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COLLISION AVOIDANCE IN GEO: THE CHALLENGES OF ORBIT DETERMINATION FOR ELECTRIC PROPULSION SATELLITES VIA OPTICAL GROUND BASED OBSERVATIONS

Abstract

The SICRAL Joint Management & Control Centre (SJMCC) is an Italian military institution in charge of the mission control of the Italian military spacecraft and the first European full-military institute capable of independently performing spacecraft housekeeping and station keeping operations. In this context, one of the most important activities is the management of collision risks. The task is accomplished by determining the orbits of secondary objects (such as neighboring geostationary satellites) and evaluating the orbital parameters, in order to assess the necessity of a collision avoidance maneuver. In recent years, a new generation of satellites equipped with innovative propulsion systems based on electric thrusters has introduced new challenges to the aforementioned operation. Electric propulsion systems provide very high thrust efficiency and low fuel consumption compared to chemical propulsion, while generically settling for lower thrust levels and longer maneuvering times. This implies that the free dynamics behavior of the spacecraft is only confined to a short fraction of the orbital period. Consequently, the typical flight dynamics approach, based on the propagation of the obtained state vector, loses its inner value since the electric propulsion spacecraft will persist in a free dynamics regime only for a limited fraction of its orbital period. From the perspective of a mission control centre, such as SJMCC, these new satellites make it necessary to drastically adapt its orbit determination capabilities. Consequently, the main goal of the research has been to model a strategy and a tool to manage the orbit determination of electric propulsion geostationary satellites. The paper thoroughly describes an innovative concept named "Continuous Obit Determination" (COD), also presenting a possible software implementation based on open-source libraries. Evaluating the challenges that electric propulsion satellites bring to satellite control centers, COD is detailed as a robust strategy able to flexibly aggregate different observational data of the secondary satellite in order to find the best fitting solution. The comparison between orbits allows the delineation of the satellite's maneuvering strategy and the selection of the most accurate orbit. Finally, the research results have been experimentally validated through observational data acquired via the "CAS telescope" managed by SJMCC for collision avoidance purposes.