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AERODYNAMICS IN LOW EARTH ORBIT

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ABSTRACT

The orbital evolution of CubeSats operating in low Earth orbit is strongly influenced by atmospheric drag, particularly during periods of elevated solar activity, which follows an approximately 11-year solar cycle. Enhanced extreme ultraviolet radiation during solar maximum leads to significant heating and expansion of the thermosphere, increasing atmospheric density at a given altitude by up to an order of magnitude compared to solar minimum conditions. Consequently, CubeSats experience accelerated orbital decay and substantially reduced mission lifetimes. In addition to drag, aerodynamic lift effects, often neglected in simplified models, can play a non-negligible role for spacecraft with asymmetric geometries and variable attitudes. For a CubeSat equipped with deployable solar panels, the effective aerodynamic properties, including both drag and lift coefficients, can vary significantly depending on its orientation relative to the incoming flow. This work presents ongoing efforts to develop a comprehensive aerodynamic model of the flow environment around a CubeSat in LEO, accounting for both drag and lift contributions. The study considers the sensitivity of aerodynamic forces to spacecraft geometry and attitude in rarefied flow conditions, with emphasis on capturing their impact on orbital motion. While drag remains the dominant effect, additional contributions arising from lift are included in the analysis to assess their potential influence on orbital evolution relative to simplified no-lift assumptions. The results are intended to support more accurate orbital propagation and to provide improved insight into aerodynamic perturbations affecting CubeSat missions, especially during periods of increased solar activity.