LOW COST MISSION DESIGN IN JOVIAN SYSTEM IN A FULL EPHEMERIS MODEL WITH TWO COUPLED RTBP ENGAGING

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Abstract *The reduction of the spacecraft's (SC) asymptotic velocity and the radiation hazard are really main problems for low-Delta V cost Jovian moons missions: orbiters and landers. Algorithm to overcome the "problem of solo disturbances" for one-body flybys around some Jovian moon with using full ephemeris with two coupled RTBP engaging has been implemented. The region where the total received radiation dose (TID) exceeds is skirted along the upper section of Tisserand–Poincaré graph. Withal low-cost reduction of the SC asymptotic velocity is required for rendezvous with small body. It became possible to find such scenarios when restricted three body problem is transformed into the two-coupled RTBP models and full ephemeris model. New Multi-Tisserand coordinates has been made for parametric passage into this region. With their help it is shown that the "cross" gravity assists at the early stage of reduction of the orbital period are required. As a result, a reasonable increase in the duration of the mission can be exchanged on a sharp decline TID and found "comfortable" (in TID) rounds scenario in the system (less than 70 krad for standard SC protection 8-10 mm Al). This will provide significant gains in the payload for spacecraft missions in Jovian system and systems of other outer planets and improving the reliability of their scientific instruments.*

Keywords: *Adaptive Mission Design, TID, Gravity Assists, Beam of Trajectories, Jovian System.*

1. Introduction

Mission design of low-Delta Vcost gravity assists tours in Jovian system for the landing on the Galilean moon is considered, taking radiation hazard into account [1]. Limited dynamic opportunities of using flybys require multiple gravity assists. Relevance of regular creation of optimum scenarios – sequences of passing of celestial bodies with definition of conditions of their execution is obvious. This work is devoted to the description of criteria for creation of such chains. New Multi-Tisserand coordinates [2] for this purpose are introduced for the best study of features for the radiation hazard decrease and the spacecraft asymptotic velocity reduction.

2. Strategy of Mission Design in the Jovian System

One of main problems of the Jovian system mission design is that the reduction of the asymptotic velocity $V\infty$ of the spacecraft with respect to the satellite for the capture of the moon is impossible. A valid reason is consist in the invariance of Jacobi integral and Tisserand parameter

in a restricted three-body model (RTBP). Furthermore, the same-body flybys sequence on the Tisserand-Poincaré graph [3] falls according the V∞-isoline to the extra radiation zone. Formalized algorithm to overcome this "problem of solo disturbances" with using full ephemeris model and with two coupled RTBP engaging has been implemented. The region of exceeding of the total received radiation dose (TID) can be bypassed along the upper section of the Tisserand-Poincaré graph. Withal low-cost reduction of the spacecraft asymptotic velocity required for the capture of the moon. For this purpose classes of “crossed” gravity assists from one small body of first CRTBP (“Ganymede”) to the second CRTBP (with small body “not Ganymede”- mostly Callisto) and then – in the opposite direction are demanded. The corresponding numerical scheme was developed with using Tisserand-Poincaré graph and the simulation of tens of millions of options. The Delta V-low cost searching was utilized also with help of the modeling of the multiple rebounds of the beam of trajectories. The techniques developed by the authors specifically to the needs of the mission "Laplas P" RSA.

3. Multi-Tisserand coordinates.

If the formalized algorithm to overcome the "paradox of solo disturbances" is found, we have answers to the questions “what” and “how”. Answer is - cross maneuvers. But it is the question when is the time for the bifurcation of cross maneuvers? New Multi-Tisserand coordinates for this purpose are introduced (This are Tisserand parameters of SC for Ganymede and for Callisto). The Multi-Tisserand graph built based on them. It is shown that the "cross" gravity assists at the early stage of SC orbital energy reduction for TID-comfortable tour are required.

4. Conclusion

Algorithm to overcome the "problem of solo disturbances" of one-body flybys with using full ephemeris model and with two coupled RTBP engaging has been implemented for the capture of the moon. The region of exceeding of the total received radiation dose (TID) skirted along the upper section of Tisserand–Poincaré graph. Withal low-cost reduction of the spacecraft asymptotic velocity required for approaching. As a result, a reasonable increase in the duration of the mission can be exchanged on a sharp decline TID and found "comfortable" (in TID) tours scenario in the system (less than 70 krad for standard SC protection 8-10 mm Al, or less than 200-300 Krad for the “light” SC with the 4-5 mm Al shield).

5. References

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