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A NOVEL DRAG COEFFICIENT MODELING FOR NANO SATELLITES

Abstract

Traditionally, from the beginning of space age, most satellite orbit control calculations used the common 2.2 as the physical drag coefficient for compactly shaped box type satellites. As missions types advanced and became more sophisticated, the need for an accurate drag coefficient modeling grew wider. Improving drag coefficient knowledge is motivated to increase orbit-prediction accuracy in space applications such as reentry forecasts, improving the accuracy of orbit determination, increasing our understanding of planetary atmospheres and providing us a more sophisticated tool for performing drag-influenced maneuvers. To form an accurate solution in any of these cases, forces on the satellite in the direction of flight must be correctly related to the properties of the atmosphere – such as density, temperature etc. Thus, Empirical drag coefficient models, based on the Boltzmann equation, were derived for simple geometries, such as a sphere and a flat plate, allowing to produce an analytical solutions for the drag coefficient at altitudes above 400 km, under a certain set of assumptions.

SAMSON (Space Autonomous Mission for Swarming and Geolocation Nanosatellites) project is a distinctive example of three cubesats performing formation flying in a cluster for geolocation mission. Another unique capability of SAMSON project is Differential Drag control – which will be tested in space to demonstrate cluster control, using the satellites' drag for maneuvering, with minimum propellant (or absolutely none). In order to perform this control method, it is essential to accurately predict the instantaneous drag of each satellite. Thus, a complex model of satellite attitude, and resulting drag, is needed.

In our paper, we have restricted our attention to SAMSON project. Using a flat plate empirical model, we derived a drag coefficient model of SAMSON satellites for various orientations, in order to form a complete and accurate simulation and to perform optimal Differential Drag control maneuvers utilizing onboard computation capabilities.

Our research integrates the use of a gas –surface interaction model, a flat plate close form solution, a projected satellite surface with special attention for panel shading against flow direction, solar pressure component in the direction of the flow, all under the assumptions of rarefied gas environment. Moreover, the calculation method was designed and proved to be quick and flexible, allowing real-time calculation in varying environmental conditions. The paper will show the performance results of the developed model.