SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

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SPACECRAFT INSERTION INTO EARTH-MOON L1 AND LUNAR ORBIT

Abstract

Some results of the analysis of spacecraft insertion into collinear point L1 of a Earth-Moon system and Lunar missions are considered. Opportunities of use of two types of propulsion are analysed (chemical engines and the low thrust engines). The purposes of research are:

- to develop regular algorithm of such analysis;
- to show the possibility of increase of spacecraft mass due to using of the low thrust engines.

The missions analysis of a spacecraft with chemical engines is traditional enough. The scheme of considered flight assumes two impulses of velocity. The first of them is given in a low circular Earth orbit (LEO). The second impulse of velocity provides necessary size and a direction of velocity of a spacecraft in a final point of a flying orbit. The analysis of low thrust trajectories is based on the several revealed properties of rational trajectories:

- Flight trajectory of a spacecraft with low thrust from LEO into a lunar orbit passes near to a point L1. Relative velocity in this point is small. Therefore the low thrust trajectory to the Moon can be presented as a sequence of two segments: a geocentrical segment of flight from an LEO up to L1 and lunar-centrical site of flight from L1 up to terminal lunar orbit.
- The analysis of properties of optimal (on minimum time), multirevolution, noncoplanar, low thrust transfer from an elliptic into a circular orbit has allowed to reveal the features of such trajectories and to synthesize control with feedback which is close to optimum control. This control provides good convergence of a trajectory to the fixed terminal circular orbit at presence of existing perturbation factors.

The listed properties have enabled to develop the regular algorithm of optimisation of a low thrust trajectory from an any circular trajectory into a point L1. The orbit of L1 is elliptic orbit and for a geocentrical site, and for a lunar-centrical site of a trajectory. Therefore results of synthesis of optimal control can be used at return integration of the equations of movement of a SC with this control at the analysis of a geocentrical site and at direct integration - for the analysis a lunar-centrical site of a trajectory. Numerical results of calculation of trajectories of flight of spacecraft with the chemical engine and with the low thrust into an circular lunar orbit are received. An estimation of demanded delta V are resulted.