TINET – A CONCEPT STUDY FOR A TITAN GEOPHYSICAL NETWORK MISSION

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Abstract

Titan is unique owing to its similarity to the Earth and terrestrial planets despite the satellite's ice-rich bulk composition. Thus, understanding the processes that characterize Titan may provide one 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 for the deployment of a geophysical network and discuss some major aspects of the mission scenario, mission architecture and the system and respective subsystem technology.

1. INTRODUCTION

1.1. Background

One important research theme to understand the evolution of life is the interior of planetary bodies, and the interaction between interior, surface and atmosphere. Titan due to its concurrent similarity with icy satellites as well as terrestrial planets and its uniqueness with regard to its surface conditions, atmosphere and interior is a key to increase the understanding of this topic. While the very successful Cassini-Huygens mission has unveiled some of the mysteries of Titan and has shown a snapshot in time and space of the conditions that are present at the surface, more mission are to come fostering our understanding of this complex target. In the recent past, NASA and ESA both have studied new big missions consisting of several elements, e.g. a lake lander, a montgolfière and an orbiter [1]. The objectives of the so called TSSM (Titan Saturn System Mission) were set to explore Titan as a system and to examine its organic inventory – both as described earlier fruitful approaches on the way to a thorough understanding of planetary evolution and life. More recently, a slightly 'lighter' i.e. less complex mission concept has been proposed to NASA, the so called Titan Mare Explorer (TiME), which is currently investigated further in the frame of the Discovery & Scout Mission Capability Expansion (DSMCE) concept-study program – expecting the next selection milestone in 2012 [2]. TiME would concentrate on the seas of Titan, e.g. the current target Ligeia Mare, especially investigating lake chemistry, physical properties and meteorology.

Inspired by the vivid interest of the planetary science community in Titan, but with the academic freedom (meaning an independence of the currently planned missions in the international community) within the Helmholtz Alliance of Planetary Evolution and Life, we have proposed and studied a different conceptual approach to the systemic exploration of Titan, i.e. a Titan geophysical network. Especially, the global distribution of several small landing packages simultaneously performing geophysical measurements can allow the investigation of global geophysical processes that cannot be assessed with a single point measurement. Moreover, such a network allows a high surface coverage, thus a multitude of measurement points with relatively simple and small systems in a robust (single-) fault tolerant mission scenario.

1.2. Study Goals and Approach

The study has been performed using the concurrent engineering approach that allows the parallel investigation of different aspects of a mission concept (e.g. power, thermal control, communication), which are normally investigated sequentially. Based on the later described assumptions and restrictions, the main goals of this study were to

i) Outline the mission architecture and concept of operations and identify landing sites,
ii) Establish a science case including a respective strawman payload that is suited for the chosen landing sites,
iii) Define a spacecraft system baseline design including the most important subsystems and identify technological showstoppers.

1.3. General Assumptions

The study has been performed using the following general assumptions and constraints:

- The mission is set in the 2030+ timeframe and restricted to the 2030+ illuminated hemisphere.
- The carrier vehicle for the interplanetary cruise has not been studied. It was assumed that a vehicle of the size of Cassini would be used to deliver a total mass of 320 kg (including EDL-subsystem and thermal protection) to the Titan orbit. For this type of vehicle the general feasibility of the interplanetary cruise in the 2030+ timeframe was investigated. Mission design for the Launch and Near-Earth Operational phase was not investigated, but the delivery and separation scenario as well as the data relay scenario.
- Ground Operations were not studied.
- The study focused on the design of the entry system and the surface element.

2. THE SCIENCE CASE BASELINE

While the very successful Cassini-Huygens mission has unveiled some of the mysteries of Titan from remote, future missions that are capable to deploy in-situ elements to Titan's surface would substantially improve our knowledge of that icy world.

