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Concept Study for a Titan Geophysical Network

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Abstract

Titan is a target of high scientific interest due to its similarity with icy satellites as well as terrestrial planets. Thus, understanding the processes that characterize Titan provide the link to understanding the origin and evolution of life. One of the main challenges in understanding such a complex body as Titan is to study global properties and processes, most of which cannot be investigated with single point measurements, but rather require a network of several small landed stations, adequately distributed over the whole body. This paper will present the science case and discuss some major aspects of the mission scenario.

1. Introduction

The Cassini-Huygens mission has and is still providing a huge amout of results that has considerably improved our understanding of Titan as an icy satellite. Moreover, it has increased the scientific interest into this body due to the proven similarity with icy satellites as well as terrestrial planets. Uniquely, Titan's surface conditions are characterized by a methane-based hydrological cycle with clouds, rain, fluvial features, and other processes, maintaining a landscape that highly resembles that of the Earth. Furthermore, Titan's atmosphere has a high concentration of organic compounds such as hydrocarbons and other pristine constituents of life. Consequently, understanding the processes that characterize Titan would provide an important link to understand the origin and evolution of life in the Solar System and beyond [1].

2. Scientific Rationale

Titan's interior is composed of equal proportions of rock and ice and only partly differentiated, although the existence of a dehydrated rock-iron core cannot be entirely ruled out [2]. The ice crust is supposed to be 50-150 km thick and likely underlain by a liquid water-ammonia ocean. Titan is tidally locked with respect to Saturn, which leads to radial surface displacements of several tens of metres peak-to-peak amplitude and changing rotational dynamics. Furthermore, tidal stresses and tidally-induced quakes are expected to result in a high level of seismic activity, possibly along with seismicity induced by active cryovolcanism. Titan's magnetic environment is governed by plasma interactions with the saturnian magnetosphere, causing inducing and induced magnetic fields as Titan orbits Saturn. The latter would provide important clues on the location and thickness of a globe-encircling, electrically conducting layer, such as a putative water-ammonia ocean.

Titan's near-surface environment is characterized by low temperatures (Tsurf < 100K) and high pressures (psurf ~1.5 bar). Whereas diurnal temperature variations at the surface are quite low, the seasonal variations in temperature and pressure are comparably large. The fluvial processes are driven by the methane cycle [3], possibly leading also to the formation of methane-soaked regolith. Increasing the knowledge about Titan means also improving our understanding of the processes that characterize interior-surface-atmosphere interactions on Titan, which would moreover provide an important link to planetary habitability [1]. One of the main challenges in understanding a complex body such as Titan is to study globally time-variable surface processes, most of which cannot be investigated with single-point measurements. Regions of interest on Titan are the satellite's atmosphere, surface (both solid and liquid areas), and subsurface [4]. In-situ measurements on Titan would primarily help understand atmosphere-surface-interior interactions in detail together with the related environmental processes ("weather"). Geophysical measurements would provide insight into the role of interior processes and key parameters that governed the formation history of Titan. Those would require a network of several small landed stations, adequately distributed over the entire surface of Titan [5]. Complementary in-situ measurements at different landing sites would provide a higher spatial resolution, thereby providing insight into the spatial variability of key geophysical properties.

A more detailed discussion of the measurement requirements and possible instruments will be shown in the poster.

3. Conceptual mission design

The conceptual mission design for the Network mission is ongoing. The current concept foresees a 3-staged mission architecture (see Figure 1 for a schematic representation), where stage 1 is a carrier delivering a number of Titan entry probes to the body, releasing them at different times during the cruise to achieve an adequate global dispersion. Stage 2 is the entry probe, which during entry into the atmosphere will break-up into several smaller landing packages - the third stage. This approach allows to establish a local dispersion as well. There will be 2 to 3 different lander designs to be studied, allowing for landing on soft surface as well as in a lake with different instruments onboard. The scientific data obtained at the surface will be relayed through the carrier which will be functioning as an orbiter later in the mission.

The process of identifying potential landing sites on Titan is based on the analyses of science cases, the definition of candidate sites, and engineering considerations [4]. The most critical engineering constraints are the atmospheric density, composition, and temperature; surface hardness, roughness, and distribution of slopes; sub-surface hardness, mechanical uniformity, composition, and layering depths; and wind and seismic noise levels. Most promising landing sites from a scientific point of view are wet polar and dry equatorial regions due to expected compositional diversity and mobility of surface materials, respectively [4]. Monitoring tidally-induced distortion of Titan would benefit from station deployment in the polar regions and near-equatorial regions of the sub- and anti-Saturnian hemisphere [6].

After the initial determination of mission objectives and measurement requirements we are currently entering the next phase of the conceptual mission design, which will provide a trade of different mission architecture options as well as rough estimates of the total system mass and other mission parameters. This phase will be backed by a concurrent engineering (CE) study that allows the parallel investigation of different aspects of a mission concept (e.g. power, thermal control, communication), which are normally investigated sequentially. Said CE study will highly benefit from the anticipated participation of the international Titan science community.

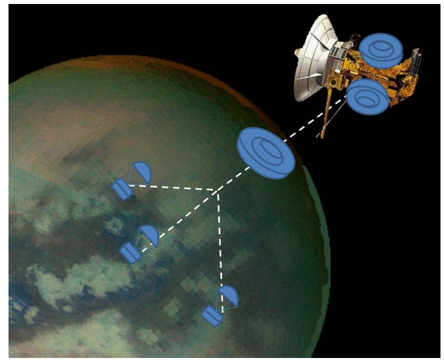

Figure 1: Schematic of separation and decent phase for the Titan Network mission scenario

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