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Future Mission to Titan and Enceladus – A Path Forward

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Abstract

The future exploration of Titan and Enceladus is of high priority for the solar system exploration community as recommended by the 2003 National Research Council (NRC) Decadal Survey [1] and ESA's Cosmic Vision Program themes. Recent Cassini-Huygens discoveries have shown that Titan is a complex world more like the Earth than any other: it has a dense, mostly nitrogen atmosphere, with an active climate and meteorological cycles where conditions are such that the working fluid, methane, plays the role that water does on Earth. Titan's geology, from lakes and seas to broad river valleys and mountains, while carved in ice is, in its morphological processes, much like Earth. Supporting this panoply of Earth-like processes is an ice crust that floats atop what appears to be a liquid water ocean. Titan is rich in organic molecules—more so than any place in the solar system, except Earth.

Enceladus is a world apart from Titan in many respects; however, the unexpected high heat flow from Enceladus' South Pole and its eruptive, water plumes indicate that it, too, may harbor liquid water beneath its surface.

The Titan Saturn System Mission (TSSM) concept, a follow-up on the 2007 TandEM ESA CV proposal [2] and the 2007 Titan Explorer NASA Flagship study [3], was studied last year [4] and prioritized to follow the Europa Jupiter System Mission by the NASA and ESA agencies in February 2009. The TSSM concept consists of an orbiter and two *in situ* elements: a Titan montgolfière hot-air balloon and a Titan lake lander. Based on the recent prioritization, such a mission would launch in the 2023-2025 time frame and arrive at Saturn around 2032-2034 for a ~4-year primary mission. Soon after arrival at Saturn, the montgolfière would be delivered and deployed in Titan's atmosphere for a 6-12 month mission of airborne, scientific observations of Titan from an altitude of about 10 km. The montgolfiere would have a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) to provide electrical power for its equipment and thermal energy for balloon buoyancy. With the predicted winds and weather conditions, the montgolfière would circumnavigate the globe more than once. The battery powered lake lander would descend through the atmosphere, making scientific measurements, much like Huygens did, and then land and float on one of Titan's seas to carry out a physical and chemical assay of the sea for a total life time of ~9 hours. After delivery of the *in situ* elements, the orbiting element of the mission would provide a data return relay for the *in situ* elements and continue to explore the Saturn system via a ~2-year tour that would include *in situ* sampling of Enceladus' plumes, subsurface sounding of Enceladus' plume region and many Titan flybys. Following the Saturn system tour, the orbiter would enter orbit around Titan and begin a global survey phase.

Results of this study as documented in the TSSM Final Report [4] and TSSM Joint Summary Report [5] demonstrate that an exciting mission to Titan and Enceladus is feasible and provide a focus for future high payoff risk reduction activities. The purpose of this paper is to provide an overview of the mission architecture, its elements and a path forward.

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[4] TSSM Final Report, 3 November 2008, NASA Task Order NMO710851

[5] TSSM NASA/ESA Joint Summary Report, 15 November 2008, NASA Task Order NMO710851