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A COMPARISON OF MARS PRECURSOR MISSION DESIGNS: LUNAR AND ARCTIC

Abstract

A manned mission to Mars remains the current far-reaching goal for human-exploration. There are many unique challenges, however, and questions yet to be answered regarding such a long and unforgiving mission. We must first develop and demonstrate technologies required to send, sustain and return the exploring astronauts during a multi-year mission. We must also demonstrate that humans have the capability to perform the mission successfully, while withstanding the physical and psychological pressures of such a long, grueling mission. This paper outlines and compares several possible precursor missions, which serve to demonstrate the readiness of the human race to undertake a Mars mission.

First, a baseline Mars mission is described and the technologies and open issues that must be demonstrated are outlined. In particular, we examine shelter, risk and transportation. From this baseline, several mission concepts are generated, each with the goal of simulating a Mars mission, while mitigating or avoiding some of the associated risk. The first mission concept involves spending six months onboard the International Space Station, travelling to and living on the moon for one year, returning to the ISS for another six months, and then returning home to Earth. This concept is compared with replacing the trip to the moon with a trip to Earth's South Pole. Several variants of each mission are considered, including provisions for landing directly on the South Pole without any outside intervention, or landing conventionally in the US and then being immediately transported to the pole.

Each precursor mission is evaluated based on quantitative estimates of mission cost (derived from orbital velocity and propulsion models) as well as qualitative measures from previous, shorter, analogue missions. The associated risks with each mission are calculated and used to evaluate the mission concepts. Trades are performed to identify the mission concepts with the highest utility. Recommendations are given based on these system engineering trades for the optimal precursor missions, given different underlying assumptions.

It is shown that each of these scenarios provides a platform to demonstrate needed technologies while mitigating the overall risk of deep space exploration. They will also serve as a "trial run" for the crewmembers who will subject their bodies and minds to the consequences of extended spaceflight and varied g-levels without actually traveling to Mars. The proposed scenarios each lay a good foundation for possible future precursor mission design.