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Conceptual design for planetary exploration missions in the framework of "Planetary Evolution and Life"

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Abstract

Since 2008, members of the Germany-based research alliance called "Planetary Evolution and life" are studying the topics of how life formed and evolved on Earth as well as possibly within and beyond our Solar System. The research alliance is tackling these questions from every possible angle, ranging from geophysics, astrobiology, and geology to engineering, where the latter discipline is basically concerned with practical problems such as conceptual mission design or instrument development to investigate planetary habitability and life. This poster presents the work that has been performed within the alliance regarding conceptual design and technology developments for future planetary exploration missions. Though this field is wide, spanning a variety of possible target bodies, target terrains and mission architectures, we have identified three prime mission concepts for further investigation, two of which will be presented in this paper. Surprisingly, the mission concepts are fairly different, but this only demonstrates how differently the overall topic can be tackled with respect to mission concept design.

1. Introduction

The key to a focussed conceptual mission design within the alliance was the identification of the stakeholder needs, in this case the planetary scientists. For this purpose, a questionnaire was sent out to establish a common understanding for the needs of new missions, comprising the more overarching scientific objectives, the required target bodies, target terrains, target materials, or approximate measurement duration. Replies were evaluated and gave a first insight into the top priority questions and targets. Surprisingly, the answers were not restricted to the most common target, i.e. Mars and the most common type of mission, i.e. sending a rover to investigate surface material regarding signs of extant or extinct life. Other target bodies such as Titan or Europa were equally important and more geophysics-oriented mission architectures such as networks were also deemed suitable for the overall theme of investigating planetary habitability and life. From the pool of possible mission concepts, and backed by the insights gained from the scientists three concepts were chosen for further studies: (i) the investigation of the habitable potential of the caves on Mars (ii) the geophysical characterization of Titan as an Earth-like but different environment and (iii) the search for life below the surface of the Jovian Moon Europa. The following sections introduce the first two missions.

2. Mars Cave Explorer

Recently, caves on Mars have been identified as interesting targets in the search for life in our Solar System. Boston [1] discusses the microbiological potential of caves and other reasons why caves in general furthermore provide a very interesting research area for mineralogy, geology and climate history. The application of this knowledge to Mars, with its very extreme surface conditions shows the potential of these unexplored regions to provide a niche where extant life may have been preserved over year millions. Though types of caves on Earth are very varied ranging from solutional karst features over lavatubes to ice caves, on Mars environmental conditions for cave formation are less varied, thus lavatube caves are most probable [2]. Only recently Cushing et al. [3] investigated some skylight-bearing rille structures north of Arsia Mons (see Figure 1) that clearly provide evidence for the existence of lava tubes on Mars.

Scientific objectives for a Mars cave explorer mission would consequently be on a very high level the (i) search for signs of past and present life in this environment (ii) characterization of this environment regarding its geochemical and geophysical properties (iii.a) investigation of the formation and preservation of minerals that could not exist on the surface and (iii.b) investigation of the climate history preserved within

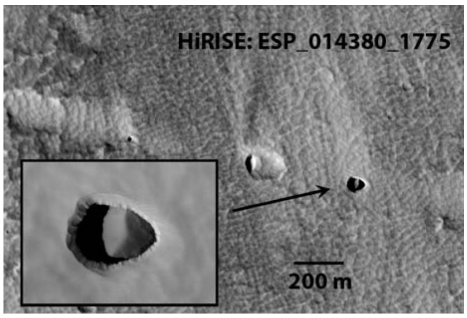

Figure 1: Possible locations of caves on Mars [3]

the caves. More detailed measurement objectives will be presented in the poster. Regarding the mission architecture, we propose a mission scenario that allows the fullfillment of these scientifc objectives, which is based on the concept of multiple distributed mobile platforms. The high level mission architecture consists of a lander, a mobile carrier unit to accomplish the traverse between landing site and cave and one to several small instrumented platforms that shall be released by the mobile carrier close to the cave entrance.

3. Titan Network

Titan, due to its interesting chemistry, is a key to understanding the origin of life and its formation. In-situ measurements at Titan's surface would primarily help to better understand atmosphere-surface-interior interactions in detail together with the related environmental processes. Geophysical measurements provide insight into the formation history and subsequent thermo-chemical evolution, which are tied to the state of internal differentiation and hydration of Titan's deep interior. Using a station network is particularly useful as to the estimation of key parameters such as the depth, thickness, and electrical conductivity of a liquid subsurface water ocean. Furthermore, a distributed approach would allow to characterize Titan's diverse landscapes, to reduce risk, and to increase the amount of surface data points. More detailed scientific objectives as well as measurement requirements and possible instrumentation will be presented in the poster. A possible deployment scenario for such a mission is depicted in Figure 2.

4. Outlook

Future studies will focus on refining the design of the mentioned missions up to demonstration of feasibility. For this purpose, we will use the concurrent engineering approach that allows the parallel investigation of different aspects of a mission concept (e.g. energy supply or communication), which are normally investigated sequentially. During the concurrent engineering studies to be performed in the timeframe of end 2011 to mid 2012, scientists of the alliance are expected to provide assistance regarding science objectives, measurements and instrumenation. Moreover, this poster shall also facilitate the discussion of the presented mission concepts among the international scientific community. By the end of the alliance the studied mission concepts are expected to significantly contribute to the overall success of the same.

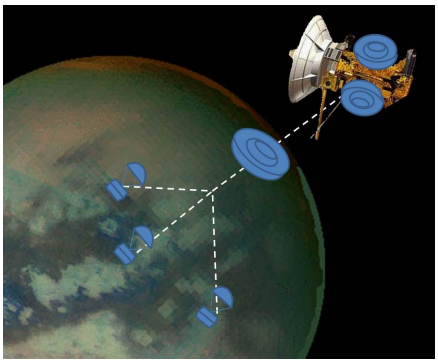

Figure 2: Schematic of separation and decent phase for the Titan Network mission scenario

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