Effective Cooperation, Coordination, and Communication in Developing Human Missions to Mars:

The Tenth Community Workshop
for Achievability and Sustainability of Human Exploration of Mars
("Achieving Mars Workshop X" or "AM X")

AM X Co-Chairs: Erik Antonsen, Bruce Jakosky, Lisa May

The George Washington University Washington, DC
Elliott School of International Affairs
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From December 5-7, 2023, Explore Mars, Inc., a 501(c)(3) non-profit, hosted the Tenth Community Workshop for Achievability and Sustainability of Human Exploration of Mars ("AM X") at The George Washington University in Washington, DC. The annual AM workshops (https://www.exploremars.org/affording-mars/) have been an essential opportunity for a broad community to contribute to the development and justification of valuable elements of NASA's human space flight program. Participants of these workshops include individuals from NASA, industry, and academia, with expertise covering a wide range of topics related to the human exploration of Mars.

The Moon-to-Mars (M2M) Architecture Definition Document (ADD) recently released by NASA provides a strong starting point for an iterative architecture process that will evolve through annual Architecture Concept Reviews (ACRs). Commercial spaceflight companies are also working on independent pathways to reach Mars. As NASA's M2M ADD continues to evolve through the ACRs, the importance of effective cooperation, coordination, and communication among key stakeholders grows. Participants in the AM X workshop offered findings and recommendations to ensure that key stakeholder communities collaborate to effectively support the planning, design, and implementation of the M2M program. Participants observed that despite recent progress, existing channels were insufficient to adequately integrate human capabilities and limitations as well as science objectives into the architecture development process. Similarly, sustainable human exploration of the Moon and Mars will not occur unless science and human exploration objectives are infused early and continuously into the systems engineering processes. This summary document provides recommendations to help improve the process.

RECOMMENDATIONS
The workshop arrived at these high-level recommendations.

Recommendation 1: Create or support new and more frequently recurring public interactive forums with the goal of developing inputs to the Architecture Definition Document.

- Highlight opportunities for public participation with diverse communities including operations, human research, science, international, and more, that empower cross-disciplinary teaming, welcome broad participation from external experts, and provide a pathway to incorporate community recommendations and findings into Mars mission planning (both for in-space and surface segments).

- Spearhead initiatives and workshops that focus on creating the necessary strategies to prepare for intelligent systems development and data analytics that will be used over the next two decades and are critical for progressive Earth independence in M2M missions.

- Align and coordinate science strategies across diverse science communities with Agency M2M objectives with the goal of iteratively prioritizing and narrowing the science objectives across the M2M missions.

- Consider creating a certification path for external groups of stakeholder experts to provide input in smaller settings and more frequently than once a year at the ACR.

Recommendation 2: Acknowledge and address the tension between scientific investment for risk mitigation purposes and investment for discovery science in planning for M2M missions. Historically, discovery science and technology and infrastructure development for future missions are often sacrificed for short-term needs.

- Increase science and Health and Human Performance (HHP) representation and responsibilities early and throughout the systems engineering process.

- Provide annual progress updates at the ACR for (1) science inclusion, (2) human systems integration, (3) software development and maturation, and (4) integrated systems testing and validation to complement the slides on hardware progress presented at the recent ACR.

- Balance hypothesis-driven research opportunities with iterative data collection and discovery science opportunities to maximize the use of new and evolving capabilities.

- Increase funding and opportunities for technology maturation, demonstration, and infusion to incorporate capabilities in rapidly advancing fields such as artificial intelligence, data management, in-space manufacturing, and others, as early in the development process as possible.

Recommendation 3: Both NASA and commercial companies interested in Mars exploration should continue to design evolvable mission and campaign architectures. This has the dual goal of ensuring that the utilization of today's technology does not limit the onboarding of future capabilities, as well as ensuring that we do not design architecture and hardware applicable only for the first mission without allowing both to evolve for subsequent missions.

- Develop common standards, requirements, and interfaces to allow the incorporation of multiple technologies, capabilities, and/or solutions as technology progresses over the next two decades.

- Create and implement a Human and System Readiness Level verification process to assess if the human, hardware, software, and planning systems are sufficiently mature as an integrated system.

- Ensure that the architecture is sufficiently flexible that it can address a wide range of missions beyond the first one.

Recommendation 4: NASA should investigate pathways to partner with commercial companies to invest in lunar capabilities and technologies that are Mars-forward. The Moon is how we learn to get to Mars, and we want companies thinking not just about getting to the Moon, but at the same time how getting there prepares us for the more challenging missions to Mars.

OUTLOOK AND SUMMARY

It has become clear that, as humanity seeks to travel farther into space, extended exposure to the spaceflight environment will decondition astronauts beyond prior experience and challenge their fitness to achieve the science goals of a Mars mission. To improve the integration of science, humans, and engineering systems, a re-envisioning of the relationship between these communities of practice and expertise is required. This includes meaningful integration of the science and HHP communities into the concept and design processes from the beginning and the creation of new forums that emphasize cross-disciplinary integration, incentivize progressively Earth-independent operations, and plan for an evolvable architecture. The ADD and ACR process created by NASA provides a strong starting point for the iterative goals of the M2M program. We feel that these suggestions can help improve the current process in place and help to align stakeholder communities behind the M2M office as we all reach towards our common goals.