HUMAN EXPLORATION OF THE MOON AND MARS SYMPOSIUM (A5)
Long Term Scenarios for Human Lunar Presence (2)

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SOLAR ELECTRIC PROPULSION FOR A FLEXIBLE PATH OF HUMAN SPACE EXPLORATION

Abstract

In the wake of the monumental achievement of extending our presence to the Moon, there has been much anticipation to further the expansion of destinations for human space exploration. For many, the next desired target is Mars; however, despite decades of proposed missions and comparative analyses there is no definite plan for how we shall go to Mars. Further, any potential mode of Mars exploration only indicates a goal for our space-faring capabilities: it does not provide the (arguably less definite) path to achieving these capabilities. We present a stepping-stone approach from low-Earth orbit to the surface of Mars that includes excursions in cis-lunar space, the surface of the Moon, near-Earth objects, and Phobos. The primary goal of this approach is to introduce flexibility into the exploration schedule while minimizing risk to the crew. Flexibility is infused by steadily implementing technologies and vehicles that enhance, but are not required to enable, the steps on the path to Mars. In this way unproven techniques may be tested in scenarios that reduce to the crew, yet continue to increase the efficiency of human space transportation. We have found that solar electric propulsion (SEP) is particularly effective in reducing the injected mass to low-Earth orbit (IMLEO) for space exploration. The key benefit is a dramatic reduction in propellant required to raise interplanetary vehicles and propulsion stages from LEO to a high-energy orbit at Earth. Once the interplanetary transfer vehicle is in a high-energy parking orbit, the crew launches in a small capsule to rendezvous and perform system checks before departing on an interplanetary mission. In this way, SEP increases the efficiency of any mission beyond LEO (requires fewer launch vehicles), but is not required for the crew to explore the target because the interplanetary vehicle can employ more traditional propulsion systems. Moreover, SEP may be used to pre-position chemical boosters and cashes of provisions along the trajectory to reduce vehicle mass and provide a range of crew return capabilities throughout the missions. Preliminary analyses have indicated a 100-200 t reduction in IMLEO for near-Earth asteroid round-trip missions.