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MARTEMIS: MARTIAN ANALOG RESEARCH AND TRAINING EXPERIMENTS ON THE MOON WITH INTERNATIONAL SIMULATIONS

Abstract

As a part of the ARTEMIS campaign, NASA plans to conduct a long-duration Mars mission simulation at the moon to reduce risk and build experience. A Mars architecture has not been selected, and many existing mission concepts have an estimated 1 in 90 to 1 in 10 chance of loss of crew, which arises when mass, power, volume, and crew time are heavily constrained to minimize cost.

To design a safe and cost-effective mission to Mars, we propose MARTEMIS: a campaign of simulations that test different mission-defining elements to inform the development of a resilient Mars architecture that significantly reduces human risk from previous iterations. The variables with the most impact on safety, performance, and cost are crew size, surface endurance, transit times, and mission margins. The various combinations of these high-impact variables lead to different Mars architectures and contribute to the non-intuitive emergence of desirable and undesirable outcomes, including those related to the 31 risks tracked by HRP.

MARTEMIS conducts 15 simulation missions with 130 total crew members, varying high-impact decisions across multiple levels. We use a design of experiments (DoE) approach to enable a systematic analysis and Taguchi Orthogonal Array methods to minimize the number of trials needed. The baseline simulation represents the most recent SAC 21 architecture which features a 12-month transit in microgravity, a 1-month lunar surface mission, and a 12-month return transit in microgravity. The architecture is dintoa-rich and will provide invaluable insights on the impact of spaceflight hazards on human psychology and physiology, the efficacy of risk mitigation strategies, and the performance of systems in prolonged space voyages. This campaign enables the advancement of more technologies and orders of magnitude more science time, serving as both a valuable Lunar mission as well as a robust Mars-forward simulation. Using a cost subscription model, an estimated 20 Artemis Accords partners can afford at least one astronaut participant, solidifying a meaningful International Collaboration that enables new players to share the benefits of space exploration.

MARTEMIS delivers increased value to stakeholders interested in human discovery science, Lunar science and infrastructure, and Mars-forward capabilities by leveraging economies of scale and falling launch costs to conduct a large international campaign. Ultimately, MARTEMIS provides extensible data to any Mars architecture and offers a safer, more sustainable pathway for human exploration beyond Earth's orbit.

This is a submission to the NASA 2024 Revolutionary Aerospace Systems Concepts - Academic Linkage (RASC-AL) competition.