

National Aeronautics and
Space Administration

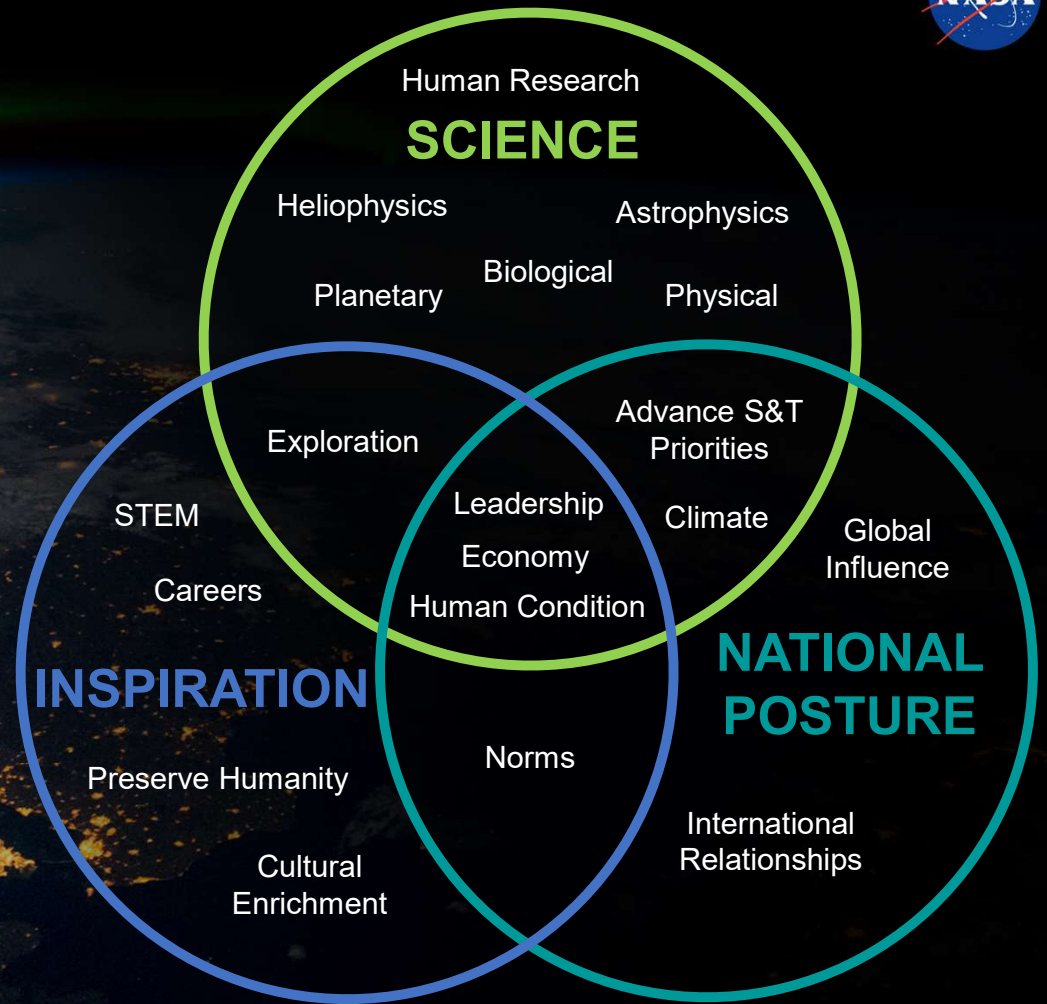


NASA's Moon to Mars Objectives

