Paper ID: 7383

ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (1)

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

SHORT-PERIOD BALLISTIC OUT-OF-ECLIPTIC TRAJECTORIES VIA MULTIPLE VENUS & EARTH SWING-BYS AND VEGA-DRIVEN MULTIPLE EARTH SWING-BYS

Abstract

About out-of-ecliptic trajectories, in other words, high inclination trajectories with respect to the ecliptic plane, most of studies used to look at the use of Jupiter swing-bys represented by Ulysses mission. However, the period of Ulysses' trajectory was quite long and did not fit for frequent scientific observation of the polar region of the Sun. Short-period but highly inclined orbits have been sought for decades.

JAXA currently intensively studies about the Hinode-follow-on, SOLAR-C missions which sees frequent solar polar observation from such orbits, i.e. short-period and highly inclined orbits. One idea is the use of propulsion to artificially make the inclination steep combined with the Earth swingbys. The method is what we call, Electric Delta-V Earth Gravity Assist (EDVEGA) strategy, which efficiently and quickly alters the inclination. The other idea is to ballistic building of short-period and highly inclined orbits via gravity assist. It does not consume any fuel, and can exclude heavy propulsion subsystem mass, and is well advantageous over the first method. The author last year presented, at the same conference, the idea of multiple synchronized Earth swing-bys following the Jupiter swing-by. This actually enables even 78 degrees inclination orbits whose orbital period is equivalent to that of Earth or shorter. Surprisingly no fuel is nominally necessary.

While that Jupiter option has significant advantage, the SOLAR-C mission prefers the spacecraft design that preferably had better not fly for distant solar system as well as quick realization. This paper presents a few alternative, still ballistic, realization of short-period and highly inclined orbits by utilizing Venus and Earth swing-bys. This paper presents therefore different new approaches.

The most straight forward approach is the multiple Venus swing-bys followed by high speed departure escape from Earth. However, the most straight forward approach of this requires the escape v-infinity of 10 km/sec and somewhat hardly practical. The next method is the use of VEGA (Venus-Earth Gravity Assist) strategy to lower the departure escape velocity from Earth. The initial escape v-infinity velocity is only 4.2 km/sec. Despite such low escape energy, through purely ballistic flight, the strategy enables 37 degrees inclination with respect to the ecliptic plane. The result is amazing and significantly relaxes the propulsion requirement enhancing the payload mass. Besides the distance from Earth is enough short for communication, while the Jupiter option cannot provide such benefit.

The paper at the same time presents the derivative idea to them. They use Earth swing-bys instead Venus for the purpose of alleviating the thermal design requirement and communication requirement at the cost of lowered inclination angle. At the same time, the paper presents also derivative strategy, co-use of Delta-VEGA (Delta-V Earth Gravity Assist) strategy for shorter realization.

From inclination point of view, still Jupiter plus synchronized multiple Earth swing-bys provides the best result. However, what this paper presents shows the use of multiple Venus and Earth swing-bys do provide practical realization, and will fir for wide variety of applications.