COLLISION AVOIDANCE STRATEGIES, IMPLEMENTATION AND OPERATIONAL EXPERIENCE FOR DEIMOS-1 AND DEIMOS-2 MISSIONS

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ABSTRACT

Deimos Imaging (Spain), a subsidiary of UrtheCast Corp. (Canada), owns two commercial Earth Observation (EO) missions, DEIMOS-1 and DEIMOS-2. Deimos Imaging is in charge of operating both satellites and commercialising their imagery. Launched in 2009, DEIMOS-1 is a 100-kg satellite based on SSTL-100 platform, and it is currently in the middle of its 10-year mission. Equipped with a multi-spectral optical instrument, having a spatial resolution of 22 m and a very wide swath of 650 km, its imagery are mainly used for large-scale agriculture applications worldwide. DEIMOS-2, launched in June 2014, has been co-developed by Elecnor Deimos (Spain) together with Satrec Initiative (South Korea), and it is an agile 300-kg satellite for very-high-resolution EO applications. DEIMOS-2 provides 75-cm pansharpened images with a swath of 12 km at nadir, mainly for mapping, monitoring and security applications.

Both satellites are equipped with a propulsion system with thrust in the milli-Newton range, with a specific impulse around 100 s for DEIMOS-1 (warm-gas resistojet), and 1000 s for DEIMOS-2 (Hall Effect Thruster). They both underwent a large orbit manoeuvring campaign just after launch, aimed at reaching the nominal operational altitude and ensuring an optimal natural (uncontrolled) evolution of the Local Time at Ascending Node (LTAN). After these initial campaigns had been successfully carried out, the activities of the Flight Dynamics (FD) team centred on collision avoidance issues.

Both missions fly on Sun-Synchronous LEO, with mean altitudes of 660 km for DEIMOS-1 and 620 km for DEIMOS-2. This orbit environment is quite littered with space debris, and an efficient Collision Avoidance (CA) procedure is of key importance for assuring the survivability of each mission. In order to maximise the effectiveness of the CA, Deimos Imaging FD team is in constant communication with the Joint Space Operations Center (JSpOC). The need to give a quick and sensible answer to Conjunction Data Messages

(CDMs) received from JSpOC drove the creation of the internal tools and operational procedures which are now the backbone of Deimos Imaging CA strategy.

Deimos Imaging' own suite of CA tools covers the full chain of CA procedures, from early detection to optimal manoeuvre computation and implementation, and to post-event analysis.

A first set of tools, aimed at anticipating possible close approaches by using multiple TLEs to refine the orbit of an object, provide quick results and help the operators to easily assess the characteristics of any possible close approach. Additionally, tools to compute the collision probability and geometry at the B-plane based on CDM data are also available and used in actual operations to ease the decision-making process. Besides, tools implementing the latest developments in algorithms to create avoidance strategies are used to cross-check and refine the avoidance strategy. Finally, visualization and data-distribution tools are continuously being improved to guarantee that relevant information is made available to the appropriate people in a clear and concise manner.

This paper presents an overview of Deimos Imaging Collision Avoidance activities, based on the operational experience for DEIMOS-1 and DEIMOS-2 missions. Operational tools, theories and procedures used are outlined, aided by real-life examples of conjunction events.

One interesting event was on November 7, 2012, a dual conjunction alert between DEIMOS-1, a FENGYUN-1C debris and an H-2A debris whose closest approaches were separated by a short time period. The case falls within a category of events where an avoidance manoeuvre can lead to worsen the situation with the second-event object.

Another remarkable event was the first conjunction detected for DEIMOS-2, with RAPIDEYE-1 as approaching object. Occurring the August 3, 2014, it shows that coordination between spacecraft operators is essential in order to avoid evasive strategies which could increase the collision risk. Furthermore, as it happened while in full manoeuvring campaign, uncertainties related to already scheduled manoeuvres (e.g. partially successful firing, thruster misalignment) are taken into account when planning avoidance strategies.

The accepted risk level, as well as the avoidance strategy selected, have a direct impact on fuel used for avoidance manoeuvres during mission-lifetime. A comparison between mission analysis estimated avoidance manoeuvres and fuel budget needed and real operational data is also presented.