Paper ID: 31661
oral

66th International Astronautical Congress 2015

45th STUDENT CONFERENCE (E2)
Student Conference - Part 2 (2)

Author: Mr. Mike Walmsley
University of Edinburgh, United Kingdom, s1220970@sms.ed.ac.uk

TRAJECTORY DESIGN FOR PLANETARY POLE-SITTER MISSIONS

Abstract

Pole-sitters are a novel satellite concept following a non-Keplerian orbit along a planetary rotation axis to allow continuous and hemispherical coverage of a planet's Polar Regions. For example, an Earth pole-sitter remains on the Earth's polar axis and allows constant coverage of the Earth's North or South Pole, enabling unique applications such as geoscience monitoring, improved high-latitude weather prediction and telecommunications. Trajectory control of such a pole-sitter orbit can be achieved through the use of solar electric propulsion (SEP) or a hybrid of SEP and solar sail propulsion. Adding the sail minimises the propellant consumption by the thruster, thereby maximising the mission lifetime and/or payload mass.

Previous work has focused solely on Earth pole-sitters and is therefore extended in this paper to pole-sitters at the other inner Solar System planets, allowing a range of novel extra-terrestrial mission applications. For example, creating a pole-sitter vantage point at Mars can enable continuous communication with Earth during Martian occultation. Of concern is that, by moving inwards to the Sun, the radiation dose received by the solar sail increases significantly, accelerating the solar sail degradation. This paper therefore, for the first time, investigates the effect of sail degradation on the pole-sitter mission performance.

Optimal pole-sitter trajectories are found with a direct multiple shooting (DMS) scheme, allowing a corroboration of previous results found through a direct pseudo-spectral method. The Earth results are in good agreement, allowing the DMS scheme to be used to generate multiple trajectories at each of the other inner Solar System planets for different levels of solar sail performance. Furthermore, a parametric analysis is conducted to create more generalised results and investigate the link between planetary variables and mission objectives. We find that, in terms of propellant consumption and therefore mission lifetime, small gravitational parameters and large axial tilts are favourable.

Finally, high-fidelity results are generated by quantifying the effect of solar sail degradation on the mission objectives. By describing the sail film's optical coefficients as a function of the cumulative radiation dose, we calculate updated mission mass profiles for a range of expected degradation factors.