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AERODYNAMIC COORDINATED CONTROL OF ATTITUDE AND RELATIVE POSITION OF A FORMATION OF MICROSATELLITES

Abstract

Microsatellite formations offer an affordable and versatile solution for space missions, particularly in Low and Very Low Earth Orbits (VLEO) where performance is high and launch costs are low. However, atmospheric density at those altitudes decreases the operational lifetime, due to a remarkable orbital decay. From another point of view, the atmospheric forces can be used as means of actuation for both the attitude and the relative position of the spacecraft, thus offering the opportunity to reconfigure the formation without propellant. This can be accomplished by incorporating movable panels on the spacecraft, which can serve as actuators. This paper first presents a study on the most promising configurations for realizing attitude and formation control maneuvers. Depending on the number and position of the panels, different performance can be obtained. A complete and detailed modeling of the spacecraft geometry allows to compute not only the usual drag component in the along-track direction, but also a lift component, which can be fruitfully exploited in particular for attitude control. The novel approach consists in controlling the panels angles in such a way that a coordinated control of the attitude and of the position is achieved. The redundancy in the number of actuators (panels) is the key for achieving the dual goal. When considering a formation of two spacecraft, the formation control is obtained by an opposite motion of the panels between the two spacecraft. This means that all the panels of one satellite are subject to a common mode motion for the formation control. The attitude control instead requires a differential motion of the panels. The combination of the common mode (formation control) and differential mode (attitude control) allows for a complete platform control. The performance and limitations of the proposed control architecture are described for different mission objectives (formation maintenance and reconfiguration) and for different orbital scenarios (different altitudes mean different control authority, while elliptic orbits imply time varying control authority). The results suggest that such a strategy can significantly increase the capabilities and potential applications of formation of microsatellites, with reduced fuel consumption and increased operational efficiency.