2.1. Relevance

Methane-based hydrological cycle with clouds, rain, fluvial features and other processes characterize Titan’s surface conditions, maintaining a landscape that highly resembles that of the Earth. Also, Titan's unique atmosphere has a high concentration of organic compounds such as hydrocarbons and nitrils, i.e. pristine constituents of life. Consequently, understanding the processes that characterize Titan would provide an important link to understand the origin and evolution of life.

Gravitational field data acquired by the Cassini spacecraft suggest that Titan’s interior is composed of a mixture of rock and ice and is only partly differentiated [4]. Titan is tidally locked with respect to Saturn and thereby subject to periodic tidal forcing of its interior and surface. Tidal variations of the degree-two gravity field coefficients C20 and C22 indicate that the ice crust is less than 100 km thick and underlain by a shallow liquid water-ammonia ocean of unknown radial extent [5]. Peak-to-peak amplitudes of tidally-induced surface displacement and tilt variation are on the order of up to a few tens of meters and a few arc seconds, respectively. Furthermore, tidal stresses are expected to induce significant seismic activity comparable to tidally-induced quakes on the Moon, and possibly along with seismicity induced by localized cryovolcanic activity.

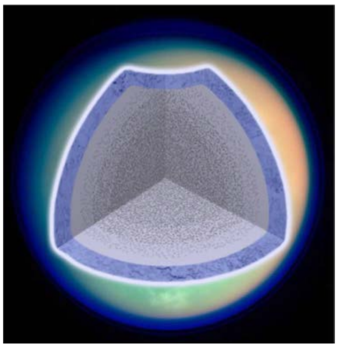

Figure 1: Schematic view of Titan’s Interior based on the acquisition of Cassini gravitational field data [3]

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 [6], 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 [7].

2.2. Science Goals and Implementation

The key issues to be addressed by a Titan geophysical station network can be divided into three primary science goals:

- Determine key geophysical parameters to address Titan’s interior, formation and evolution
- Characterize and monitor environment to address Titan’s habitability
- Investigate coupling between atmosphere, surface, and interior on Titan

To achieve these goals, it is mandatory to globally study 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 [8].

2.3. Science Objectives and Investigations

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. This would require a network of several small landed stations, adequately distributed over the entire surface. The prime scientific objectives of the proposed Titan geophysical station network are to:

- Measure tidally induced surface displacements and forced librations of Titan’s outer ice shell
- Measure time-variable magnetic field (induced and inducing) to determine location and thickness of internal ocean
- Measure the level of seismic activity to determine the structure of the outer ice shell and deduce clues on an internal ocean
- Measure the surface’s regolith properties
- Measure the atmospheric composition
- Optional: Determine the Titan lake composition

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. The process of identifying potential landing sites on Titan is based on detailed analysis of the science case, the definition of candidate sites, and engineering considerations.

Table 1: Science Traceability Matrix

Science Objective	Measurement	Instrument	Priority
Pressure, Temperature, Winds	Pressure, temperature, winds	In-situ MET station	Mid
Atmospheric composition	Chemical constituents and isotopic compositions	GC/MS	Mid
N2, NH3, CH4, CO origins	Isotopic ratios	GC/MS	High
H2O and CH4 abundances	Humidity measurements	Humidity sensor	Low
Regolith chemical properties	Organic fallout speciation	Raman spectrometer, LIBS, GC/MS	High
Regolith physical properties	Permittivity and magnetic suszeptibility	Permittivity probe	Mid
Amount of cryovolcanisms	Tribolelectric effect	Triboelectric sensors	Low
Internal differentiation of the deep interior	Tides, heat flow, seismicity, rotational state	Radio Science, Seismometer, Heat flow probe,	High
Magnetic field environment	Electrical field, induced and inducing magnetic fields, and their time rates of change	Magnetometer, permittivity probe	High
Interior composition: thickness and rigidity of ice layer; thickness, depth and electrical conductivity of liquid water ocean	Tides, seismicity, permittivity, rotational state	Radio Science, seismometer, permittivity probe	High

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 [8]. Required measurements stemming from these science objectives are shown in Table 1.

