

ANALYSIS OF STATION-KEEPING MANOUVRES STRATEGIES FOR METEOSAT THIRD GENERATION

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Abstract: *Meteosat Third Generation (MTG) is the next series of the European operational meteorological satellites of EUMETSAT in geostationary orbit. Six satellites will carry imaging and sounding payloads, the first of them will be launched in 2019. Due to the in-orbit deployment plan of the satellites, there could be up to 4 MTG spacecraft flying together. Therefore, the mission analysis from the space segment procurement has been based on the most constraining scenario that is to operate up to 4 satellites in the same longitude slot. The proposed station-keeping strategy, typically intended for telecommunication satellites, is based on maintenance of a proper separation of the relative eccentricity/inclination of the satellites in the slot of $\pm 0.1^\circ$ longitude, $\pm 0.15^\circ$ latitude, and typical manoeuvres' cycles of 28 days (for both in-plane and out-of plane control). The current geostationary slots registered to EUMETSAT and the operational baseline allows deploying 4 satellites in 3 different slots, with only 2 of them in the same slot, with a wider longitude and inclination dead-bands. Different analyses have been performed to optimise the station keeping strategy not only for propellant consumption, but also for typical operational aspects, such as the load on the control centre and the service outages*

Keywords: *MTG, mission analysis, orbit control, geostationary, station-keeping.*

1. Introduction

This paper presents the results of the trade-off among various station-keeping strategies, using high fidelity models, for selecting an orbit control scheme that optimises not only the propellant consumption, but also the load on the control centre, and the service outages for the system due to manoeuvres: the paper demonstrates how to consider relevant operational aspects, typically not considered in preliminary mission analysis performed for space segment procurement.

2. The MTG programme, deployment scenarios and orbit control constraints

The Meteosat Third Generation (MTG) System of EUMETSAT is the next series of the European operational meteorological satellites in geostationary orbit; it will provide observations with higher spatial/spectral/temporal resolution with respect to previous generations. The MTG Imager (MTG-I) will be a 3.6-tonne satellite with 16 spectral channels. Not present in previous generations, there will be also an MTG Sounder (MTG-S), based on the same platform but carrying different instruments. Unlike all the predecessors spin-stabilised Meteosats, MTG will be based on three-axes stabilized platform, to achieve compliance with more demanding requirements and to conduct soundings from geostationary orbit. In routine operations phase, the attitude will be controlled by reaction wheels, driven by signals coming from star trackers. The programme is currently in Phase-C, the first launch is scheduled at the end of 2019. The mission will comprise 6 satellites: 4 imagers and 2 sounders. The Full Operational Capability (FOC) foresees 4 satellites in-flight at the same time. The system is designed to operate in the most demanding scenario, meaning with up to 4 satellites in the same slot of $\pm 0.1^\circ$ longitude, $\pm 0.15^\circ$ latitude. Due to service constraints and thanks to the geostationary ring's slots registered to EUMETSAT, the baseline deployment plan in FOC is the following: one Imager operating the Earth "Full Disk" service (basic instrument repeat cycle of 10 minutes), one Sounder in the same

longitude slot (nominally at 0° longitude); it is to be noted the actual width of EUMETSAT longitude slot in this position is relatively wider, $\pm 0.5^\circ$; another Imager will be positioned at 9.5°E for the European “Regional-Rapid-Scan” service (one-quarter of the full disk, repeat cycle of 2.5 minutes); a fourth satellite may be simultaneously launched/deployed at 3.4°W , for the commissioning phase. Furthermore, the inclination is to be kept nominal in a wider band, below 1° . Due to the propulsion system design and accommodation, the maximum delta-V that can be delivered is 3.8 m/s; furthermore, when executing an out-of-plane ΔV , there is stochastic in-plane cross-coupling, in addition to a deterministic coupling in radial direction (up to $\sim 4\%$). The platform has 2 sets of thrusters for inclination control on 2 opposite satellite faces, allowing the execution of both North and South burns. The co-located satellites have to be kept at 1.15° angular separation, as seen from Earth, to receive telemetry from a single ground-station. A conjunction in geostationary orbit is potentially harmful with a miss-distance of 5km, a minimum inter-satellite distance of 10km is a safe approach for constellation control.

3. Station-keeping manoeuvres simulation and trade-off analysis

The Station-Keeping strategy from MTG Space Segment procurement is based on 4 spacecrafts, all in $\pm 0.1^\circ$ longitude slot, with the co-location scheme eccentricity/inclination vector separation: to keep the constellation, a 28-day control cycle for each satellite was initially envisaged, with the execution of a single North-South (NS) inclination control manoeuvres, with magnitude up the maximum of 3.8 m/s, followed by a single-burn East-West (EW) for combined longitude/eccentricity control; reaction wheels off-loadings can be combined with NS, or executed asynchronously. This control scheme may easily end up in high workloads, in intense manned support and also in frequent service outages associated with each ΔV . As seen before, the actual deployment scenario and available system margins triggered the analysis presented in this paper. The simulation of end-to-end manoeuvre scenarios for satellite constellation has been executed, with high fidelity models for both space environment disturbance and thrusters’ performances (see orbit control plots examples). Different options have been analysed: first a control concept based on longitude separation (in distinct or overlapping bands): this allows a greater independence of in-plane and out-of-plane orbit control. As a consequence, inclination manoeuvres can be executed in less-frequent campaigns, splitting the total required ΔV in sub-cycles executed at consecutive orbit nodes.

If the use of North/South thrusters is alternated, it is possible to execute NS sub-cycles half orbit apart, providing self-compensation of the deterministic radial cross-coupling. Finally, exploiting the possibility of attitude bias of the spacecraft, it is also possible to tilt the NS ΔV to get the necessary in-plane component for longitude control, thus reducing the total number of executed manoeuvres.

The selected station-keeping strategy has many advantages, as it optimises the propellant consumption (greater flexibility in selecting NS control targets), it concentrates the operational load in less frequent periods, also reducing the service outages.

