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Author: Mr. Vladislav Zubko
Space Research Institute (IKI), Russian Academy of Sciences (RAS), Russian Federation

Dr. Alexander Sukhanov
Space Research Institute (IKI), RAS, Russian Federation
Mr. Konstantin Fedyaev
Space Research Institute (IKI), RAS, Russian Federation
Dr. Vsevolod Koryanov
Bauman Moscow State Technical University, Russian Federation
Mr. Andrey Belyaev
Bauman Moscow State Technical University, Russian Federation

OPTIMAL FLIGHT TRAJECTORIES TO TRANS-NEPTUNIAN OBJECT (90377) SEDNA

Abstract

In this research, we focus on the problem of constructing and analyzing optimal trajectories to the trans-Neptunian object (90377) Sedna. While currently classified as a scattered-disk object, Sedna may also belong to the inner part of the Oort Cloud, since its perihelion and aphelion are about 76 AU and 1000 AU, respectively, Sedna's orbital period is about 11,000 years. According to NASA's JPL Propulsion Laboratory data, Sedna is expected to reach perihelion in 2073-2076.

We use the Keplerian model for the calculation of the spacecraft (SC) motion. To obtain the trajectory of the spacecraft with gravity assist maneuvers near planets, we use the well-known method of patched conic approximation, which allows to significantly simplify the process of calculating the trajectories of spacecraft motion. Heliocentric arcs of the SC motion from one planet to another are determined by solving the Lambert problem.

The launch windows from 2029 to 2034 are considered. The trajectories of direct flight to Sedna and gravity assist maneuvers near Venus, Earth, and the giant planets are investigated. The schemes of the gravity assist maneuvers used in our research are separated into ones based on Venus-Earth-Earth Gravity Assist (VEEGA) and Venus-Earth-ΔV_α -Earth Gravity Assist (VEΔV_αEGA) maneuvers, with the ΔV_α impulse in the vicinity of the aphelion of the Earth-Earth loop in the second case.

The result of the research shows that a direct flight to Sedna with ΔV costs at least 8.9 km/s would take more than 120 years. Flight to Sedna with only one gravity assist of Jupiter can reduce the time of flight to 25 years at the cost of not less than 7.4 km/s for the launch in 2033. The analysis of the schemes described above showed that flight to Sedna with VEEGA and VEΔV_αEGA maneuvers, reduces the required ΔV, on average, to 5 km/s for the time of flight of 25 to 30 years. However, for the flight in 2029 and any time of flight, the required ΔV is less than 6.2 km/s in all cases, and for 35-years flight is 4.2 km/s.