

National Aeronautics and Space Administration

International Partnerships and NASA's Moon to Mars Architecture

Introduction

Since its inception, NASA has engaged the international community to advance its science, exploration, and space technology goals. Cooperation between NASA and international partners typically occurs on a no-exchange-of-funds basis, where each party funds its respective activities in pursuit of shared goals. Incredible programs like the International Space Station and James Webb Space Telescope would not be possible without international cooperation. International relationships also broaden NASA's education and public engagement efforts, inspiring people from the U.S. and around the globe.

Today, international partnerships are an essential part of NASA's ambitions for deep space exploration, enabling humanity's return to the Moon and the journey to Mars and beyond. International space agencies provide essential capabilities that will enable NASA to achieve its Moon to Mars Objectives.

Published in 2022, NASA's Moon to Mars Objectives define the agency's goals of deep space exploration.^[1] NASA's Moon to Mars Architecture decomposes the objectives into the functions needed to achieve them.^[2] International cooperation encompasses all aspects of the architecture, but it is especially important for addressing capability gaps.

NASA's Moon to Mars Objectives, Recurring Tenet 1

International Collaboration: partner with international community to achieve common goals and objectives.

NASA's process for incorporating cooperative activities into the Moon to Mars Architecture involves a series of pre-formulation activities and milestones that vary depending on the nature of the proposed cooperation — for example, activities for science payloads may be different than those for human-tended infrastructure. This white paper details how NASA engages with prospective international partners in support of the agency's science, exploration, and space technology goals.



Figure 1: Decomposition of NASA's Moon to Mars Objectives into component architecture features. (NASA)



2024 Moon to Mars Architecture



Figure 2: ESDMD pre-formulation process, including partner roles. (NASA)

Getting Started

Each year, NASA publishes a suite of documents updating the Moon to Mars Architecture. This includes white papers^[3] that dive into specific technical topics and the Architecture Definition Document (ADD),^[4] which captures the current state of the architecture. NASA houses these resources on a dedicated website^[2] alongside other supporting materials and links to related resources. These documents serve as the basis for NASA's collaboration with industry, academia, and the international community.

The ADD decomposes the Moon to Mars Objectives into the characteristics and needs of an architecture that could satisfy them. This process of architecting from the right is outlined on NASA's architecture website,^[5] in NASA's Moon to Mars Strategy and Objectives Development document,^[6] and in Figure 1.

Architecture gaps (i.e., use cases and functions that do not currently trace to an element) are areas ripe for collaboration and serve as excellent starting points for initial discussions on partnerships. NASA is open for international partners to provide exploration assets — ranging from scientific instruments to entire elements — that map to unallocated use cases and functions and fill architecture gaps.

Establishing a study agreement between NASA and an international partner can be an effective first step to identifying shared interests. These agreements enable technical interchange and more detailed conversations between the agencies about needs and capabilities.

Pre-Formulation Milestones

Once NASA and a partner have identified one or more viable areas for potential cooperation, they engage in studies and technical discussions. These engagements refine element concepts* and define the use cases and functions they would perform to advance the Moon to Mars Architecture.

***Note:** This section focuses on elements, which are substantial, architecture-level contributions. This paper addresses avenues for collaboration on smaller payloads or scientific instruments in later sections.

As Moon to Mars Architecture element concepts mature through NASA's pre-formulation process, the first major milestone is element initiation. During the element initiation milestone, NASA assesses whether an element concept meets priority architectural needs and whether prospective technologies and capabilities are likely to demonstrate sufficient maturity. After a successful element initiation, element concepts are further refined through trade studies and technical interchanges. This overarching element definition process culminates in the mission concept review, which evaluates the proposed concept's feasibility, ability to fulfil its objectives, and maturity to begin formulation.

Following mission concept review, NASA undertakes an acquisition planning process that culminates in an acquisition strategy meeting to determine whether to make, buy, or partner on a particular element. If NASA decides to proceed with a partnership approach, NASA would then engage its

potential international partner to establish an agreement that formalizes respective roles and responsibilities for formulation and implementation. Only once that international agreement is completed will NASA document elements as partner-provided in the next revision of the ADD.

