IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)
Astrobiology and Exploration (6)

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A NEW APPROACH FOR THE SEARCH OF BIO-SIGNATURES AND ASSESSMENT OF HABITABILITY ON MARS USING A SWARM OF WIND-DRIVEN MOBILE IMPACTORS

Abstract

The search for life and its constituents has been the goal of scientific investigations on numerous Mars missions. Over its history, Mars is thought to have had a thicker atmosphere, and liquid water on the surface, which may have created conditions suitable for the emergence of microbial life. Contemporary lander and rover-based missions have yielded irregular, single-point measurements while searching for bio-signatures.

Due to limitations on mobility and the localized nature of observations, the datasets generated by instruments used in these missions lack sufficient coverage, comparability, and spatiotemporal resolution. This approach has produced inconclusive results for life detection, necessitating a diversification of exploration strategy. Hence, a new paradigm and accompanying platforms are needed to continue this search in a holistic and effective manner. The objective of this paper is to describe how a swarm of wind-driven mobile impactors can be used to fulfill this significant scientific gap while exploring Mars.

We construct a preliminary science case delineating how a swarm of wind-driven Tumbleweed Rovers can be used for life detection. After presenting the preliminary mission concept and spacecraft architecture, we discuss how putative bio-signatures in the near-surface environment can be identified and characterized using methods such as spectroscopy, spectrometry, informational polymer detection, and electrochemistry. Probing remote and previously inaccessible features such as lava tubes, fossae, polar ice, and steep crater walls is a significant advantage provided by the swarm. We also describe experiments that could be conducted to probe further into the nature of purported bio-signatures and to discriminate for terrestrial contamination.

The swarm is able to provide rich datasets with a high spatial and temporal resolution, enabling a significant improvement in the assessment of local habitability. As a precursor to responsible and sustainable human exploration in the future, the interaction of contaminants with components of the Martian environment such as dust storms can be experimentally investigated. Consequently, using a systems engineering-based approach, a set of potential instruments employed within the constraints of the Tumbleweed Science Mission are highlighted.

The proposed network of Tumbleweed Measurement Stations can be used to search for bio-signatures on Mars with unprecedented coverage and effectiveness. Additionally, such a network can be used to study the extent of forward contamination from robotic spacecraft. This marks a significant step in the utilization of a broader, more pragmatic strategy which would also yield auxiliary benefits in the domains of atmospheric science and surface geology.