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OPTIMAL USE OF ELECTRIC PROPULSION FOR DRAG COMPENSATION IN VERY LOW EARTH ORBIT ON SATELLITES WITH DEPLOYABLE SOLAR PANELS

Abstract

In recent years, thanks to advancements in commercial hardware technology miniaturization, small satellites have become more and more important and effective in the Space ecosystem. In previous papers it has been demonstrated that future smallsat observation systems, operating at a lower altitude than traditional systems, have the potential for comparable or better performance, much lower overall mission cost, lower risk, shorter schedules, lower up-front development cost, more sustainable business model, mitigating the problem of orbital debris. Flying in very low earth orbit requires the addition of a propulsion system capable of providing drag compensation. Thanks to its high specific impulse, electric propulsion is potentially well suited for this task. However, the use of an electric thruster often requires significant power that can be provided only with deployable solar panels. To minimize the drag, the solar panels should be aligned with the satellite orbital velocity. At the same time, to maximize the power input, the solar panel surfaces should point toward the Sun. In the majority of cases these two conditions are not met simultaneously, so an optimal trade-off is needed. This topic is investigated in this paper by the use of an orbital model of a generic satellite with deployable solar panels. The model is able to simulate any circular orbit of the satellite in any day of the year and calculate both the power input and the drag from the solar panels based on their inclination. An equivalent specific impulse is also defined taking into account the thrust that the electric thruster has to provide only to push the area of the solar panels required to power the propulsion system. The results show, as expected, that the sun-synchronous dawn-dusk orbit is the preferred one for the electric propulsion as the velocity vector and the Sun vector are almost orthogonal. In the other cases, at very low earth orbit, even small inclinations of the solar panels respect to the velocity vector have a significant impact on the drag produced, increasing the propellant consumption and the required power. Nevertheless, it is shown also that if the solar panels are aligned with the velocity, the power lost can be kept reasonable. The same analysis could also apply to a satellite in low earth orbit that does not employ an electric thruster but still needs deployable solar panels because of other sources of high power consumption (e.g. the payload).