ASTRODYNAMICS SYMPOSIUM (C1)
Optimization (1)

Author: Dr. Junichiro Kawaguchi
Japan Aerospace Exploration Agency (JAXA), Japan, Kawaguchi.Junichiro@jaxa.jp

A NEW OPTIMIZED APPROACH FOR BALLISTIC CAPTURE TO THE MOON UTILIZING LOW THRUST PROPULSION

Abstract

Recent lunar exploration activities have intensively looked at the enhanced transportation capability to the Moon. The destination can be assumed the Low Lunar Orbit (LLO) instead of the Lunar Surface (LS), since the landing has to rely on the propulsion means with higher thrust which inevitably is limited to the conventional chemical propulsion. As a result, enhancing transportation capability leads to the optimization in trans-lunar flight to the LLO. As long as the chemical propulsion is used, the capability is almost automatically determined and there is little possibility for enhancement. The author and his colleagues in early 1990s developed the ballistic capture strategies making use of the solar tidal perturbation effect while the spacecraft flies in the boundary region of the Earth gravity field. The method was actually applied to the Japan's Hiten spacecraft that was successfully inserted on the orbit around the moon in 1991. The strategy effectively reduces the delta-V required for the insertion to the LLO. However, one major drawback associated with it is in the lack of enough launch window assured. Especially when the lunar swing-by is incorporated for further enhancement, the lunar swingby opportunities are restricted very precisely to almost one day per half a month. It is hardly practical for the operational transport to the LLO. The authors in 2008 revealed the updated study to alleviate the restriction and succeeded in expanding the window width utilizing the low thrust propulsion. The result was rewarded significantly and the scheme practically expanded the operational width of launch windows. It dealt the problem in three bodies motion and the orbit synthesis did not include the lunar gravity, while the gravitational capture always occurs only in case the lunar gravity is present. This means the previous work by the authors were not well rigorous and how the low thrust propulsion, especially the steering shall be has not been well studied, while the essence of the gravitational capture is in the approach path to the moon with its gravity present, so that the orbit energy can be efficiently absorbed by it. This paper discusses first how the $V_infinity(excessvelocity)tothemooncanbereducedbythelowthrustpropulsionduringtheflightintheEarthgravityboundar$