Science Cooperation

Science is one of the three pillars of NASA's Moon to Mars Strategy,^[6] alongside national posture and inspiration. Because scientific experiments and instruments carry less of a financial burden than elements, science is an excellent way for international partners to collaborate with NASA.

Moon to Mars exploration seeks to address the important science-based questions that will help inform our understanding of Earth, the Moon, Mars, and the universe. NASA welcomes collaboration to achieve the high-priority science goals outlined in the Moon to Mars Objectives and decadal surveys produced by the National Academies of Sciences, Engineering, and Medicine.^[7]

International space agencies seeking to partner on science experiments may join U.S.-led proposals to Payload and Research Investigation from the Surface of the Moon (PRISM) and Artemis Deployed Instruments Program solicitations. These solicitations can be found through the online NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) system.^[8] NASA selects scientific investigations from these solicitations for delivery as payloads on human or robotic missions to the lunar surface.

NASA may also provide opportunities for international partners to submit proposals directly, without a U.S.-led partner. The 2023 Artemis III Deployed Instruments Program solicitation offered this opportunity, and NASA expects to continue international-led science proposals for future Artemis Deployed Instrument Program solicitations. The cost of developing these proposals and the instruments themselves must be covered by the sponsoring international agency or institution.

If NASA selects an international proposal, the U.S. and the international partner may establish a formal cooperation agreement. NASA has also contributed scientific instruments to international-led missions and plans to continue to do so on a cooperative basis. The assessment of Recurring Tenet 1: International Collaboration in the ADD contains more detail about NASA's current international science cooperation efforts.^[4]

Opportunities for Continued Engagement

As NASA refines its Moon to Mars Architecture and incorporates feedback from the international community, new avenues for international cooperation may emerge, enabling NASA to engage new partners and leverage existing partners in new ways. The agency is actively seeking international collaboration to expand humanity's reach throughout the solar system.

NASA's Office of International and Interagency Relations (OIIR) manages the agency's international engagements, facilitating dialogue, and establishing cooperation. OIIR can help international space agencies hold preliminary discussions to understand the intent, purpose, and scope of proposed cooperation.

International agencies with cooperative proposals that fill identified gaps in the Moon to Mars Architecture should reach out to the appropriate OIIR point of contact, as listed on the Moon to Mars Architecture website.^[9] NASA also encourages prospective international partners to attend its Moon to Mars workshops, held annually following the release of the latest architecture products. For the latest, navigate to the architecture website and subscribe to updates.^[2]



Figure 3: Three pillars of exploration. (NASA)

Key Takeaways

NASA considers international cooperation foundational for deep space exploration and a key part of its Moon to Mars strategy.

International partners can cooperate with NASA in a variety of ways, from participating in scientific investigations to providing exploration assets or elements that fill gaps in the architecture.

For exploration elements — substantial, architecture-level contributions — NASA has defined a clear pre-formulation process that incorporates partners at every step.

NASA encourages new and existing partners to engage its Office of International and Interagency Relations with questions or to begin partnership discussions.

References

- 1. Moon to Mars Objectives https://www.nasa.gov/wp-content/uploads/2022/09/m2m-objectives-exec-summary.pdf
- 2. Moon to Mars Architecture https://www.nasa.gov/moontomarsarchitecture/
- 3. Architecture White Papers https://www.nasa.gov/moontomarsarchitecture-whitepapers/
- 4. Moon to Mars Architecture Definition Document https://www.nasa.gov/moontomarsarchitecture-architecturedefinitiondocuments/
- 5. Architecting from the Right https://www.nasa.gov/moontomarsarchitecture-architectingfromtheright/
- 6. Moon to Mars Strategy and Objectives Development https://www.nasa.gov/wp-content/uploads/2023/04/m2m_strategy_and_objectives_development.pdf
- 7. Decadal Surveys https://science.nasa.gov/about-us/science-strategy/decadal-surveys/
- 8. NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) https://nspires.nasaprs.com/
- 9. Moon to Mars Architecture: International Engagement https://www.nasa.gov/moontomarsarchitecture-internationalengagement/