2.4. Payload Options and Strawman Payload

We will address possible measurements of global tidal distortion by using a network of several small landed stations. Each of those would have to carry an instrument suite to monitor tidally-induced changes of local gravity, tilt relative to the direction of gravity, and areal strain at the surface of Titan. The payload options are summarized in Table 1, allocated with a priority for our application.

3. MISSION DESIGN

The study investigated the overall mission design that would enable the deployment of a Titan Network given the respective constraints. After the launch, the mission is separated in (i) interplanetary cruise with several swing-by's, (ii) arrival at Titan and Orbit insertion and (iii) Network Deployment with Entry, Descent and Landing (EDL) Phase and Surface Operations (See Figure 2).

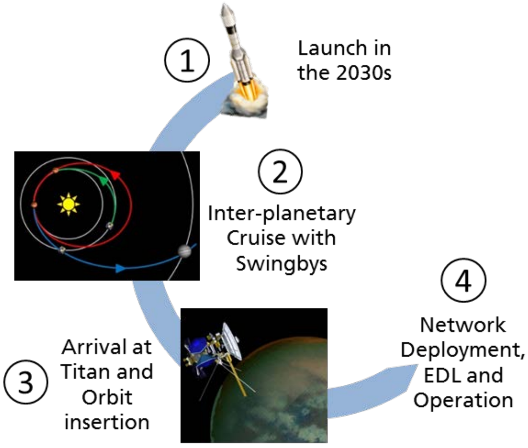

Figure 2: TiNet Mission Phases

The TiNet Network consists of three entry probes, each with a mass of around 120 kg that enter the Titan atmosphere at three different locations, reaching three different landing sites, thus realizing a global dispersion over the Titan surface. Each of these entry probes consists of a Hub and three sub-units, the so called Remote Units. Those will be deployed during the EDL-Phase to allow a locally distributed measurement setup, which is necessary from a scientific point of view to measure certain effects of the local seismometry and magnet field environment, but also allows to investigate the local variation of atmospheric and regolith properties. During the whole mission, the carrier collects and relays the science data to Earth, later during the mission from a polar Titan orbit.

The following chapter gives an overview over the mission design for the aforementioned phases.

3.1. Interplanetary Cruise and Network Deployment

As stated in chapter 1.3, the carrier is assumed to be of Cassini-size, i.e. having a total wet launch mass of 5636 kg [9].

It should be mentioned here, that current and planned future launch systems are not capable to deliver this mass on a direct trajectory to Saturn. Consequently, gravity assist manoeuvres are necessary to reach Saturn. A gravity assist sequence with multiple flybys at Venus and Earth is preferred, because such a sequence results in a flight time of 8 - 10 years, whereas Jupiter and Mars gravity assists are not investigated in this analysis, because their synodic periods are too high to make the mission independent from dedicated launch windows.

Launch opportunities with Jupiter flybys are possible in the planned mission timeframe and will appear in the mid-2030s. A Jupiter flyby would reduce the flight time by 1-3 years for the cost of a higher arrival velocity at the Saturn system. A high arrival velocity requires a higher Δv of the spacecraft and therefore more fuel for the orbit insertion around Saturn. Another option to reduce the flight time is the use of a solar electric propulsion stage (SEP) on the spacecraft. This would lower the flight time by 1.5-3 years, but results in a higher launch mass and higher development costs.

Once the spacecraft is in the Saturn system, there are several options to reach an orbit around Titan (which has been chosen for data relay purposes as well as separation point for the landing units). A direct transfer to Titan using the engines of the spacecraft is possible in principle, but due to the high amount of required fuel usually not applicable. A Saturn moon tour is another option. The spacecraft uses flybys at the moons of Saturn to reach Titan. This option would reduce the required fuel for the Titan orbit insertion at the cost of extra flight time of several years. Other options are aerobraking and aerocapture manoeuvres. Until now no spacecraft has ever performed an aerocapture manoeuvre.

The best suitable option for the analysed mission is the aerobraking procedure. The extensive atmosphere of Titan can be used to lower the velocity of the spacecraft to enter an orbit around Titan.