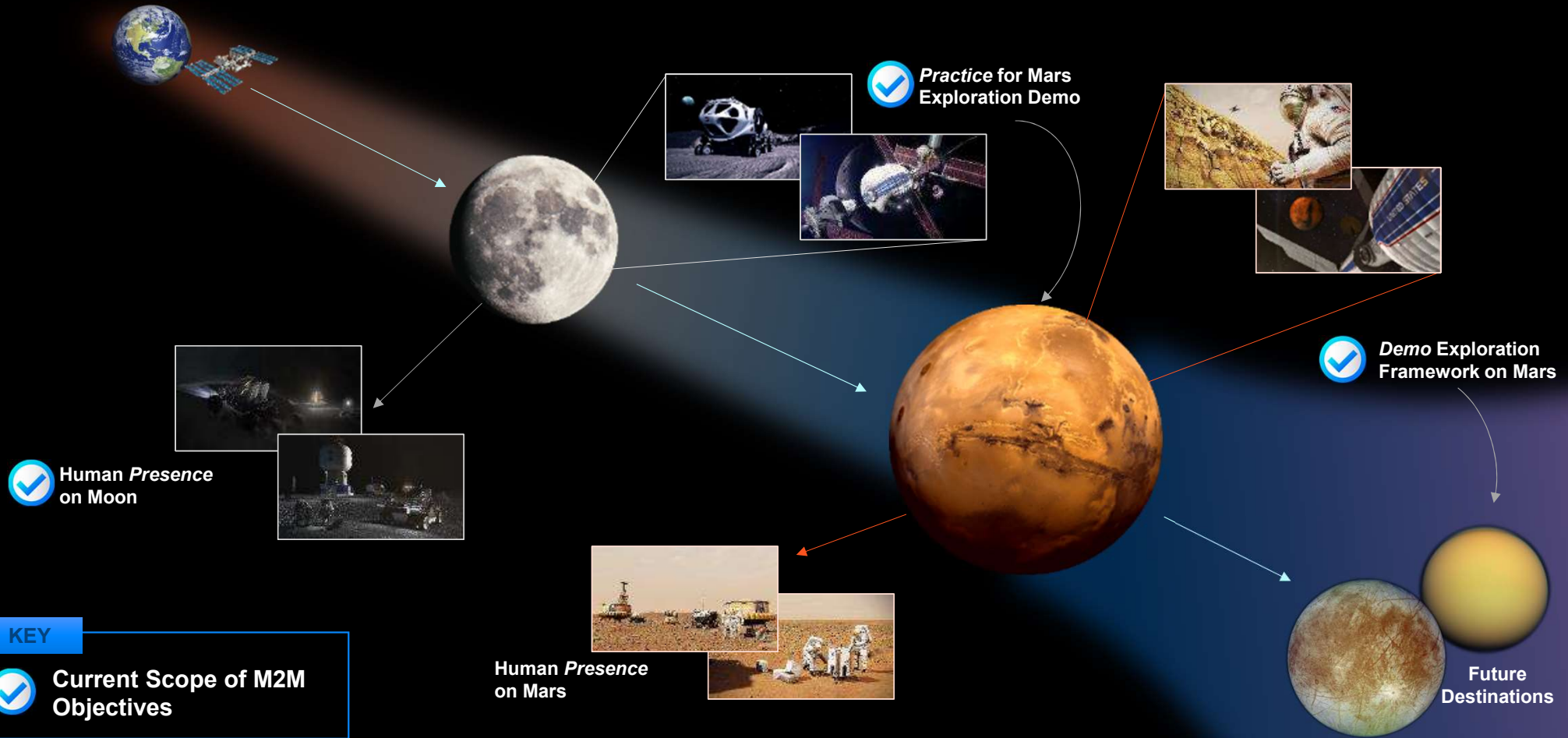
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Why Go?

