Advanced System Concept for Total ISRU-Based Propulsion and Power Systems for Unmanned and Manned Mars Exploration

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ORBITEC proposes to conceptualize cost-beneficial Mars ISRU-based systems and an overall architecture for producing and utilizing optimized Mars-based ISRU propellant combinations that are derived from the atmosphere to support ground and flight transportation and power systems. For ground systems, we include: automated unmanned roving vehicles, personal vehicles, two-person unpressurized rovers, manned pressurized transport rovers and larger cargo transports. For flight systems, we include: Mars sample return vehicles, unmanned and manned surface-to-surface “ballistic hoppers,” surface-to-orbit vehicles, interplanetary transport vehicles, powered balloons, winged aerocraft, single-person rocket backpacks, and single-person rocket platforms. Auxiliary power systems include: Brayton cycle turbines and fuel cells for small Mars outposts.

In Phase I, we accomplished a preliminary systems study which provided the approach needed to ultimately assess the benefits of our ISRU proposed architecture. For the cost-effective human exploration of Mars, we will need to use in-situ resources that are available on Mars, such as: energy (solar); gases or liquids for life support, ground transportation, and flight to and from other surface locations, orbit and Earth; and materials for shielding, habitats and infrastructure. Probably the most cost-effective and easiest use of Martian resources is the atmosphere (95.5% CO_2). CO_2 can be easily processed and converted to carbon monoxide or carbon and oxygen propellants (SCO/LOX, C/LOX) and with hydrogen, either Earth-supplied or also derived from the Mars atmosphere (via H_2O) or Mars soil, many more ISRU propellant options become available, including: C_2H_2/LOX, C_2H_4/LOX, CH_3OH/LOX, CH_4/LOX, C_3Hg/LOX, LH_2/SOX, LH_2/LOX, CH_3OH/H_2O_2, etc. With small amounts of N_2 also in the atmosphere (2.7%), propellant ingredients such as N_2O, N_2O_4, N_2H_4, MMH, UDMH are possible.

ORBITEC proposes to conduct the necessary advanced concept analysis that will provide the knowledge base required to eventually select the resources and systems that are the most effective in keeping space exploration costs low. In this study, we will focus on the innovative and revolutionary use of solid CO, C and C_2H_2 as fuels in hybrid rocket propulsion and power system applications. However, we plan to evaluate all reasonable potential ISRU propellant options and develop “families” of propellants that are optimally used in the overall transportation and chemical energy storage systems. New advanced cryogenic hybrid rocket propulsion systems are also proposed that will tremendously improve the performance of CO/O_2, C/O_2, or C_2H_2/O_2 propulsion (as well as others, e.g., CH_4/LOX) such that these could be the best options for transportation and power needs. The implementation of this architecture is expected to greatly support logistics and base operations by providing a reliable and simple way to store solar or nuclear generated energy in the form of chemical energy that can be used for ground transportation and power generators. ORBITEC has proven that the CO/O_2 propulsion concept is technically feasible by conducting test firings of a small-scale solid CO/O_2 hybrid!

In this Phase II effort, ORBITEC proposes to completely develop a long-term Mars ISRU-based propellant architecture that is optimized to keep Mars exploration and colonization costs to a minimum. We propose to conduct some straightforward rocket engine tests in our current hardware with SC/O_2 and SC_2H_2/O_2 to determine the feasibility of these higher performing propellant combinations. We expect that our analysis shall show significant cost-benefit for ISRU propellants and that we shall be able to confidently recommend the top groups or families of propellant combinations that can satisfy the across-the-board transportation and auxiliary power needs of our Mars exploration/colonization activities of the 21st century. This information should then allow the right emphasis on technology and system development