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Mars Exploration – missions current and future (3A)

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MODELING A MARS LOX/LH2 ARCHITECTURE WITH CRYO-MANAGEMENT, ISRU, AND FUEL CELLS

Abstract

LOX/LH_2 Mars architectures have historically been ruled out in favor of LOX/CH_4 architectures, which leaves a gap in literature and technology development in support of LH_2 architectures. This leads to a perceived risk with long-term LH_2 cryo-management and fuel ISRU, even though discoveries suggest that water is widely accessible on Mars. We model a LOX/LH_2 Mars architecture with passive and active cryo-technologies, fuel cells to produce water and power from the otherwise wasted boiloff, and fuel ISRU.

As these technologies are switched on and off in combinations, the resulting mass that has to be sent to Earth's orbit, or upmass, is compared with a constant payload is assumed to go to the surface. Alternatively, another analysis shows how much payload could be achieved given a constant upmass. With improved MLI and cryocoolers, a $5\% - 10\%$ upmass saving was achieved, or an increase in landed mass from 22 to 28mT. The addition of fuel cells only gave a marginal benefit of 0.7% upmass savings, but they add operational flexibility for power and life support. Further, the added mass due to Mars water ISRU infrastructure pays off due to mass savings just after the second crewed mission. These results suggest a Mars LOX/LH_2 architecture with improved MLI and cryocoolers will be competitive with a LOX/LCH_4 architecture.