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IONOSPHERIC DRAG FOR ACCELERATED DEORBIT FROM UPPER LOW-EARTH-ORBIT

Abstract

Orbit debris mitigation restrictions placed on the growing number of miniaturised spacecraft often constrain their operational altitudes to less than approximately 600km where drag accelerations are sufficient to deorbit the spacecraft within a tolerable amount of time. Operation at higher, Low Earth Orbit (LEO) altitudes often necessitates active measures to deorbit miniaturised spacecraft such as propulsion systems. However, the inclusion of propulsion systems adds cost and complexity and is not always desirable, particularly for adopters of agile spacecraft development methodologies. This work investigates the feasibility of ionospheric drag, the component of drag caused by an electrically charged body's exchange of momentum with ions and electrons of the ionosphere, to accelerate the deorbit of miniaturised spacecraft in high LEO (600-1000 km altitude). This work will study how actively charging the surface of a miniaturised satellite in high LEO may enhance the overall magnitude of the drag acceleration, due to the ionospheric drag, acting to deorbit the spacecraft. This work takes surrogate models of the charged drag coefficient, as a function of scaling parameters, generated by Particle-in-Cell simulations. The charged drag coefficient surrogate model is incorporated into an orbit propagator where deorbit times are predicted over various orbital and vehicular initial conditions. Results suggest that the ratio of the ionospheric drag component to the neutral drag component is large at high LEO due to the relatively high ratio of ionospheric to thermospheric density. Therefore, ionospheric drag is relatively more efficient at deorbiting spacecraft at high LEO compared to neutral drag. Additionally, the magnitude of ionospheric drag is tailorable based on changes in the electrical surface potential of the satellite relative to the free-stream plasma. The primary payload of many miniaturised spacecraft often require high-voltage electrical systems. These same electrical systems could conceivably be utilised to generate ionospheric drag via surface charging, at the end of the mission-life, at little additional cost or system complexity. Thus, the implications of this work include the possible uncovering of a simple mechanism for deorbiting miniaturised spacecraft from high LEO altitudes for compliance with orbit debris mitigation restrictions.