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EARTH OBSERVATION SYMPOSIUM (B1)
Future Earth Observation Systems (2)

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EXTENSION OF EARTH OBSERVATION ORBITS USING LOW-THRUST PROPULSION

Abstract

Earth Observation spacecraft are increasingly focused on a single primary application, typically conducted from a small set of classical orbits which limits the range of vantage points and hence the type of observations which can be made. The next generation of innovative, fit-for-purpose Earth Observation (EO) spacecraft may however only be enabled through new orbit options not considered in the past. The use of low-thrust propulsion systems to significantly enlarge the set of potential EO orbits is presented, focusing particularly on extending conventional Sun-synchronous and Molniya orbits. These new orbits will use existing low-thrust propulsion technology to enable new EO science and offer a radically new set of tools for EO mission design.

The primary motivation for the utilisation of space for environmental science, and in-particular EO, is the unique vantage point which a spacecraft can provide. For example, a spacecraft can provide a global dataset with a much higher temporal resolution than any other platform. Consequently, space-based EO measurements for climate change and other monitoring applications are of fundamental importance for validation and assimilation into Earth system models; CEOS and GCOS have identified 21 Essential Climate Variables (ECVs) that are largely dependent on EO. However, it is of note that the vantage points currently used by spacecraft for environmental science and EO represent only a small subset of those available.

Continuous low-thrust propulsion is applied to extend both the Sun-synchronous orbit and the Molniya orbit. It is shown that the critical inclination of the Molniya orbit can be altered from 63.4 to around 90, while maintaining the zero change in argument of perigee condition which characterises the Molniya orbit, creating a Polar-Molniya orbit. As such, real-time continuous observation of the poles is enabled with fewer spacecraft than the traditional Sun-synchronous polar orbit would allow. Similarly, it is shown that low-thrust propulsion can be applied to the Sun-synchronous orbit, allowing free selection of orbit altitude and inclination while maintaining a fixed repeat ground-track period and/or allowing multiple spacecraft to populate a single Mean Local Solar Time-slot. It is noted that the basic principle of using low-thrust propulsion to extend the range of feasible EO orbits has been demonstrated by the GOCE spacecraft; hence these new orbits are a logical extension of such a demonstration.