

66th International Astronautical Congress 2015

SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations (IP)

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ANALYSIS OF THE FLIGHT PATHS TO JUPITER USING THE SEQUENCE OF GRAVITATIONAL
MANEUVERS

Abstract

Within the project Laplace, devoted to the study of Jupiter's moons, the choice of flight paths for the spacecraft delivery to the vicinity Jupiter is an urgent problem. The paper analyzes the complicated flight routes to Jupiter using gravity assists from Earth, Venus and Mars and deep space maneuvers for the next launch window. Several of routes were examined. Each of them was optimized by the criterion of minimum of total impulse of velocity. The problem has been formulated as the problem of unconstrained minimization of a function of a large number of variables. The existence of many local minima complicates the analysis. Overcoming this difficulty is the main difficulty of the research. In this paper, the method of evolution strategy with covariance matrix adaptation is used. The results of analysis of trajectory characteristics for the four routes to Jupiter are presented: • Earth – Earth – Jupiter; • Earth – Mars – Earth – Jupiter; • Earth – Venus – Earth – Mars – Earth – Jupiter; • Earth – Venus – Earth – Earth – Jupiter. The mass characteristics of the spacecraft are presented for case of using the transport system based on the launch vehicle Angara-A5, the oxygen-hydrogen chemical upper stage KVTK and spacecraft's chemical engine with specific impulse 310 seconds. The spacecraft of maximal mass (6633 kg) can be delivered into the Jupiter's vicinity when the route Earth - Venus - Earth - Mars - Earth - Jupiter is used. The optimal date of start is 28th May 2023. The total time of mission is 6.4 years. When using of this route, deep space maneuver should not be provided. Spacecraft's chemical engine is used only for correction the trajectory and for a velocity impulse in the Jupiter's vicinity. The spacecraft mass of 6385 kg can be delivered to Jupiter when the route Earth - Venus - Earth - Earth – Jupiter is used. The optimal date of start is 15th November 2029. The total time of mission is 6 years. One deep space maneuver is required during the flight.