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TITAN EXPLORATION AFTER CASSINI-HUYGENS: EVOLUTION FROM FLAGSHIPS TO DRAGONFLY AND BEYOND

Abstract

Even before Cassini arrived at Titan, it was recognized that the most compelling scientific objective there after the mission would be to understand the detailed composition of Titan's diverse surface, and the possibility that aerial mobility could enable such exploration was noted.

While an APL-led Flagship mission study ("Titan Explorer") in 2007, and the subsequent, more constrained, TSSM variant, both recognized the synergies of contemporaneous orbiter, balloon and lander measurements, pursuit of these architectures was deferred by the prioritization of Europa exploration. The 2011 Planetary Science Decadal Survey acknowledged the breadth and depth of scientific interest at Titan.

A particular, but fleeting, opportunity to explore Titan's seas emerged in the 2010 NASA Discovery competition, where a Lockheed-APL proposal, TiME (Titan Mare Explorer) was funded through Phase A. The concept of a self-contained splashdown capsule (in effect a drifting buoy) relied on direct-to-Earth communication from Titan's near-polar sea Ligeia Mare in 2023, in late northern summer. It also relied on a dynamic (Stirling) radioisotope power source which then suffered some development challenges and the mission was not selected for implementation.

The New Frontiers (NF) solicitation in 2016 permitted Titan mission proposals (for the first time in this mission class). The combination of drone technology development in the previous two decades, and the availability of the MultiMission Radioisotope Thermoelectric Generator (MMRTG) set the stage for a radical concept – Dragonfly. This lander – similar in size to the Curiosity Mars rover – would use eight rotors to effect a soft landing, guided by lidar hazard avoidance and optical navigation. A large battery would be charged up by the MMRTG over the 8-day Titan night to permit relocation of the lander using the same rotors. Such a rotorcraft lander can fly further in a single hour-long flight than any Mars rover has ever driven! After completing a Phase A study in 2019, APL was selected by NASA to build Dragonfly for launch in 2026 and arrival in 2034.

Titan orbiter and multiple-flyby concepts have been proposed to ESA programs and NASA Discovery/NF solicitations, so far without success, but indeed the global survey science objectives identified in the Flagship studies will remain to be addressed by future missions after Dragonfly. Although conventional orbiter architectures are perfectly viable at Titan, the capabilities of a Titan orbiter could be enhanced by the application of aerocapture and/or fission power.