EPSC Abstracts
Vol. 5, EPSC2010-649, 2010
European Planetary Science Congress 2010

Flagship class missions to Titan

J.I. Lunine[1], A. Coustenis[2], TSSM SDT
[1]Dipartimento di Fisica, Università degli Studi di Roma "Tor Vergata", Rome, Italy; [2]LESIA, Observatoire de Meudon, France.

1. Background

Saturn's largest moon Titan has been an enigma at every stage of its exploration. Discoveries by Voyager I in the 1980's and Hubble Space Telescope observations in the 1990's provided valuable insight into the secrets of this unique world from a distance but did not reveal the complexity of the surface that Cassini-Huygens would uncover beginning in 2004. These recent discoveries leave us with many questions that require a future mission to answer. These include whether methane is outgassing from the interior or ice crust today, whether the lakes are fed primarily by rain or underground methane-ethane aquifers (more properly, "alkanofers"), how often heavy methane rains come to the equatorial region, whether Titan's surface supported vaster seas of methane in the past, and whether complex self-organizing chemical systems have come and gone in the water volcanism, or even exist in exotic form today in the high latitude lakes. The composition of the surface and the geographic distribution of various organic constituents remain poorly known. Key questions remain about the ages of surface features, specifically whether cryovolcanism and tectonism are actively ongoing or are relics of a more active past. Ammonia, circumstantially suggested to be present by a variety of different kinds of Cassini-Huygens data, has yet to be seen. The presence of a magnetic field has yet to be established. The chemistry that drives complex ion formation in the upper atmosphere was unforeseen and is poorly understood. A large altitude range in the atmosphere, from 400–900 km in altitude, will remain poorly explored after Cassini. Much remains to be understood about seasonal changes of the atmosphere at all levels, and the long-term escape of constituents to space. No single target in the outer solar system encompasses such a breadth of disciplines within the planetary sciences as does Titan. It is a complete world in the sense that the Earth is, with the substitution of abiotic or prebiotic organic chemistry for life. Together Titan and Enceladus trump any other pairing beyond the asteroid belt for their promise of a wealth of new discoveries, and for their environments suitable for exploration in truly novel ways.

2. Science

The key scientific questions for the Titan Saturn System Mission divide into three goals [1]:

Goal A: Explore Titan, an Earth-like system: How does Titan function as a system? How are the similarities and differences with Earth, and other solar system bodies, a result of the interplay of the geology, hydrology, meteorology, and aeronomy present in the Titan system?

Goal B: Examine Titan's Organic Inventory—A path to prebiotic molecules: What is the complexity of Titan's organic chemistry in the atmosphere, within its lakes, on its surface, and in its putative subsurface water ocean? How does this inventory differ from known abiotic organic material in meteorites and contribute to our understanding of the origin of life in the Solar System?

Goal C: Explore Enceladus and Saturn's magnetosphere: Clues to Titan's origin and Evolution. What is the exchange of energy and material between the Saturn magnetosphere, solar wind and Titan? What is the source of geysers on Enceladus? Does complex chemistry occur in the geyser source?

3. Mission description

TSSM could launch in 2020 (2018 is also feasible), beginning a nine-year cruise on an Earth-Venus-Earth-Earth gravity-assist trajectory to the Saturn system, augmented for the first five years by solar electric propulsion. At arrival, the spacecraft would perform an orbit insertion burn to capture into Saturn orbit. The montgolfière, targeted for Titan, would be dropped off just prior to the first Titan flyby (following Saturn orbit insertion). Data relay from the montgolfière would continue through its six-month mission via the orbiter telecommunications system. The lander element, targeted for Kraken Mare (a northern lake) would be dropped off at the second Titan flyby and the orbiter would perform dedicated science data capture and relay for the ninehour length of the lander's mission. During a two-year Saturn tour phase, the orbiter would perform seven close flybys of Enceladus as well as 16 Titan flybys. Finally, the Titan orbit phase would commence with a Titan orbit insertion burn, placing the orbiter in an elliptical orbit that would be used for concurrent aerobraking and aerosampling. The orbit would be circularized over two months, beginning a 20-month Titan orbit phase.

4. Status

Although the Titan Saturn System Mission, a joint endeavor between NASA and ESA, was not selected to proceed directly to a mission, when NASA and ESA made their selection in Feb 2008, the science for the mission was deemed to be exceptional by the review teams. Accordingly, NASA is initiating efforts to reduce the risk elements of the mission and conduct a series of focused studies on alternative mission options. The mission studies were an input into the ongoing Decadal Survey for Solar System Exploration of the U.S. National Academy of Sciences.

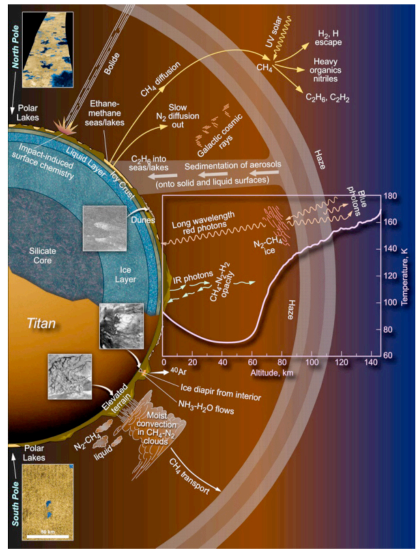

Figure 1: Summary of processes generally known to occur on the surface, and in the interior and atmosphere of Titan. From [1].

Acknowledgements

A portion of J.I.L.'s work was financed within the scope of the program "Incentivazione alla mobilita' di studiosi straineri e italiani residenti all'estero", M.I.U.R., Italy.

References

[1] http://opfm.jpl.nasa.gov/index.cfm