DEIMOS-1 MID-LIFE LOCAL TIME CONTROL STRATEGY: ANALYSIS AND OPERATIONAL IMPLEMENTATION

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ABSTRACT

DEIMOS-1 is a LEO mission dedicated to Earth Observation, fully owned and operated by Deimos Imaging (Spain), a subsidiary of UrtheCast Corp. (Canada). It was developed in collaboration with Surrey Satellite Technology Limited (SSTL), and it is based on a SSTL-100 platform. Successfully launched on July 29, 2009 from the Baikonur Launch Complex (Kazakhstan), the satellite acquires imagery for commercial applications, for government use, and for rapid-response following disasters. The payload is a three-band multispectral imager system with a 22-m Ground Sample Distance (GSD) at the nominal altitude of 663 km, with 650 km swath and 10 bits radiometric depth. Its unique combination of wide swath and spatial resolution has converted DEIMOS-1 in one of the most used satellites for agriculture monitoring worldwide, and a successful Copernicus Contributing Mission.

DEIMOS-1 reached five years of operations, its original design lifetime, in July 2014. The excellent status and performance of the satellite allowed a mission extension of another five years. Luckily, the mission was originally designed with this extension in mind.

The satellite Sun-Synchronous, frozen orbit was designed to have a Local Time of Ascending Node (LTAN) centred at 10:30, and varying within a band of ± 30 minutes over the nominal lifetime. Thanks to a careful design of its initial operational orbit and its evolution, this behaviour was achieved without any orbit maintenance, due to the balancing effects of the natural evolution of orbit inclination and of the orbit altitude decay. After the first five years of mission, the LTAN was approaching 10:00 and it was naturally lowering towards dawn with a parabolic behaviour. Within a year or two, the illumination conditions would not have been suitable anymore for commercial imagery.

In order to guarantee the best imaging conditions during the extended lifetime, the LTAN needed to be maintained near 10:30, within the design ±30-minute window. Deimos Imaging performed a dedicated study both at flight dynamics and operational level, to design the optimal mid-life manoeuvring campaign which assured this orbit evolution.

The required orbital change, aimed at changing long-term evolution of LTAN, needed to comply with three main requirements: (1) keep the payload performances like TDI Line Rate setting range and GSD, (2) use most of the available propellant on-board but maintain a safety margin for collision avoidance during extended lifetime, and (3) avoid the degradation of orbit characteristics, like repeat cycle, revisit time and frozen conditions.

After analysing the effects of possible combinations of in-plane and out-of-plane manoeuvres, a pure orbit inclination-changing campaign was deemed the best suited to fulfil all the above criteria. A preliminary analysis showed that around 400 out-of-plane manoeuvres were required to reach the target orbit.

This anyway posed a further problem, since DEIMOS-1 never performed an inclination manoeuvre before, and the experience with inclination manoeuvres with SSTL-100 platforms was very scarce. Prior to the start of the manoeuvring campaign, a series of calibration tests were conducted to assess the real conditions at which it could be performed. Special care had to be taken with respect to the Propulsion Subsystem, AOCS and Power Subsystem as it was going to be the first time for DEIMOS-1 to perform inclination manoeuvres, and for any SSTL-100 platform to perform several hundred consecutive inclination manoeuvres. It was decided to perform all manoeuvres in eclipse, to avoid the risk of inadvertently exposing the imaging payload directly to the Sun during the manoeuvres.

To exhaustively monitor the manoeuvre campaign, analyses of reference altitude and LTAN evolution, thruster parameters and power budget were carried out daily. In the middle of campaign, pointing accuracy and frozen orbit conditions were also evaluated for manoeuvre refinement.

The overall mid-life orbit control campaign finally consisted of 395 out-of-plane manoeuvres carried out over two and a half months, from November 2014 to January 2015, and resulted in the expected change of 0.096º of the mean orbit inclination.

DEIMOS-1 is now on an orbit which guarantees, through a sound LTAN evolution, stable illumination conditions for its imagery at least until the end of the decade, allowing the needed 5-year extension of its mission.

This paper provides a comprehensive overview of DEIMOS-1 mid-life orbital manoeuvring campaign to control the long-term evolution of the local time at node, giving particular attention to the operational aspects.