For this study the reference orbit of the spacecraft around Titan is a polar orbit with an inclination of 85º and an altitude of 1500 km. A polar orbit is suitable to cover the whole surface of Titan in a short period of time. This is necessary for a mission with three globally distributed landing units.

The separation of the entry probes from the spacecraft while in an orbit around Titan is the best option to deliver the three probes to their assigned landing sites. This procedure leads to a flexible separation time, a low entry velocity (1500 – 1700 m/s) of the probes and higher target accuracy. The disadvantage of this sequence is that the mass of the entry probes has to be inserted into the Titan orbit. This results in higher fuel consumption for the Titan orbit insertion. The separation out of the reference orbit requires a Δv of 130 – 170 m/s per probe.

3.2. Entry, Descent and Landing

The entry, descent and landing phase is separated into four phases: (i) the hot phase of entry into the atmosphere, (ii) the deployment of the backside heat shields, (iii) the Remote Unit separation and (iv) the separation of two heat shields to accomplish atmospheric measurements (see Figure 3).

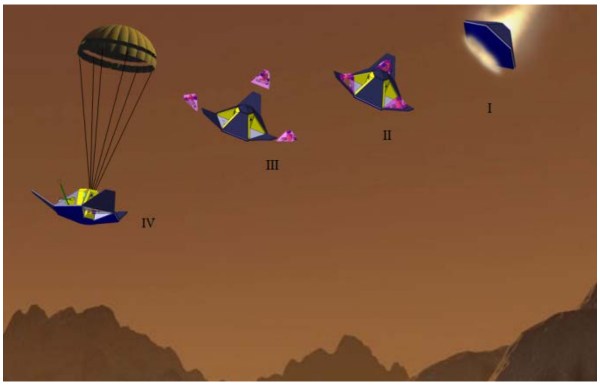

Figure 3: Four phases during the entry and descend of the lander. I. Hot phase of entry into the atmosphere, II. Deployment of the backside heat shields, III. Remote Unit separation, IV. Separation of two heat shields to accomplish atmospheric measurements.

The hot atmospheric entry starts at a height of 1000 km and a velocity of 1500 m/s. The DLR trajectory tool TOSCA 1.15 was used for calculating the entry trajectory, which is given in Figure 4. It was discovered that the flight path angle on entry should lie between 10° and 11°. A smaller flight path angle would cause the entry probe to be deflected by the dense atmosphere. Even a slight deflection produces a bump in the descent trajectory, which in turn reduces the landing accuracy. A larger flight path angle would only lead to a steeper entry trajectory and thus to a higher velocity on landing. The trajectory simulation showed that a probe without a parachute would touch the ground with 5.3 m/s. The velocity at a height of 60 km, which is of interest for the separation of the Remote Units, is 27 m/s. During descent a maximum acceleration of 0.3 g_E is reached. The maximum dynamic pressure is 133 Pa. Both events take place at the same time.

