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CASE STUDIES FOR CHOOSING PROPULSION SYSTEMS IN FORMATION FLYING MISSIONS

Abstract

In the recent decades, spaceflight has seen many innovative applications that subsequently became routine. Even today, new services, such as mission extension or mobile space-based telecom, occasionally emerge. There is also a group of applications featuring the so-called swarm control. In these missions, several satellites would maintain their orbital positions within a formation that acts like a single object in order to perform various tasks. These tasks may include message display with sunlight reflectors or lasers, or scientific research missions, where maintaining the distance between the satellites would be essential for the scientific goals. In terms of propulsion system operations, swarm missions imply three stages: phasing, formation-keeping, and disposal. In many cases, keeping the formation stable in orbital reference frame (for example, to make it appear as a rigid body to a ground observer), would require excessive maneuvering and maintaining non-Keplerian orbits, which would result in huge propellant consumption rate. This work presents a method that would maintain the distances within the formation at a lower cost, but the whole formation will rotate around a certain reference point. This makes the orbits of the satellites close to the Keplerian, but certain maneuvering is still needed. However, the maneuvers in question are a series of pulses so small, that minimal pulse time becomes a driving requirement for the propulsion system. Higher priority is also given to the thrust vector accuracy and attitude control requirements. In the present paper, an analysis has been made to see which of the existing propulsion system solutions would fit for swarm missions. Two cases are studied, based on several missions that have been announced in the recent years: first, where numerous satellites would be used to form pixelated images in the night sky, and second, where a group of satellites forms a precise tetrahedron to provide radiation measurements. The algorithms for phasing, formation control, and deorbiting are discussed depending on the values of position control tolerance. Through this analysis, basic requirements for the propulsion accuracy are defined. It is established whether or not existing propulsion systems would fit for the suggested algorithms. Finally, a set of specific guidelines is suggested to choosing a propulsion system for swarm missions.