ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (1) (4)

Author: Dr. Alexey Grushevskii
Keldysh Institute of Applied Mathematics of RAS, Russian Federation, alexgrush@rambler.ru

Prof. Yury Golubev
Keldysh Institute of Applied Mathematics of RAS, Russian Federation, golubev@keldysh.ru
Mr. Victor Koryanov
Keldysh Institute of Applied Mathematics of RAS, Russian Federation, korianov@keldysh.ru
Dr. Andrey Tuchin
Keldysh Institute of Applied Mathematics of RAS, Russian Federation, tag@kiam1.rssi.ru
Mr. Denis Tuchin
Keldysh Institute of Applied Mathematics, RAS, Russian Federation, den@kiam1.rssi.ru

ADVANCED METHODS OF LOW COST MISSION DESIGN FOR OUTER PLANETS MOONS' ORBITERS AND LANDERS

Abstract

The forthcoming complex cosmic missions in systems of giant planets require approaching to one of the satellites and even landing on its surface. To solve the stated problem, it is necessary to decrease the spacecraft's asymptotic velocity relative to local moon. A decrease in the spacecraft's asymptotic velocity can be attained for the purpose of fuel economy due to numerous low cost gravity assist maneuvers. Limitations of the problem are caused by the high radiation level in the Jovian system and the maximally admissible duration of the space mission (2–3 years). Therefore, we should take into account the total ionizing dose (TID). One of main problems of planet-giant's mission design (JUICE, Laplas-P) is that the reduction of the asymptotic velocity of the spacecraft (SC) with respect to the satellite for the capture is impossible. A valid reason is in the invariance of Jacobi integral and Tisserand parameter in a restricted three-body model (RTBP). Furthermore, the same-body flybys tour falls into the hazard radiation zone according the Tisserand-Poincaré graph. Formalized beam's algorithm to overcome this problem with using full ephemeris model and with several coupled RTBP engaging has been implemented. Withal low-cost reduction of the spacecraft's asymptotic velocity for the moon capture is realized. The corresponding numerical scheme was developed with using Tisserand-Poincare graph and the simulation of tens of millions of options. The Delta V-low cost searching was utilized also with help of the modeling of the multiple rebounds (cross gravity assists) for beams of trajectories. The techniques are developed by the authors specifically to the needs of the mission "Laplas P" of Roscosmos. If we have answers to the questions "what kind of gravity assists", we need answer on the question "when". New Multi-Tisserand coordinates for this purpose are introduced. They are Tisserand parameters of SC relative some small bodies in several local RTBP. The Multi-Tisserand graph built based on them. It is shown that the "cross" gravity assists at the early stage of SC orbital energy reduction for TID-comfortable tour are required. As a result, a reasonable increase in the duration of the missions of the Jovian moons exploration can be exchanged on a sharp decline TID and "comfortable" (in TID) tours scenario can be found in the Jovian system (less than 200-300 Krad for the "light" SC with the 4-5 mm Al shield or less than 70 Krad for standard SC protection 8-10 mm Al).