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Systems and Infrastructures to Implement Future Building Blocks in Space Exploration and Development (2)

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MARS IN-SITU WATER EXTRACTION WHILE PREPARING A HARDENED LANDING ZONE

Abstract

Two of the most difficult hurdles for human missions to Mars are: The challenge of landing human-class (>20 mT) payloads on the surface and extracting water from the environment both for human consumption and for fuel.

Beyond the problems of entry and descent, thruster-fired landings have the potential of damaging the landing site, scattering debris, and even excavating a crater that could swallow the lander. This could jeopardize both the landed infrastructure as well as the payload. Preparation of a landing surface resistant to thruster fire may be a critical pre-requisite for ensuring crew safety and mission success.

In addition, using in-situ resources(ISRU) has been deemed a critical strategy for reducing the mass transport requirements to feasible levels by NASA Mars mission architectures since the 1990s. Even though water-bearing resources are now believed to be commonplace on Mars, extraction methods are difficult to develop and test, complicated by the distance to the production site.

However, a mitigation for both these problems is advanced preparation of a landing site, as well as stockpiling of water resources, before human-class landers are sent. Preparation of a landing zone will require traversal of a large surface area, as well as a high energy process for hardening the surface. Extracting water from regolith is a high temperature process, with a high volume of regolith required to produce sufficient water. A single mission that performs these two processes while traversing the same terrain would retire two mission-critical risks: landing safely and demonstrating resource extraction.

This study modeled several options for hardening surface regolith while simultaneously extracting water content from the regolith. The energy requirements for extracting water from different grades of regolith were assessed, and preliminary attempts to model the in-place water extraction processes were undertaken. In addition, several methods for hardening regolith to prepare landing zones were analyzed, including production of regolith tiles, solar sintering and microwave sintering. Microwave sintering was studied in detail, and a parametric model created to assess system performance in the two mission goals: water extraction and regolith sintering. The result is that a precursor mission to Mars could prepare a landing zone while stockpiling sufficient water resources to produce methane propellant and crew consumables for a 4-person 2-year mission.