ASTRODYNAMICS SYMPOSIUM (C1)
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MOON SWINGBY AT REALIZATION OF TRAJECTORIES OF INTERPLANETARY FLIGHT

Abstract

The opportunity of Moon's swingby using is researched for the interplanetary trajectory. The following flight plan is researched. A spacecraft gets a velocity impulse at low Earth circular orbit and reaches the Moon's vicinity, before being inserted into a heliocentrical trajectory of flight. Due to Moon swingby a spacecraft gets additional velocity, which allows reaching a purpose planet with smaller expenses of delta V of a chemical upper stage. The purpose of research is to carry out the full analysis of an opportunity of use of Moon swingby at interplanetary flight. This analysis includes:

- the analysis of existence of the solution of a problem of interplanetary flight with lunar swingby;
- definition of quantity of possible circuits of Moon swingby at interplanetary flights and the analysis of their properties;
- the analysis of possible reduction of demanded delta V due to using of lunar swingby;
- the analysis of characteristics of start windows at use of Moon swingby.

Methodology. At first the method of an influence spheres was used. After that the limited problem of four bodies was analyzed. The analysis showed:

- There are from zero to two trajectory after Moon swingby with fixed hyperbolic excess velocity.
- There are two types of a geocentric trajectory of flight to the Moon.
- The maximal number of Moon swingby trajectory is equal to 4 (the decision of the algebraic equation of the fourth order). Only one or two of them can be satisfied the condition: the perilune height should be more than Moon radius.

On a plane: the launch date – time of flight to Mars we have constructed isoclines, which describe reduction of demanded fuel of chemical upper stage due to the Moon's swingby using. Results. The analysis shows that the Moon's swingby using for interplanetary flight to Mars can enable to decrease the velocity impulse of a chemical upper stage on 100 ... 130 m/s (approximately by 3%). The analysis of isoclines shows, that the significant economy of fuel mass leads to strong narrowing of the launch windows (up to parts of the day). On the other hand, if the no maximum mass economy is used (for exzample, 2%), the Moon's swingby using expands the launch windows. It was unexpected result for us. The Mars's research missions for three consecutive windows of start to Mars (epochs 2009, 2011, 2013) was analyzed.