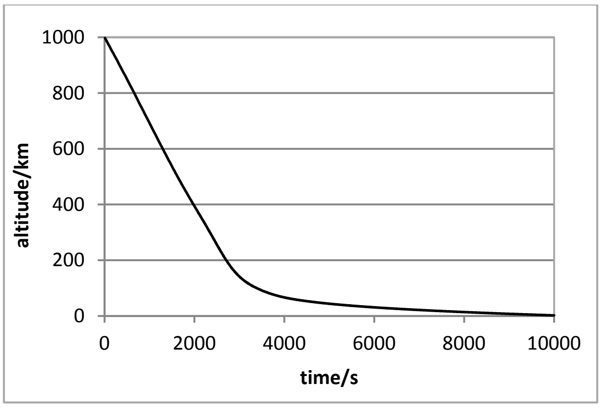

Figure 4: TiNet entry trajectory

The calculation of the aerodynamic coefficients was performed with the DLR tool HOTSOSE 1.85. The calculations show that the coefficient of drag for the hub is about 1.6 for an angle of attack of 0°. In addition, the heat flux distribution over the entire heat shield was calculated for the trajectory point where the highest heat flux according to the trajectory simulation occurs. For comparison, the same calculation was also conducted for the Huygens probe [10]. For the Huygens probe a maximum value of 290 kW/m² was found while for TiNet a maximum value of 3.7 kW/m² was calculated. This means that TiNet has to endure a maximum heat flux that is 78 times lower than in the case of Huygens. Please note that the absolute heat flux values have no specific meaning, but are well suited for comparison of different mission scenarios, in this case Huygens and TiNet.

4. SPACECRAFT DESIGN

4.1. Architecture and System

As described before, the surface element of the TiNet mission consists – per landing site - of one main unit, the so called Hub and three Remote Units to be deployed during EDL. Figure 5 shows an impression of the fully deployed Hub on the Titan surface with the Remote Unit in the background. Table 2 shows the mass allocation including the instrument mass for Entry-Probe (i.e. the equipment attached to the Hub to sustain the atmospheric entry, such as a back cover and a parachute), Hub and Remote Unit.

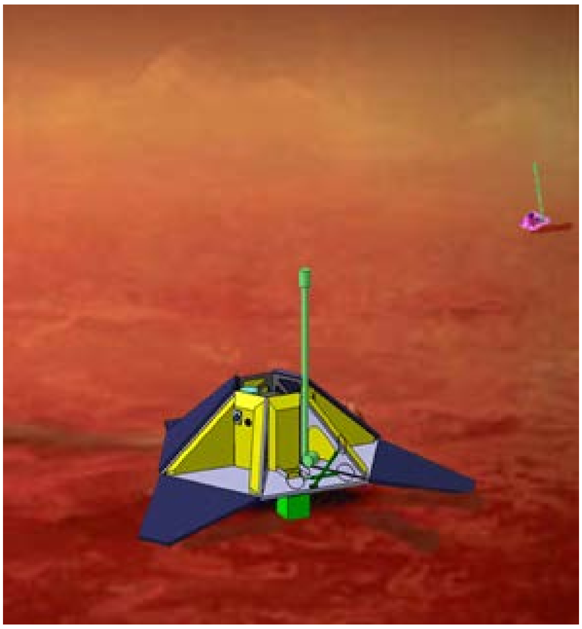

Figure 5: Fully deployed lander on the Titan surface with the Remote Unit in the background

Table 2: Mass Overview

	Mass [kg]	Mass incl. margins [kg]	Instrument Mass [kg]
Entry Probe	10.58	12.69	1.4
Hub	54.85	65.82	10.75
Remote Unit	11.86	14.23	1.7
Total per Landing Site	101.01	121.2	
Total 3 Sites	303.03	363.6	41.55

4.2. Structural design and P/L accommodation

The structural design of the lander is based on a typical entry capsule design with forebody and aftbody, only dividing the body into 6 bays, thus forming a hexagon shape (see Figure 6). This design has been chosen due to several benefits: first of all, the forebody or front-shield is an integral part of the spacecraft, which will not be separated during the descend phase. This results in a lower mass for the heat shields. Also, they can be used as a part of the spacecraft support structure. A further advantage is the sharp edged shape of the spacecraft, which has several advantages for the manufacturing and the EDL thermal behavior. Third, the six bays accommodated around a central hexagon, allow a modular design and a flexible accommodation of payloads, including respective thermal insulation as well as the accommodation of three Remote Units.

