ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (1) (2)

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ON BALLISTIC ACQUISITION OF SHORT PERIOD OUT-OF-ECLIPTIC TRAJECTORIES

Abstract

This paper presents new orbital synthesis results to achieve ballistic and short period out-of-ecliptic trajectories, instead of using electric propulsion or solar sail acceleration. The strategy developed utilizes a Jovian gravity assist first, followed by polar very high speed gravity assists by Earth or Venus. So far, the use of very high speed gravity assists has been conceived not practically useful. However, this paper presents that those still effectively contribute to amending the trajectories periods, and to acquiring small sized out-of-ecliptic ballistic trajectories. The biggest advantage of this strategy is to reduce propellant mass carried drastically and is to enable large spacecraft placed on such orbit.

ULYSSES spacecraft launched in 1990 successfully has observed solar polar region from high solar latitude. It is well known that the trajectory of it first made use of a Jovian gravity assist to attain a highly inclined orbit with respect to the ecliptic plane. Intensive scientific demand in pursuing such highly inclined orbits has been shown to the orbit synthesis community. The demand is not only in helio-physics observation but also in the astronomy that is eager to get out of the solar system dust cocoon. It shall be stressed here that such scientific demand, at the same time, requests the orbital period had better be as shortest as possible to have frequent observation opportunities. This study was motivated by the helio-physics scientists who desire the polar region observation of the Sun much more frequently than that performed by the Ulysses spacecraft. Recent studies about the nearest star, the Sun, has intrigued the solar physics scientists to have more intimate and high latitude observation of it. The Solar Orbiter mission concept has been investigated in Europe for years, and it assumes the trajectory strategy of using multi-Venus gravity assist instead of the Jupiter. It is mainly due to the preference that science observation be commenced as quickly as possible, and has tried to avoid extra flight period prior to it. The trajectory synthesis for the Solar Orbiter was well performed to access the Sun very closely with relatively higher latitude. The Solar Probe+ mission has been studied at NASA to have a similar observation of the Sun through also repetition of Venus swingbys. The purpose of the Solar Probe+ mission is relatively to reduce the distance to the Sun rather than acquiring higher solar latitude. The paper aims at finding suitable highly inclined orbits with short period which shall be devised for the SOLAR-C mission of Japan Aerospace Exploration Agency (JAXA). The SOLAR-C is the mission following its predecessor SOLAR-B ('Hinode') that has been orbiting on a Sun Synchronous Orbit around the Earth, and made a great success in observing the nearest star, the Sun by first detailed close-up of the surface structure. The solar physics community intends to have much more new discoveries by putting an observatory on a highly inclined orbit with respect to the ecliptic plane, while it should have a short period that enables the spacecraft to have multiple observation opportunities during its mission duration. Besides, acquiring the orbit had better not consume propellant to carry as much payload as possible. In conventional planetary missions, these two requirements contradict with each other, and finding a solution has never been successfully done so far. The orbit that the Ulysses mission adopted does not fit for this purpose. To this end, an

international workshop was held at JAXA on November 18th to 21st of 2008, when the idea this paper describes here was devised and presented to the world wide participants comprising Japan, Europe and United States.