

## **Refueling with In-Situ Produced Propellants**

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In-situ produced propellants have been identified in many architecture studies as key to implementing feasible chemical propulsion missions to destinations beyond lunar orbit. Some of the more noteworthy ones include: launching from Mars to return to Earth (either direct from the surface, or via an orbital rendezvous); using the Earth-Moon Lagrange point as a place to refuel Mars transfer stages with Lunar surface produced propellants; and using Mars' Moon Phobos as a place to produce propellants for descent and ascent stages bound for the Mars surface. However successful implementation of these strategies require an ability to successfully transfer propellants from the in-situ production equipment into the propellant tankage of the rocket stage used to move to the desired location. In many circumstances the most desirable location for this transfer to occur is in the low-gravity environment of space. In support of low earth orbit propellant depot concepts, extensive studies have been conducted on transferring propellants in space. Most of these propellant transfer techniques will be applicable to low gravity operations in other locations. Even "ground-based" transfer operations on the Moon, Mars, and especially Phobos could benefit from the propellant conserving techniques used for depot refueling. This paper will review the literature of in-situ propellants and refueling to: assess the performance benefits of the use in-situ propellants for mission concepts; review the parallels with propellant depot efforts; assess the progress of the techniques required; and provide recommendations for future research.