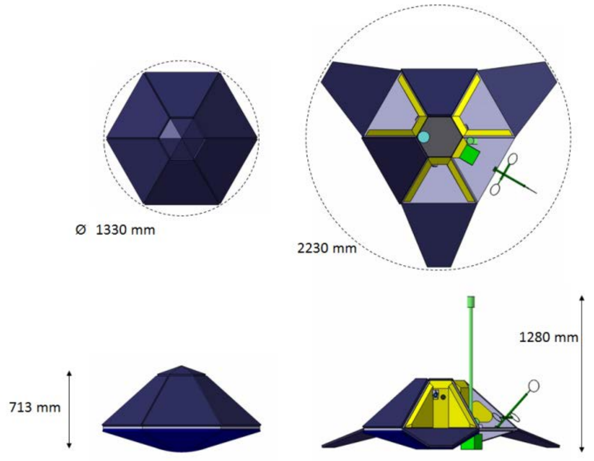

Figure 6: Geometrical dimensions of the lander, on the right side the size during entry and on the left the full deployed size is shown.

Figure 7 shows a more detailed view of the Hub unit. Due to the hexagonal shape, the Hub unit can accommodate 3 Remote Units and 3 payload bays. In the current design, two of those are environmentally isolated and one is open to the environment, i.e. for instruments requiring access to the atmosphere. Figure 7 shows two empty Remote Unit bays and two payload bays. In payload bay the TEEP-L instrument package and the UHF antenna are accommodated. In the second payload bay the Titan probe imager radiometer spectrometer and lamp are placed. The core subsystems (i.e. the OBDH and communication equipment as well as thermal control and power) of the lander are placed in the hexagonal central element. On top of this the X-Band antenna is placed. Inside the Remote Unit bays, there is enough space to accommodate a wide angle camera and a radiometer, thermally insulated, that can be used after the Remote Units have been separated.

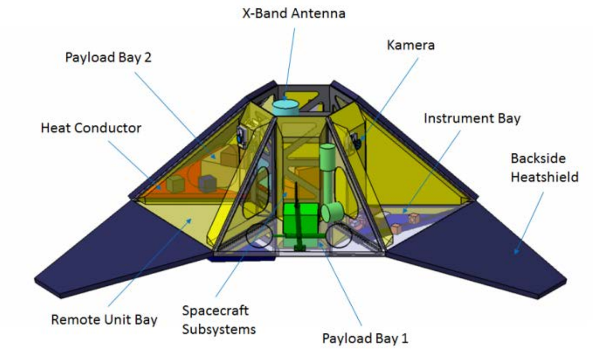

Figure 7: Side view of the lander with deployed backside heat shields as well as a transparent body to show the different payload- and Remote Unit bay.

After the hot phase of the EDL, the three backside heat shields above the Remote Unit compartments will be deployed and used as small wings to control the descent and to separate the Remote Units. The wings will slow down the descent speed by generating atmospheric drag. During the last phase (a small parachute will be open to increase the descent time. After the parachute is open two heat shields from the instrument compartments will be separated to allow the atmospheric instruments to begin with their measurements.

After the lander hits the surface the three backside heat shields above the Remote Unit bays will be used to reposition the lander on the surface. If the lander is in the right position, the UHF-antenna will be deployed and instruments requiring contact to the Titan surface will be positioned.

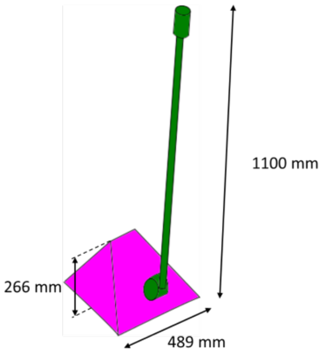

Figure 8: Dimensions of the Remote Unit with deployed UHF antenna

The remote unit is shown in Figure 8, the pink body shows the available volume to accommodate the Remote Unit instruments such as Micro-Seismometer, Magnetometer, Micro-Mass-Spectrometer and Meteorological Boom, as well as the subsystem equipment for power, OBDH and communication.

4.3. Power supply

The power subsystem has been investigated for the Hub unit and for the Remote Units separately. Due to the thermal environmental conditions, it is necessary to heat both units, the Hub unit and the Remote Unit (see also chapter 4.4 Thermal design). Looking at the consumers like instruments and OBDH, the power budget of the Hub unit requires 9.8 Watts peak-power for the instruments and 50 Watts for the communication mode (with just short duty cycles). For the Remote units it is 11.2 Watts peak-power for the instruments, an extra 10 Watts for the MMS (micro-mass-spectrometer) with a duty cycle of 10% and another 5 Watts for the communication to the Hub Unit.

