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OPTIMIZATION OF TRANSFER SCHEMES BETWEEN PASSIVE SPACE OBJECTS IN GEO VICINITY

Abstract

According to the existing standards, all spacecrafts (SC) operating in GEO should be transferred to a disposal orbit (DO) at the end of their life span. However, in GEO protective region there still remain numerous large-size objects which can be delivered to DO only by using a special SC-collector. A transfer scheme should allow one to visit the maximum possible number of passive objects subject to fuel and time constraints. Because of gravitational perturbations due to the Earth and the Moon, orbital inclination of such objects is characterized by long-period (approximately 51 years) oscillations under which the orbital plane inclination may be as high as 15-16 deg. The Right Ascension of the Ascending Node (RAAN) with an ideal geostationary orbit is a degenerated parameter, but with increasing inclination the object's orbit is also described by a concrete value of RAAN. So, in constructing transfer schemes between objects one needs to consider a totality of orbits that have differences in all parameters and for which RAAN deviations can have arbitrary values. The authors have considered the motion of more than 100 existing upper stages in the vicinity of GEO and proposed two concepts of transfer schemes between them based on the analysis of the inclination evolution portrait for their orbits with time. Under the first approach, a transfer between orbits is executed when the orbits have the same inclination near the equator, and under the second approach, when the orbit of the next object has the smallest inclination. The proposed solutions are based on the fact that in the near-equatorial region the angle between planes of orbits remains small even under severe differences in RAAN. Namely, for orbital maneuvers, the most ΔV is spent on the change of the orbital plane. Our calculations show that both transfer schemes are equivalent in their average ΔV required for a transfer between two objects. For example, within 30 years of continuous mission execution by several SC-collectors working in succession, only 55 objects can be re-orbited under the first approach, while in the second scheme 83 objects can be re-orbited. An SC-collector with sufficient life span and fuel budget (similar to those for modern GEO SCs) is capable of re-orbiting up to 15 passive objects from the protected region. This requires up to 750 m/s ΔV budget for one SC-collector with at most 8 years time in operation.