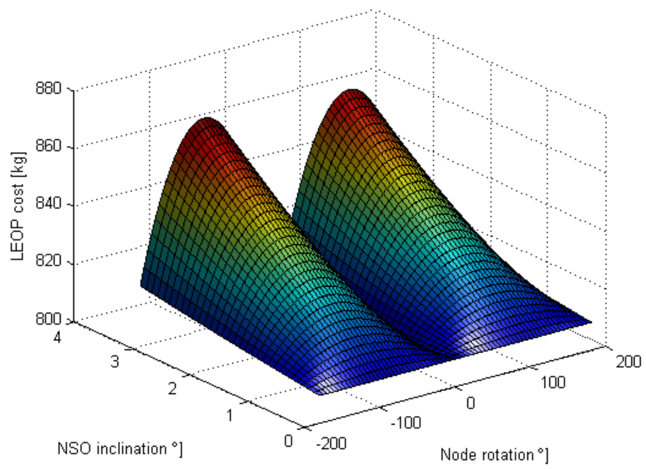
The standard GTO of Ariane-5 was changed after MSG-2 launch from 620km to 250km, for compliance with space debris mitigation rules, speeding up the re-entry of upper stages. As a drawback, a bigger increase of perigee height has then to be provided for MSG-3&4 with its own propellant system during LEOP, with subsequent decrease of total mission lifetime with respect to the first 2 launches.

To counteract this and thanks to the operational experience acquired in the station keeping phase of the first 2 satellites, it has been decided to improve the selection of the orbital node rotation for GEO insertion in Near-Synchronous-Orbit (NSO): previously, this was done considering the propellant optimisation only of the LEOP phase, which consists in 90% of the total mission cost.

All MSGs have a nominal inclination control dead-band of 1 degree that makes the Station-Keeping costs highly dependent on the initial orbit node, which affects the inclination drift speed due to Sun/Moon and Earth geo-potentials. For MSG-3 a dedicated analysis was run to characterise the Station-Keeping cost during the extended lifetime as function of the GEO insertion node (see figure aside: equinoctial inclination, lifetime evolution for various GEO-insertion nodes). The pre-launch mission analysis considered this in combination with the LEOP propellant consumption for optimisation of the overall node rotation.



For MSG-4, the same combined optimisation was performed with some further improvement: dedicated analysis showed the economic benefit of storing the satellite in orbit, once fully integrated and tested on-ground, in case of earlier availability of the spacecraft with respect to the planned start of the operational service. The mission analysis considered as an additional optimisation parameter also the inclination at GEO insertion, to allow important propellant saving with respect to the previous mission regardless of a long period of in-orbit storage - 1.5 years before 9 years of operations (see figure aside, LEOP cost as function of NSO inclination and node). In addition, the Station-Keeping inclination control cycle has been enlarged, after verification of the negligible potential impact in the products generated by the MSG system.



Author(s) statement for acceptance: this paper describes the process of mission analysis for the various MSG spacecraft, with emphasis on the novel concept adopted for the last 2 launches in the program. The concepts indicated are of general interest for geosynchronous mission, especially for those missions with a large Station-Keeping inclination dead-band.