Different options have been analyzed for the above given power scenarios: batteries as energy source for heating and electric power, heating with methane from the atmosphere, electric and thermal energy from RHUs and a Battery/RHU mixture.

The first scenario with batteries only was calculated with an average electrical power of 5 Watts (Hub or Remote unit) and 45 Watts heating power for the remote unit, which results in 56 kg of batteries (SAFT LSH20 Primary Batteries, 468 Wh/kg) for each of the Remote units, which is by far too much for the Remote units. Using secondary batteries in combination with solar panels is not effective, due to the very small solar power at Saturn (9.5 AU), which is only about 1% than the solar power density at Earth (1 AU).

Heating with Methane from the atmosphere would need extra oxygen: 100 Watts heating power for 24 days result in 17 kg of Oxygen.

The most realistic option is the common use of RHU and batteries for covering the electrical peaks (communication, mass spectrometer, etc.). The best RTGs for this type of mission would be the GPHS based Small-RTGs which are still under NASA development. Those will have electric power from 12 to 32 Watts and 250 Watts thermal power with a weight of 6 kg, with further development options down to 3.5 kg [11,12].

Beside the proposed RHUs, Batteries are needed for peak power times in the Remote units as well as in the Hub unit. For the Remote units, the Science Mode of the MMS is no longer than 1 Minute of 10 Watts with several minutes break between. For the Hub unit, the Communication Mode is about 0.25 h by 50 Watts which does not exceed 13 Wh. For both options, SAFT VL10E cells with 36 Wh and a weight of 0.25 kg seem to be appropriate.

Small BCDR (Battery Charge/Discharge Units) are available from TERMA, Denmark as well as Power Distribution units (PDU), 550 grams each. The exact layout of those has to be studied in more detail.

4.4. Thermal design

The thermal environment for a mission to Titan is challenging especially to the Thermal Control System (TCS). The thermal concept has been designed to cope with the five very different operational phases during the system lifetime:

1. The cruise phase, which will last for approx. 10 years. Hereby cold case (e.g. deep space), as well as hot case scenarios (e.g. Venus flyby) have been investigated.
2. The period of time next to the Saturn and the time in the orbit of Titan are described as coast phase. This phase is representing a cold case due to the large distance to the sun and the resulting low solar constant. It will last one year in maximum.
3. The entry phase is representing a hot case due to aero-thermal heating. This phase will end

as soon as the parachute opens and is then followed by the descent phase. Due to the slow descent speed on the parachute the descent phase is considered a cold case.

4. The ground operation is the most important phase, because it includes the scientific measurements. Since the temperature on the surface does not exceed 94 K this phase has to be considered a cold case as well.

A minimum life time of 20 earth days has been defined in the mission’s objective. The payload components require temperatures between 280K and 300K during all five phases of the mission. The TCS should be capable of dealing with all of these environmental conditions and requirements. Thus, the current thermal concept includes the following specifications:

- Insulation concept similar to the one used for Huygens: 50 mm layer of Illtec (formerly Basotec) melamine foam [13,14] wrapped in aluminized foil
- Outside of the lander is covered with multi-layer insulation (MLI, RUAG MLI AAErotherm S22-190).
- A GPHS RTG (230 W thermal power) as described in 4.3 used in the hub and a smaller fractional GPHS RTG (120 W thermal power) used for the remote units. The RTG is mounted on a baseplate which is thermally isolated from the outside walls. The baseplate itself will be a customized plate made of beryllium with Thermacore® k-core material.
- Three two-phase closed heat circuits for depositing heat during cruise to the radiator (see Figure 9).

