Paper ID: 22643
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ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations and Optimization (1) (8)

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QUASI-PERIODIC ORBITS IN THE VICINITY OF THE SUN-EARTH SYSTEM L2 POINT AND THEIR IMPLEMENTATION IN "SPECTR-RG" AND "MILLIMETRON" MISSIONS

Abstract

This work considers construction of quasi-periodic orbits in the vicinity of the Sun-Earth system L2 libration point that are suitable for the upcoming Roscosmos "Spectr-RG" and "Millimetron" missions. Both missions presuppose deployment of an astrophysical observatory in a quasi-periodic orbit around Lagrangian L2 point. Since the scientific goals of these missions differ, different types of orbits have been proposed – "Spectr-RG" spacecraft should be placed in a lissajous orbit lying in a close vicinity of the L2 point whereas "Millimetron" spacecraft should use a large radius halo orbit going 1 mln km away from the ecliptics plane. To construct these orbits a new method and new mathematical algorithm providing ballistic design of the spacecraft transfer to the vicinity of the libration point and quasi-periodic motion in orbits with prescribed geometry in this area has been developed and implemented. Since the collinear equilibrium point L2 and halo orbits around it have strong hyperbolic character it is possible to use the latter's stable manifold for the transfer from Earth. A modified local approximation (solution of three body problem motion equations obtained with the help of Lindstedt-Poincaree technique) of the stable manifold at a certain number of points of the nominal orbit is taken. The state vector at each point is propagated backwards in time until the trajectory comes close enough to Earth to intersect with the parking orbit. All dots of the phase space satisfying given conditions at both endings of the transfer trajectory (parking orbit height at the Earth ending and A, B parameters, describing halo orbit geometry) compose the set of isolines, serving as initial approximation for the exact numerical calculation of the transfer trajectory. Since the vicinity of the collinear libration points is a hyperbolically unstable motion area, a flexible algorithm, calculating stationkeeping maneuver impulses and providing optimal strategy for the whole spacecraft lifetime has been developed, V costs have been evaluated. The idea is to keep the spacecraft in a tube around the approximation, derived from the selected quasi-periodic solution of the elliptical restricted three-body problem. The halo orbits and transfer trajectories calculated with the help of the methods described above have been selected as the nominal ones for "Spectr-RG" and "Millimetron" missions.