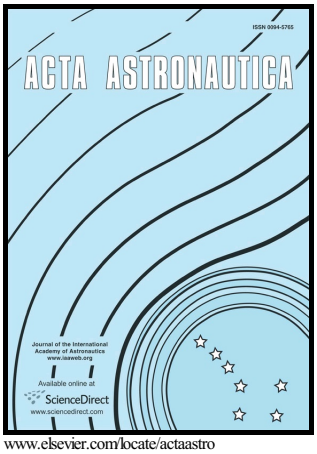

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METHOD OF INTERPLANETARY TRAJECTORY OPTIMIZATION FOR THE SPACECRAFT WITH LOW THRUST AND SWING-BYS

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Abstract

The method developed to avoid the complexity of solving the multipoint boundary value problem while optimizing interplanetary trajectories of the spacecraft with electric propulsion and a sequence of swing-bys is presented in the paper. This method is based on the use of the preliminary problem solutions for the impulsive trajectories. The preliminary problem analyzed at the first stage of the study is formulated so that the analysis and optimization of a particular flight path is considered as the unconstrained minimum in the space of the selectable parameters. The existing methods can effectively solve this problem and make it possible to identify rational flight paths (the sequence of swing-bys) to receive the initial approximation for the main characteristics of the flight path (dates, values of the hyperbolic excess velocity, etc.). These characteristics can be used to optimize the trajectory of the spacecraft with electric propulsion. The special feature of the work is the introduction of the second (intermediate) stage of the research. At this stage some characteristics of the analyzed flight path (e.g. dates of swing-bys) are fixed and the problem is formulated so that the trajectory of the spacecraft with electric propulsion is optimized on selected sites of the flight path. The end-to-end optimization is carried out at the third (final) stage of the research. The distinctive feature of this stage is the analysis of the full set of optimal conditions for the considered flight path. The analysis of the characteristics of the optimal flight trajectories to Jupiter with Earth, Venus and Mars swing-bys for the spacecraft with electric propulsion are presented. The paper shows that the spacecraft weighing more than 7150 kg can be delivered into the vicinity of Jupiter along the trajectory with two Earth swing-bys by use of the space transportation system based on the "Angara A5" rocket launcher, the chemical upper stage "KVTK" and the electric propulsion system with input electrical power of 100 kW.

Keywords: spacecraft; electric propulsion; swing-by; trajectory optimization

Introduction

The optimization problem of the interplanetary flight with a sequence of swing-bys has been investigated a lot. In [1, 2] the authors have developed a new procedure which minimizes the total impulsive velocity for multiple-flyby trajectories with constraints on flyby parameters.