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TALISE: Titan Lake In-situ Sampling Propelled Explorer

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1. Introduction

Titan is the largest satellite of Saturn System, the only one in the Solar System with a significant atmosphere. About 95% is nitrogen, approximately 3% is methane, and the remaining 2% percent consists of hydrogen, little vapour water, other hydrocarbons, and possibly argon. Hydrocarbons may rain down on the surface, forming enclosed seas, lakes, and ponds. Radar images obtained appear to show lakes of liquid hydrocarbon (such as methane and ethane) in Titan's northern latitudes. The chemical composition of the lakes of Titan is still not well determined. The detection of other compounds and the investigation of influence of both, photochemistry and the atmosphere on the chemical composition of liquids of Titan lakes remain challenging in the absence of in situ measurements. Therefore, it is next step to understand the Titan lakes environment, its relationship with the climate behavior, the surrounding solid substrate and analyze the organic inventory including the possibility of prebiotic compounds.

2. Mission requirements

TALISE (which means beautiful water in Native American) is the Lander proposed for developing a focused and cost-effective in-situ sampling mission that would address the key questions about Titan left by Cassini-Huygens and have the capability to make new discoveries. The principle objective shall be to characterize Titan environment, lakes and terrain chemical composition, rich in hydrocarbons and nitrogen. The Titan northern hemisphere lakes have been selected as exploration target area. The displacement along lake till shore and terrain shall be considered as a goal, which would allow the liquid and solid sampling of different scenarios of Titan surface.

3. Trade-offs

Several mission architectures and trades have been explored to accomplish the mission requirements: 1) landing accuracy (passive vs active controlled landing, [4],[10]), 2) orbiter vs no orbiter, 3) with/without propelled lander, 4) power subsystem (RPS [1] vs batteries) and 5) science instrument selection.

3.2 Propulsion system

One of trade-offs has defined the most innovative system of TALISE, the propulsion system, capable of displacing the Lander along the lakes. Following concepts have been proposed: 1) Screw propelled, 2) Paddle wheels, 3) Inflatable wheels, 4) Tank wheels, 5) Air propeller, 6) Liquid propeller and 7) Hovercraft. After the evaluation of selection criteria the options 1, 2 and 3 would remain for next phase study.

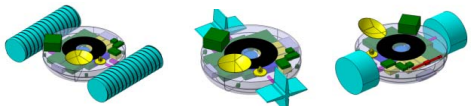

Figure 1: Screw propelled (left), paddle wheels (centre) and inflatable wheels (right) concepts.

3.3 Payload instruments

As part of this study, some instruments have settled on capable of fulfilling the science objectives. Following table shows considered instruments classified depending on the science that they could provide. As initial design, a gas chromatograph was proposed although posterior trade-offs was concluded that to carry GMCS [7] implied high penalty of mass and power for a large duration mission. Moreover, diverse configurations have been analyzed from mechanical, thermal and power consumption point of view.

Table 1: Instrument classification (● main data, ○ secondary data) [2], [7],[8],[15]

Instruments	Astrobiology	Environment	Atmospheric Science	Geophysics
Meteo TSSM		●	○	
MET-LIDAR	○	●	●	
Magnetometer		●		○
µseismometer		●		●
Acoustic sounder		●	○	○
Imager TIPI	○	●		○
PanCam	○	●		○
MIMS	●	○		
LMS	●	○		
Remote Raman	●	○		●
GMCS	●	○	●	
LIBS	●	○		●
Raman-LIBS	●	○		●

Taking account all those aspects and the main objective of astrobiology, Membrane Inlet Mass Spectrometer and Remote Raman have been finally selected as minimum payload. In addition, as auxiliary instruments for meteorological and environmental analysis TIPI imager, meteorological package, acoustic sounder and microseismometer for terrain phase have been proposed.

4. Summary and Conclusions

Baseline mission is the resolution from a comprehensive assessment of alternative concepts and the optimal balance between science, cost, and risk. It includes a preliminary design of a 100kg lander, TALISE, with a dedicated orbiter and a passive control entry, descent and landing system which would place it on Ligeria Lake. A proper propulsion system would allow the controlled displacement from landing site to closest shore. This movement capability would permit to divide science mission in three phases: liquid sampling of landing area, liquid sampling along the cruise phase and solid sampling on terrain.

The study described here demonstrates the feasibility of TALISE using one or two small-RPSs. Therefore, the RPS-enabled lander would have a lifetime potentially much greater than the nominal TSSM mission. Its power system would be sized to handle peak power demands and to maintain a positive energy balance, based on typical daily surface activities. The highest power usage would be contributed to mobility and telecom for this configuration.

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