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HIGH-PRECISION SPACECRAFT ATTITUDE AND MANOEUVRE CONTROL USING ELECTRIC PROPULSION

Abstract

An earth observation spacecraft placed in geostationary orbit has the advantage of having a continuous coverage of a given region, enabling it to revisit locations of interest in that coverage area at a very high rate. However, in order to produce a useful and competitive product to the customer, such a geostationary earth observation platform will have to provide a very high absolute and relative pointing accuracy for the instrument. For geostationary earth observation missions, like the European Space Agency's Geo-Oculus mission, a pointing accuracy in the order of 50 μrad and a pointing stability in the order of 0.1 μrad/s are required. In this domain, micro-vibrations caused by actuators such as reaction wheels and control moment gyros would be prohibitively high compared to the requirements. Moreover, wheel desaturation manoeuvres cause undesired outage times. To alleviate such drawbacks, a novel spacecraft actuation approach has been developed and studied in detail in the framework of the HOPAS-III study, conducted jointly by EADS Astrium GmbH and the German Aerospace Centre (DLR). This study looks at the feasibility of using a solely electric propulsion based system for highly accurate spacecraft attitude and manoeuvre control. The impact of an electric propulsion system on the pointing accuracy performance and achievable manoeuvre times of a geostationary earth observation spacecraft are outlined. To determine the pointing accuracy of a geostationary platform, an advanced simulator based on Matlab/Simulink has been developed, using well-proven and close-to-real-world simulation models to correctly simulate the spacecraft dynamical behaviour and all disturbances experienced from the environment and the spacecraft itself. New electric thruster models were developed to reflect the performance expected from the 50 mN high efficiency multi-stage plasma thrusters (HEMPTs) from Thales (Ulm, Germany). The simulation results show that it is possible to both have pointing accuracies below 100 μrad and be able to manoeuvre the instrument field of view to multiple locations a few degrees apart several times per hour. This is possible with a total fuel consumption of less than 100 kg over 10 years of operations. However, two different sets of thrusters are required, mN-class thrusters to achieve acceptable manoeuvre times, and μN-class thrusters for high precision attitude control with acceptable overall propellant consumption. Whereas earlier publications have looked at station keeping and orbit manoeuvres using electric propulsion, the novelty of this paper is founded in the development of a full-fledged three-axes attitude and orbit control system, including necessary subsystems and under reasonable system requirements.