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PATHWAYS TO ESTABLISH A 50-PERSON BASE ON MARS FOR PIONEERING HUMANS

Abstract

Mars is the horizon goal for NASA, and there has been increasing excitement and expectation for humans to once again leave the confines of Earth and expand human exploration. Currently, many different architectures or pathways exist such as NASA's Design Reference Architecture 5.0, JPL's Minimal Mars, Zubrin's Mars Direct, Buzz Aldrin's Cycling Pathways, Lockheed Martin's Mars Base Camp, Boeing's Path to Mars, and SpaceX's Interplanetary Transport System. The different pathways to Mars have various pros and cons that must be considered to select the most resilient one. To increase resiliency, NASA's Evolvable Mars Campaign (EMC) included missions and hardware as flexible as possible to allow the design to adapt over time with new information. Several resilient and flexible architectures are desired to handle future unknowns such as budgetary changes, political priorities, new scientific discoveries, technological breakthroughs, evolving partnerships, and new risk factors.

The paper outlines three pathways that leads to the development of a Martian base as the first step for pioneering human activities for a sustainable human presence on Mars. The martian base is analogous to the US Amundsen-Scott South Pole Station during winter operations in Antarctica. Missions were selected that spanned the mid-2020s to the year 2100 with the order and purpose focused on validating new technologies, building capabilities, and reducing the risk of subsequent missions while remaining constrained to fiscal realism.

First, the baseline pathway uses ballistic trajectories for crewed missions and solar electric propulsion trajectories for cargo missions. Second, the cycler pathway relies on the S1L1 cycler trajectory for crewed missions. Lastly, the ballistic pathway is constrained to using ballistic trajectories and eliminates the use of any solar electric propulsion for both crewed and cargo missions. All three pathways minimize risk and technology developments while staying constrained to the projected budget of NASA's human spaceflight program.

The paper also includes the life cycle cost (using a new cost tool developed) and probabilistic risk assessment at both the mission and architecture levels. Using the standardized set of missions and systems for all three pathways, the relative merits are compared and evaluated.