Paper ID: 62107
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# FLIGHT TRAJECTORIES DESIGN USING GRAVITY ASSIST MANEUVERS TO THE TRANS-NEPTUNIAN OBJECT (90377) SEDNA

**Abstract**

The Oort Cloud is a hypothetical outer part of the Solar System and is basically considered a source of long-periodic comets that can occasionally be visible while approaching the Sun. Other bodies belonging to the Oort Cloud may stay at a very significant distance from the Sun and be considered asteroids or planetoids, depending on their sizes. Orbits of these objects are expected to be at the boundary of stability, and as the result of different perturbations, the objects may approach the inner part of the Solar System and be observed.

The trans-Neptunian object (90377) Sedna discovered in 2004 is probably related to the Oort Cloud since its orbit's aphelion is estimated at 1 thousand a.u. with an orbital period of about 11 thousand years. In 2074-75, Sedna will be in the vicinity of its perihelion at a distance of about 74 AU. That provides a unique chance to study this object from a close distance.

The current research focuses on analyzing possible flight trajectories to Sedna at launch in 2029-2034. Two possible ways to reach Sedna are considered: a direct flight and a flight using gravity assists maneuvers. It is shown that for a direct flight, a total characteristic velocity ($\Delta$V) of at least 8.9 km/s with a flight duration of 120 to 140 years is required. Using gravity assists maneuvers reduces the required $\Delta$V with a significant decrease of flight duration. Gravity assist maneuvers at Venus, Earth, Jupiter, Saturn, and Neptune are discussed. For launch dates in 2029-2031, a sequence of gravity assists near Venus, Earth, and Jupiter allow one to significantly reduce the total $\Delta$V required, with a flight duration constraint of 20 to 50 years. Gravity assist near Neptune allows reducing $\Delta$V for the flight to Sedna at launch from 2034 with a duration of at least 27.5 years.

As a result of the research, it has been found a flight trajectory that allows reaching Sedna with total $\Delta$V does not exceed 4.65 km/s with flight duration less than 30 years. Simultaneously, without considering constraints for flight duration, it is possible to find a trajectory with a total $\Delta$V not exceeding 3.91 km/s at a duration no more than 50, and in some cases even 40 years.