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PERFORMANCE AND LIFETIME EVALUATION OF A SMALL SATELLITE FORMATION WITH LIMITED CONTROL AND NAVIGATION CAPABILITIES

Abstract

Nowadays, CubeSats or in general small satellites have become one of the possible solutions for several space mission scenarios because of their low realization cost and accessibility to both industries and universities. Many of the possible applications would benefit from the implementation of a formation made up of more than one small platform, increasing in this way the performance of the payloads of the individual satellite (which is usually not very high compared to standard spacecraft). However, formation navigation and control of small satellites introduces new challenges. The acquisition and tracking of a given relative trajectory with respect to the other members of the formation is a task that has been extensively analyzed in the past, but in this study it is tailored on the specific case of small satellites. The navigation system consists of a filter using the measurements coming from a GPS receiver and an intersatellite link, reaching a 1m level accuracy in relative position. The classic architecture for the attitude determination and control is considered, including star trackers, gyros and magnetometers for sensing, and a set of four reaction wheels for actuation. The attitude control system is fundamental both to achieve mission goals and to realize the formation orbital control. In fact, it is reasonable to think that onboard of small satellites (especially micro and nano satellites) only one thruster is available, acting on a single direction. This means that an attitude maneuver must be completed each time a ΔV must be provided in a different direction to reach a certain formation configuration. Moreover, the thrust level is also usually limited and constrained to a fixed value (e.g., for cold gas monopropellant thrusters). As a consequence of all these limitations on the onboard hardware, the available performance differs from the ones commonly associated to formations made up of large platforms. The suggested optimal control strategy, which includes the thruster characteristics into account, helps in mitigating the degradation in the performance. A complete formation flying software tool, purposely developed from scratches to simulate this realistic scenario, allows to better estimate not only the accuracy and feasibility of the possible maneuvers, whose choice is driven from specific mission requirements, but also the total propellant cost and, finally, the expected operational lifetime of the formation in several scenarios.