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ADAPTIVE LOW RADIATION MULTIBODY GRAVITY ASSIST TOURS DESIGN IN JOVIAN SYSTEM FOR THE LANDING ON JOVIAN'S MOONS

Abstract

Modern space missions inside Jovian system are not possible without multiple gravity assists (as well as in Saturnian system, etc.). The orbit design for real upcoming, very complicated missions by NASA, ESA, RSA should be adaptive to mission parameters: the time of Jovian system arrival, incomplete information about ephemeris of Galilean Moons and their gravitational fields, errors of flybys implementation, instrumentation deflections. Flexible algorithm of current mission scenarios synthesis (specially selected) and their operative transformation is required.

Mission design is complicated due to requirements of the Ganymede Orbit Insertion (”JUICE” ESA) and also Ganymede Landing implementation (”Laplas-P” RSA). Thus such scenario splits in two parts.

Part P1 would be used to reduce the SpaceCraft's (SC's) orbital energy with respect to Jupiter and set up the conditions for more frequent flybys. Part P2 would be used to lower the SC's Ganymede relative velocity to set up the correct conditions for the GOI. The technique of P1 implementation is well known: it is the sequence of resonant same-body transfers "Ganymede-Ganymede"(based on the Lambert solution technique). But the P2 implementation couldn't be the same (in requirements of quasi ballistic gravity assist with low cost propellant consumption). The cause is the invariance of Tisserand's parameter in a circular restricted three-body system, also of the magnitude of SC's asymptotic velocity respect to the Ganymede. Furthermore, the same-body flybys sequence on the Tisserand-Poincare graph falls according the V-isoline to the "Extra Radiation" zone with low orbit pericenters. So regular expensive corrections of pericenter's increase are demanding in this case.

But the other implementation of P2 can be used. They are: "Crossed" gravity assists (CrossGA) from one small body "Ganymede" to the second small body "Not Ganymede" (possible Callisto) and then in the opposite direction. We can "to outwit" the Tisserand's criterion like this.

As the result, the idea of adaptive synthesis of mission design was constructed by authors. Then it was implemented by effective phase-beam low cost DeltaV algorithm. The corresponding numerical scheme was developed with using NAIF JPL NASA Ephemeris. For hundreds of thousands of options for each date only chains which forms closed loops on Ganymede gravity assist after intermediate Callisto's flybys was selected.

The adaptive scheme, which retains the flexibility to clarify or an unforeseen change in external conditions, also in the case of errors during encounters implementations is presented, that provides the reliability of the mission and its multivariant flexibility.