63rd International Astronautical Congress 2012

Paper ID: 13914
oral
student

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

Author: Ms. Pamela Anderson
Advanced Space Concept Laboratory, University of Strathclyde, United Kingdom

Dr. Malcolm Macdonald
University of Strathclyde, United Kingdom

SUN-SYNCHRONOUS HIGHLY ELLIPTICAL ORBITS USING LOW-THRUST PROPULSION

Abstract

In recent years, there has been significant interest in building a comprehensive Arctic observing system to accurately track environmental processes in this region. The rapidly changing environment of the Arctic is of high meteorological significance, as weather there has an impact on global climate predictions. Currently, observations of high-latitude regions are conducted using composite images from spacecraft in Geostationary (GEO) and Low-Earth orbits (LEOs) which are typically Sun-synchronous. However, the oblique viewing geometry of geostationary systems to latitudes above approximately 55deg, coupled with the low-temporal resolution of spacecraft in LEO means there is no available imagery of the Polar-Regions to the same temporal resolution as the tropics, and the temporal resolution is insufficient for many Polar remote sensing objectives. As a potential solution to this, Highly-Elliptical Orbits (HEOs), such as the Molniya orbit, have been proposed for observation of high-latitude regions. Such orbits have recently been endorsed by the World Meteorological Society, stating the requirement for a constellation of spacecraft on HEOs to complement the constellation of spacecraft in GEO, completing the Global Observing System and allowing quasi-continuous coverage of Earth. However, the fixed 'critical inclination' of the Molniya orbit at 63.43deg means that imaging of high-latitude regions to equal quality of that provided for the tropics is not possible using a single platform, with as many as 15 spacecraft being required. Consequently, the authors previously introduced an extension to stable highly-elliptical orbits for improved high-latitude imaging using continuous low-thrust propulsion. These novel orbits, termed Taranis orbits, compensate for the drift in the apsidal line caused by the oblateness of the Earth to allow free selection of the inclination to any inclination to optimally fulfill the mission objectives; for example, to 90deg for improved Polar observation. Within this work, the Sun-synchronous orbit condition, a steady change in ascending node angle of 1deg per day is added to the zero change in argument of perigee condition. This is accomplished through addition of a further element of continuous low-thrust, directed out of the orbit plane, and ensures that the rate of change of ascending node of the Taranis orbit matches the mean rotation of the Sun within an Earth-centered inertial frame. Whilst the near constant illumination conditions of any Sun-synchronous orbit are beneficial for remote sensing, it is likely that further benefits will be found in simplified instrument design through the simplification of the spacecraft thermal environment.