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MARS GAS STATION: TRANSITION FROM INDEPENDENT MISSIONS OF PROPELLANT PRODUCTION HARDWARE TO EXTRATERRESTRIAL "GAS STATIONS" SUPPORTING REUSABLE LANDERS

Abstract

The most recent comprehensive mission architecture for human missions to Mars is the NASA Design Reference Architecture V5 (DRA5), which includes in-situ production of liquid oxygen (LOX) from atmospheric methane as a critical mission factor in drastically reducing the mass of oxygen required to be sent to Mars. The atmosphere-only fuel production option is selected, since prospecting and extracting water on Mars was deemed too risky. However, if this problem can be solved, much lower energy processes to produce LOX while at the same time producing methane fuel can be achieved.

This study examined several candidate technologies for methane production on Mars, evaluating the processing requirements, and calculating the energy costs of methane production and storage on the surface. The technology candidates included solid oxide electrolysis (SOXE) to produce LOX only, and several others to produce LOX/methane: Sabatier/electrolysis, Sabatier/SOXE processing, and electrochemical production using ionic liquid cells. In addition to the production energy costs, liquification of the output products as well as energy costs of storage were also calculated.

The study used the detailed designs from the Mars DRA5, augmented with more recent conceptual design specifications of Mars landers from the Evolvable Mars Campaign (EMC). The EMC design has 3 Mars Descent Modules (MDM)s and one Mars Ascent Vehicle (MAV) per human mission. In the EMC design, the propellant production unit fills the MAV tanks for the return to Mars orbit. Using this design envelope, the study calculated the energy increase required to convert from LOX-only, to methane and LOX production, as well as the energy requirements of using the landed mission assets over time to create a Mars gas station infrastructure to provide fuel for the next generation of reusable vehicles. Each human mission would land a power supply, a production plant, and enough storage tanks for its own return flight. However, if these systems continue to produce fuel after the initial mission period, storing the new production in unused landed tanks in the MDMs, then an additional 30 mT of fuel can be produced per synodic period, per set of landed hardware. After three missions to the same location using this disposable hardware, there would be enough propellant production and storage capability at this Mars base to fully fuel a reusable transport system.