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ANALYSIS OF SOLAR SAILING AS A MEANS OF ORBIT MANEUVERING FOR NANOSATELLITES IN LOW EARTH ORBIT

Abstract

The paper presents a detailed analysis of the feasibility and effectiveness of solar sailing as a means of orbit maneuvering for nano satellites orbiting in low-earth orbits. Demonstrating orbit maneuvering using solar sails is the scientific objective of COEPSAT-2, a satellite being developed by undergraduate students of College of Engineering, Pune. Solar sailing proves to be a cost effective and energy efficient means of orbit maneuvering for nanosats considering their mass, size and energy constraints. A comparative study of solar sails with thrusters, which are a common means of orbit maneuvering, has also been carried out. Solar sailing works on the principle of momentum transfer due to solar radiation. The aim of the Attitude Determination and Control System (ADCS) of satellite is to orient the satellite in such a way that the thrust in the direction of velocity is maximized and the drag force is minimized over the orbit. Consequently, at higher altitudes, the average thrust due to solar radiation pressure will be greater than the average drag, resulting in increase in kinetic energy of satellite. This increase in energy will cause a rise in the satellite's orbit. De-orbiting of the satellite will be carried out on reaching maximum desired altitude, by using another set of orientations. These orientations will use drag and solar radiation pressure both, to generate maximum thrust in the direction opposite to the orbital velocity. The paper presents sail orientations for orbit raising and de-orbiting along with simulation results to support their effectiveness. As solar sailing involves continuous thrust, a numerical propagator was used for simulations. Precise models to determine solar thrust and drag force have been incorporated in this simulation. Standard

atmosphere models like MSISE-90 and Jacchia-Roberts were used to calculate the atmospheric density and drag forces at different altitudes. The paper also presents a comparison between solar thrust and drag force for orbits of various altitudes. Simulations were carried out for different initial values of inclination, semi-major axes and area of sail to observe their effects on the values of thrust, drag and the final shape of the orbit. The analysis and simulations presented in the paper give us a preliminary assurance of successful orbit maneuvering using solar sail.