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DEPLOYMENT STRATEGIES FOR A FORMATION OF PICO-SATELLITES

Abstract

Recently, feasibility studies have been exploring the opportunity to launch a formation of satellites in assembled configuration, to be deployed once in orbit. This option seems especially appealing for really small spacecraft, since all the formation's members could be stored in the cargo-bay of a mother platform. An example of this mission concept is a pico-satellite formation, aimed to gather – at a reasonable cost – spatially and temporally correlated data. Of course, all operation issues relevant to this mission concept should face severe constraints coming from the limited resources of the spacecraft: in particular, pico–satellites (like the standard Cubesat, or even smaller) usually lack of orbital control capability, which results in an interesting technical problem for deployment phase.

In fact, a short relative distance between the formation and the mother spacecraft must be kept during the operational lifetime, in order to preserve the inter-satellite communication link, which is strongly limited by the power available onboard. If no active control is present, the only way to prevent the formation to spread too far apart consists in a wise deployment strategy.

Two opposite drivers guide the release of the members: the collision avoidance and the minimization of the relative drift. The relative drift is due to gravitational causes (even a slight difference in semiaxis causes a separation approximately ten times larger in one orbit) and to perturbation forces, mainly the differential air drag. The collision risk is instead due to a periodic component in the relative motion, that brings the members of a formation close to each other once every orbit. Simulations show that zero drift implies high collision risk, and vice versa, low collision risk is usually matched to large separation after a few days. An ad hoc deployment strategy, in terms of release direction, separation velocity and deployment sequence is proposed in this paper, with the aim to satisfy both requirements, thus maximizing the mission duration.

The paper also introduces a way for a very simple solution for navigating the deployed formation with respect to the mother platform. The automatic control gain of the receiver onboard the mother-spacecraft freely provides the level of signal power, which is an observable, poor and inaccurate, related to the scalar distance of each pico–satellite. A Kalman filter including a suitable dynamical model can exploit these measurements in order to estimate the formation kinematic state at a very limited cost.