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MetNet Mars Mission – New Lander Generation for Martian in situ Surface Observations

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Abstract

MetNet Lander (MNL), a small semi-hard penetrator design with an innovative Entry, Descent and Landing System (EDLS) with payload mass fraction of approximately 17 % has been developed. The MNL EDLS is based on inflatable structures capable of decelarating the lander from interplanetary transfer velocities down to 50–70 m/s at surface and surface impact deceleration of < 500 g during the period of less than 20 ms. The available payload mass is especially well suited for meteorological and atmospheric observations, but also for other environmental investigations — which both require modest energy, data storage & transmission resources. Due to the small size of a single lander, MNLs are highly suitable for piggy-backing on larger spacecraft. The small size and low cost make MNLs attractive for missions such as surface networks, landings to risky terrains and pathfinders for high-value landed missions.

1. Introduction

This is the introduction section of your paper. All section headings are in a large bold font. All sections and subsections should be numbered, respectively. In order to guarantee the correct formatting of section and sub-section titles, please use the auto-formatting styles "Section_heading" and "Subsection_heading", respectively, provided in this document.

2. MetNet System concept

We have developed a new kind of planetary exploration tool – a semi-hard penetrating MetNet Lander for Martian investigations. The Entry, Descent and Landing System (EDLS) of the MetNet Lander (MNL) will utilize inflatable structures capable of decelerating a MNL from entry speed of up to about 6 km/s down to 50–70 m/s at impact to the Martian ground. During the impact the main body of MNL will penetrate into the Martian soil thus facilitating the proper upright position and operational attitude for the MNL. The payload bay inside the penetrating probe has support struts that will deform during the impact and thus absorb the remaining kinetic energy. This will grant an additional deceleration length for the payload bay of about 40 cm. The maximum deceleration of the MNL payload bay during the impact will be less than 500 g for the period of less than 20 ms.

The mass of the payload bay with its container and thermal insulation is 4 kg and the total entry mass of the MNL is about 24 kg. This will give a payload mass fraction (ratio of payload and total entry masses) of the order of 17 %, which is an excellent number compared to earlier planned Mars landers with similar characteristics.

A major advantage of the MNL is the fact that after a successful landing the front part is submerged in the Martian soil and in good thermal contact with its surroundings. Since the amplitude of the temperature variations tend to decline fairly rapidly with increased depth, this results in smaller thermal variations and hence in less demanding thermal control and management requirements for those payload components and spacecraft subsystems housed in the front part of the lander. Some parts of the lander remain above the surface. The subsystems and parts of the payload housed there face comparatively much wider temperature variations.

The eventual position of the MNL system, where the payload bay and its outer support structures are penetrated under the Martian surface with only the sensor boom, antenna and the outer rim above the surface. Such a position results in a favorable situation, where the payload bay will be surrounded by a natural thermal environment with temperature ranging from 230 K down to 210 K. These temperatures are still good for the electronics and other parts of the payload with the exception of batteries that need to be protected with additional thermal system. The position underneath the surface is extremely advantageous for a small probe like MNL from a thermal design point of view. At the Martian surface a small payload with low thermal inertia would require heating systems to survive the low nighttime temperatures of the order of 170–190 K over a wide range of latitudes. The additional heating system would eat up a large fraction of the payload mass. Hence the MNL concept is giving both thermal shelter and a correct operational position for the payload.

The real strength of the MNL is demonstrated by atmospheric science missions requiring only modest amount of data bandwidth, electrical energy and mass allocation for their scientific payloads. This facilitates the use of a highly versatile payload within the relavitely small mass allocation of the MNL vehicle. Furthermore, the MNL EDLS is inherently such that it requires less pyrotechnics (such as explosive bolts) and associated triggering commands than, e.g., a traditional parachute-based landing system. This increases the overall likelihood of mission success.

The MNL EDLS allows for deployment to the Martian surface either directly from an interplanetary (hyperbolic) trajectory or from an orbit around Mars. Deployment from orbit enables more accurate landing, wheareas direct deployment gives a wider selection of landing sites with the same v budget. Due to fuel mass savings, direct deployment is often an appealing option — especially for atmospheric science missions for which modest landing precision is often adequate.

The eventual goal of the MetNet Mission concept is to create a network of MNLs at the Martian surface operating simultaneously. Presently two complete MNL vehicles have been manufactured and tested. They will be used on MetNet Precursor missions (launche opportunities in the 2018–2020 launch windows) to demonstrate and validate the robusteness and efficiency of the design. Prior to the launches delicate parts of the MNLs, such as the fabrics of the inflatable EDLS components will be replaced or refurbished. The Precursor landers will also carry out scientific observations and the development of two sets of atmospheric science payloads is currently under way.

3. Summary and Conclusions

We have developed a Mars lander concept — the MetNet Lander (MNL)—that provides a key landing technology for the future exploration of the environment of Mars. By providing a platform for a 4 kg scientific payload the MNL is capable of serving various kinds of atmospheric science missions, as well as other kinds of environmental exploration missions. The semi-hard nature of the entry, descent and landing system provides an excellent payload mass to overall mass ratio of about 0.2 facilitating an efficient use of the mass allocation of a scientific mission. The MNL is a highly suitable vehicle for deploying relatively small payloads of the order of a few kg on the Martian surface. A specific mission concept could be a Martian network mission comprising some tens of payloads operating simultanepously and spread around the Martian planetary surface.

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