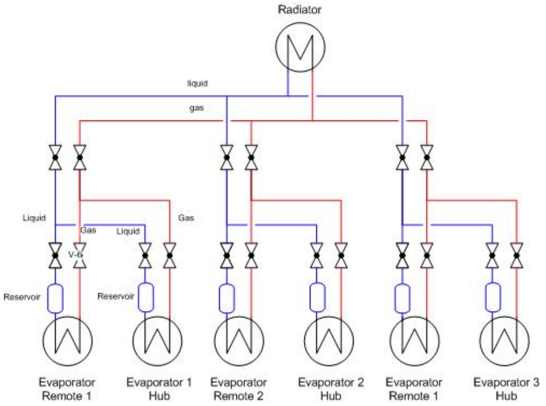

Figure 9: Diagram of heat circuits in one lander

Quickcouplings between the remote units and the hub as well as between the hub and the orbiter will keep the different units seperable

4.5. Communication

The analysis of the communication subsystem has been based on the fulfillment of the following three tasks:

- To ensure the data exchange between Remote Units and Hub-Lander
- To ensure data exchange between Hub-Lander and Orbiter
- To ensure distance measurement-triangulation between Orbiter and Landers

The link between the Remote Unit and the Lander has communication power of 1W in UHF range of 400MHz, using string antennas on both sides, with the data exchange speed of 9.6kbps. For the Remote Unit, the antenna is attached to the scientific equipment. For the Lander, the UHF antenna is inflatable and to be deployed before landing.
The link between Orbiter and Lander has communication power of 25W and uses X-Band frequencies around 7GHz. The link provided a data rate of 2Mbps for uplink. The communication link antenna onboard the Orbiter is a pointed helix antenna, whereas the Hub-Lander uses an array-plate.

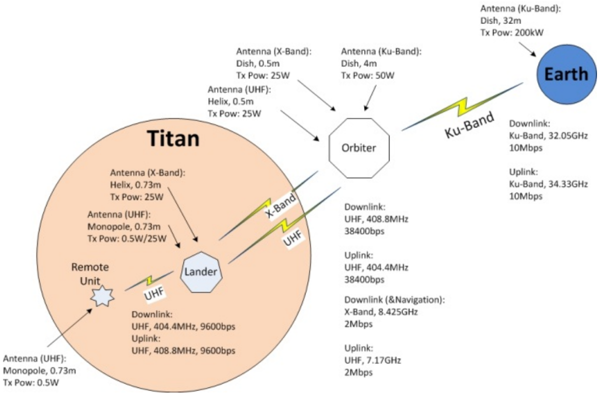

Figure 10: Communication Architecture

A secondary communication equipment and thus a redundancy for the link between Lander and Orbiter is implemented via the present UHF transmitter on the Lander, by switching on an additional 25W power amplifier to the output of UHF’s Transceiver, using the same antenna and equipment which is used to communicate with Remote Units. The communication speed to Orbiter from Lander via UHF is 38.4kbps. In case some malfunction had to happen to the X-Band Transceiver, this data link will be used as backup solution to provide uploading of housekeeping as well as some part of the scientific data.
Within the Lander, from separation up to landing phase, there will be the UHF transceiver with power

amplifier switched on, to provide real-time telemetry data during the flight phase.

The X-Band will also be used for distance measurements from Orbiter to Landers, for scientific purposes to detect tidal surface displacements on Titan. For this purpose a precise timing pattern recognition signal will be used in the sender-responder-register path to detect the distance.

5. CONCLUSION AND OUTLOOK

The TiNet Study performed in 2011 at DLR using the concurrent engineering approach has brought some insight into the overall requirements and possible mission design of such an endeavour. The here proposed architecture is highly innovative and would thereby provide new means of scientific investigations of high interest to the planetary science community.

During the course of the study, we have identified interesting instrument suites for both, the Hub and the Remote Unit and looked into the most important subsystems for these landing elements, i.e. thermal, power and communication.

Work will be enhanced regarding some open mission aspects such as the descent phase of the Remote Units, as well as subsystems aspects like the Onboard Data Handling and Instrument Control. The structural and thermal design will be investigated more in detail in the near future.

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