Martian Lava Tube Exploration with Aerial Delivery Vehicle

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Lava tubes on Mars provide insight into Martian geography and may be critical for future manned missions. In volcanic regions of Mars, lava flows clear out these large pristine caverns. As the tubes provide stabilization and protection from the Martian surface atmosphere and environment, they may be the key to developing human shelters on Mars. There are over 1,000 potential lava tubes in the Tharsis Mons volcanic region of Mars. These detected lava tubes have large skylight entrances formed by collapsed ceilings, where the ground below is filled with rocky debris. This presents a mobility concern entering the skylight without damaging the environment and passing over the rough terrain to get to the lava tube.

We propose a solar balloon for surface travel that houses and lowers an inflatable wheeled rover designed for traversing challenging terrain. Martian wind currents propel the solar balloon, and propellers provide directional control. It is powered using a solar panel skin and rechargeable batteries. The solar balloon hovers over a skylight entrance and lowers a rover to explore the lava tubes via a tether spool system. The rover carries instrumentation that collects a 3D point map and photographic images to characterize the environment of the lava tube. It deploys an antenna relay communication system that transmits data between the rover and the solar balloon.

In this paper, we will discuss the details of our proposed design of a solar balloon and inflatable rover system. We perform comparisons of various aerial components, instrumentation, and guidance and control devices. We analyze a simulation of the communication relay. We discuss the initial testing procedure, and results of the rover lowering mechanism and navigation in an applicable environment. We also identify shortcomings of our research and discuss future research and testing.

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