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Comparison of Propulsion Options for Human Exploration of Mars

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NASA continues to advance plans to extend human presence beyond low-Earth orbit leading to human exploration of Mars. The plans being laid out follow an incremental path, beginning with initial flight tests followed by deployment of a Deep Space Gateway (DSG) in cislunar space. This Gateway, will serve as the initial transportation node for departing and returning Mars spacecraft. Human exploration of Mars represents the next leap for humankind because it will require leaving Earth on a long mission with very limited return, rescue, or resupply capabilities. Although Mars missions are long, approaches and technologies are desired which can reduce the time that the crew is away from Earth. This paper builds off past analyses of NASA's exploration strategy by providing more detail on the performance of alternative in-space transportation options with an emphasis on reducing total mission duration. Key options discussed include advanced chemical, nuclear thermal, nuclear electric, solar electric, as well as an emerging hybrid propulsion system which utilizes a combination of both solar electric and chemical propulsion.