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FORMATION ACQUISITION AND CONTROL STRATEGIES FOR FORMATIONS IN HIGHLY ELLIPTIC ORBITS

Abstract

Over the past few years, formation flying in elliptical orbits has become an active area of research. A case in point is the PROBA-3 solar coronagraph mission. The PROBA-3 mission will use a virtual structure formation-flying concept, consisting of an occulter spacecraft, which will block the Sun disk, and a coronagraph spacecraft, which will perform the coronagraph measurements. In addition to this scientific objective, the mission will provide a crucial engineering test bed for formation flying in highly elliptic orbits. The formation-flying scenario during one orbit consists of a precisely controlled Sun-pointing arc around apogee, and a free-flying transfer during perigee. The formation flying strategy needs to be adapted to the level of accuracy that can be attained in the determination of the relative trajectory. Relative GPS will be available for about an hour around perigee, supplemented in with a relative RF sensor after the initial formation acquisition. These sensors provide a coarse estimate of the relative state. Precise measurements are available only when the formation is in alignment with the Sun, and these measurements are provided by a camera and a shadow sensor. The formation flying strategy for the free flight segments needs to balance formation safety against the available accuracy of the sensors. The most critical mission phase in this respect is the formation acquisition. During this phase, the relative sensors will not yet have been calibrated and the knowledge of the relative trajectory will be imprecise. Several strategies for the formation acquisition will be discussed and compared. Ultimately, the most promising strategy is an extension of the general strategy for low precision control of the formation. This allows the overall approach to the design of the algorithms to remain simple. The strategy for low precision formation control leads to trajectories that remain passively safe for long periods, and this trajectory safety can be maintained when the formation control strategy is adapted to formation acquisition. The low-precision formation control strategy itself is based on controlling the relative angular momentum and eccentricity vectors in such a way that the formation aligns with the Sun at certain points along the orbit. This allows the spacecraft to take precise relative measurements at that point.