A NOVEL TRAJECTORY CONCEPT FOR A MISSION TO THE INNER LARGE MOONS OF SATURN.

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Introduction: The moons of the giant planets are attracting the interest of the scientific community due to their dynamical role within their respective systems and the signs of habitability suggested in some cases by surface and subsurface features [1,2,3]. The discovery of water vapor plumes at the poles of Enceladus and the evidence of subsurface water at the major moons of Saturn has driven the scientific interest into these worlds and revived plans for a return to Saturn. In order to gain insight into the nature of this planet and the Inner Large Moons (ILMs), i.e., Mimas, Enceladus, Tethys and Dione, an *in situ* mission is needed. As a matter of fact, flyby missions are adequate for the preliminary exploration phase of a celestial body, but for a deeper understanding of the physical phenomena that characterize these icy worlds, extended observations by an orbiter are necessary.

Sending a probe to orbit the ILMs is challenging for three reasons: the long duration of the interplanetary transfer, the large amount of fuel required to decelerate the spacecraft and insert it into orbit around Saturn, and the high cost of achieving orbit around the moons themselves. This contribution tackles the three problems and proposes a complete trajectory concept from Earth departure to orbit around Dione, Tethys, Enceladus and Mimas.

Methodology: Cassini/Huygens reached Saturn on a multi-gravity assist trajectory passing by Venus, Earth and Jupiter [4]. Its 6.7-year journey was aided by a chemical thruster. The Saturn orbit insertion operations burnt 1112 kg of propellant (20% of the spacecraft's launch mass of 5655 kg) to compensate for the 5.7 km/s of speed difference with Saturn. This maneuver was followed by a 17-year tour consisting in several flybys with Titan and the other major moons. The concept proposed here relies on long thrust arcs, instead of impulsive maneuvers, and the propulsion system envisaged is of electric type. The approach aims at reducing the propellant budget, leading to smaller launch masses and, thus, lower mission costs and/or larger payloads. A similar approach has been recently followed in the preliminary design of the mission to Saturn – Titan, DragonFly, including the requirement of a direct atmospheric entry in Titan's atmosphere [5].

Results: The interplanetary transfer includes planetary gravity assists and is optimized to reduce the relative velocity of the spacecraft upon arrival at Saturn to 1 km/s. In this way, the orbit insertion can be achieved with the aid of the gravity of Titan only. A sequence of unpowered flybys with this moon assists the spacecraft in approaching the ILMs. Low-thrust propulsion, then, enables capture at Dione, the outermost moon of the system where an observational tour starts which alternates between orbits around the several targets and moon-to-moon transfers. The contribution includes a discussion on the performance of the proposed concept, with special emphasis on the observational features (coverage, altitudes, speeds, etc.) of the orbits around the icy moons.

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