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FEASIBILITY STUDY OF AN ALL-ELECTRIC RENDEZVOUS MISSION IN GEO ORBIT

Abstract

Orbital rendez-vous (RDV) becomes of increasing interest in the space community. It is involved in different kinds of missions such as active debris removal, on-orbit servicing and in-orbit assembly. The use of electric propulsion presents advantages with respect to the chemical one because of its higher specific impulse and the consequent possibility of saving fuel mass. Nevertheless, the lower level of thrust magnitude induces long thrust arcs and entails checking the feasibility of each fixed-time RDV phase. This paper develops a RDV operational concept in GEO orbit considering a particular full-electric propulsion system mounted on the servicer satellite. A feasibility study is performed for the last three phases of the approach to a GEO target satellite collaborative and cooperative, starting from a relative distance equal to 4 km. The first phase is a hopping from 4 km to 1.5 km along the V-bar axis. The second phase is a hopping from 1.5 km on V-bar to 150 m on R-bar. The final approach, from a 150 m relative distance, is along R-bar from the anti-Earth side so that the GEO target satellite may continue to communicate with the Earth. Guidance and control tasks are tailored to the specific propulsion system proposed with a particular TMF (Thruster Management Function). A focus is done on the final approach phase. Firstly, the final approach strategy is improved to increase the passive safety of the mission even in case of failures. Partial and full conditions of failure of the propulsion system are considered to demonstrate that the servicer does not collide with the target satellite. Secondly, the performances at the direct docking point are verified using two different models and control strategies. First, two 3 DOF (Degree Of Freedom) models are considered, one for translation and the other for rotation, each one being associated with a PID controller. Then, a translation-rotation coupled 6 DOF model is developed. The guidance law is found with a LQR (Linear Quadratic Regulator) method coupled with PID controllers for tracking the reference guidance trajectories. Both approaches guarantee the satisfaction of the docking performance specification, taking into account environmental disturbing contributions in closed loop simulations. The second approach is used in cases where the target satellite is pitched with respect to the ideal GEO orientation. The LQR method, finely tuned and applied to a port-to-port 6 DOF model, allows obtaining a simultaneous translation and rotation guidance satisfying the docking specifications.