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A SYNERGISTIC APPROACH TOWARDS ADVANCING MARS ROBOTIC EXPLORATION AND SUSTAINABLE HUMAN EXPLORATION

Abstract

In-situ resource utilization (ISRU), a technology that has been espoused for over three decades as a means to enhance and even enable long-term exploration and sustained human presence, suffers perennially from the classic ‘Catch-22’: it won’t be relied upon for a critical propulsion system until it has been proven in a critical propulsion system. An effective risk mitigation strategy begins with demonstrating ISRU in a low-criticality surface exploration mission. A successful first mission can then lead to relying on in-situ propellants for progressively more critical missions including sample return and eventually human missions to Mars, for which in-situ propellants are considered to be an enabling technology. Concurrent with the development of the Mars in-situ production plant, the technology for acquisition and processing of the carbon dioxide atmosphere can be applied to carbon-neutral fuel production on Earth.

Surface exploration of Mars has so far been conducted with rovers that are limited by terrain and soil stability challenges. At the same time, analysis for sample return missions is mired in the traditional approach of bringing all the return propellant from Earth, resulting in the most recent Mars sample return plan that calls for three launches over 10 years (National Research Council report, “Vision and Voyages for Planetary Science in the Decade 2013 – 2022”). A Mars mobility concept where the vehicle performs a series of suborbital ballistic hops can cover greater distances than a rover and can surpass difficult terrain un-passable by a surface vehicle. If this vehicle also carries with it a propellant production plant that can refill the tanks from in-situ resources at every stop, then it can serve the dual purpose of performing exciting Mars scientific exploration while providing critical demonstrations of a game-changing exploration concept that will lead to sustainable and affordable exploration of our closest neighbor.

This paper will discuss an affordable and realistic phased approach to developing and demonstrating in-situ propellant production technologies for Mars that will 1) reduce the risk in preparation for sample return and eventual human missions, 2) increase the science return and the explored surface area of Mars, and 3) advance critical technologies to produce synthetic fuels on Earth that do not contribute to an increase in atmospheric carbon pollution.