Highlighting the Need for In-Situ-Derived Propellants for Cislunar and Near-Earth Applications

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In-situ-derived cryogens and cryogenic fluid management have been a large focus of recent NASA attention. For example, the 2020 NASA Tipping Point distributed $256 million of the $370 million Tipping Point budget to companies for cryogenic projects [1]. While cryogenics provide high thrust and a specific impulse typically higher than mono and bi-propellants, they fit only a narrow use case involving large scale, high power, complex systems over short periods. This leaves many spacecraft form factors that provide the instrumental building blocks of lunar infrastructure and support without a propellant that can be created from lunar resources, generating issues with long term sustainability. This results in a need for a storable, high impulse propellant derived from lunar resources. Up to this point, little work has been undertaken by the industry to satisfy this need, but based on a number of previous studies, Orbit Fab believes that high-test peroxide (HTP) is the best and only option for a storable high impulse ISRU derived propellant in cislunar space, and as such is developing a system capable of producing HTP from water.

This work will explore the use cases for the two major high-impulse propellants that can be created from Lunar resources: bipropellant hydrolox, and monopropellant HTP, and bring more clarity to their useful market and logistics segments within the cislunar economy. The propellants will be analyzed with respect to various spacecraft size classes, mission concepts of operations, storage requirements, risk margins, and anticipated market needs currently expected to emerge. The expectation is that cryogens will remain the obvious choice for large spacecraft performing high delta-V escape transfers, but HTP will represent a large market share across smaller and longer term spacecraft performing operations in the cislunar region, which do not have a long term thermal solution or size, mass, power, and cost (SWaP-C) allocation for a cryogenic fluid management system. The exact breakeven points across different spacecraft scales and delta-V requirements will be a critical outcome of this work, to help further define the relative priority that each type of propellant should hold when it comes to ISRU funding.

To sustainably fulfill this market segment and prove the feasibility and SWaP-C of HTP compared to non-ISRU storables, such as hydrazine, Orbit Fab's HTP Production System which generates HTP from water, can be combined with other extraction and water purification processes in order to resource-effectively produce HTP propellant on the surface of the Moon from icy regolith. These combinations can create an end-to-end supply chain that is currently being examined with a growing number of collaborators who are coming onboard with the HTP architecture. A unique finding is that when comparing the relative SWaP-C, it is estimated that a demonstration of this technology on the surface of the Moon could cost at least 10 times less than the demonstration of a comparable system designed to produce and store cryogenic propellant. Such a mission could occur in the next few years. Because of this, the authors believe that HTP represents a low-cost and low-risk development that requires greater attention and funding. The goal of this work is to promote that idea by demonstrating the valuable use cases of HTP to sustainably create the required architecture for the cislunar economy to best flourish.

[1] Loura Hall, "2020 NASA Tipping Point Selections." NASA, NASA, 13 Oct. 2020.