Benefit to Citizens

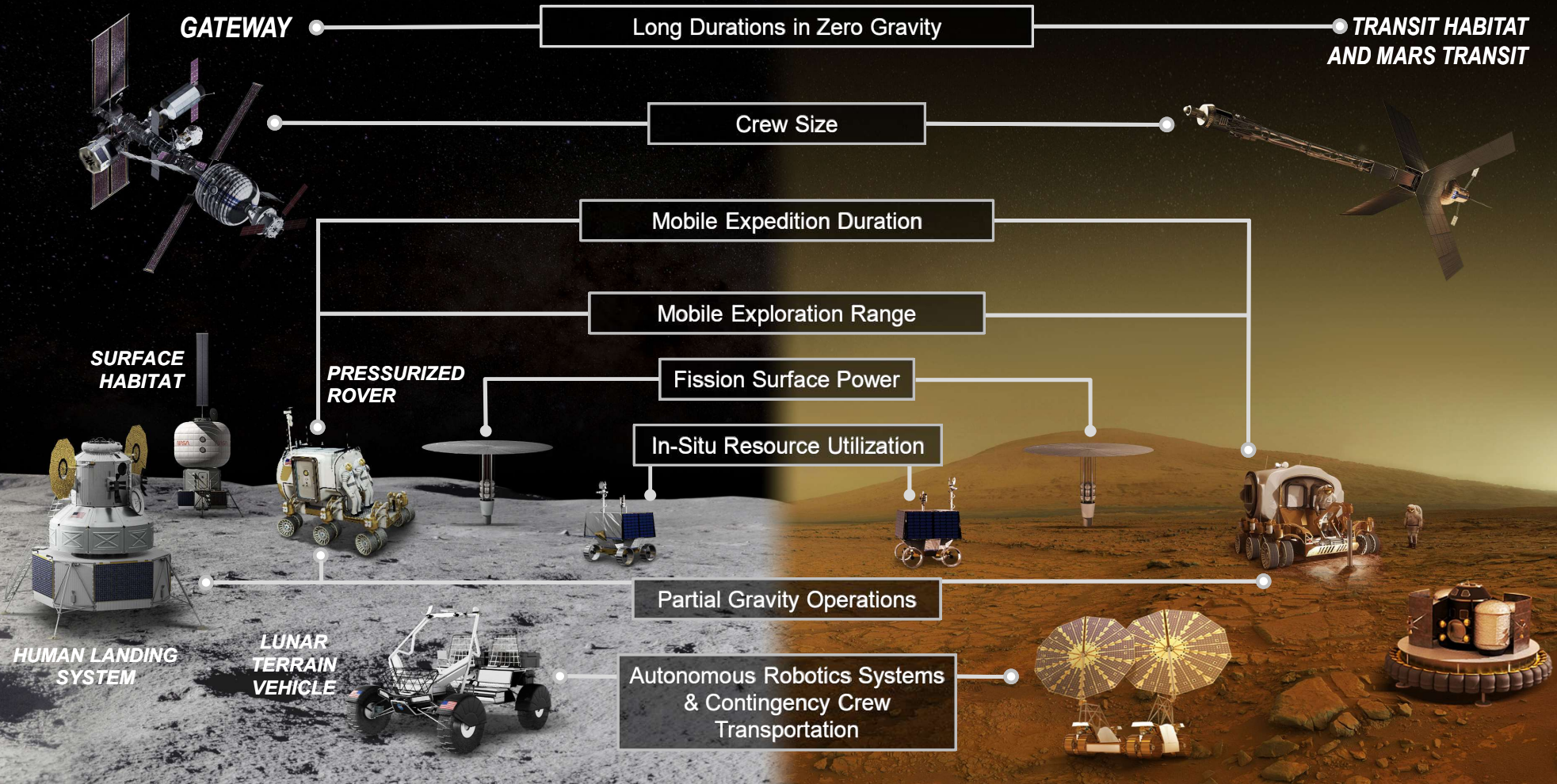


Current Moon to Mars Scope



Moon to Mars Exploration Strategy

Operations on and around the Moon will help prepare for the first human mission to Mars



Methodology Principles of the M2M Strategy



The methodology for the M2M Strategy is guided by 5 inter-related Principles:

- **Objective-Based Approach**

- Know your goal up front (the “what”) and create an integrated plan to achieve it

- **Architect from the Right / Execute from the Left**

- Work backwards from the defined goal to establish the complete set of elements that will be required for success
- Execute development of all elements in regular fashion, integrating as you move from the left according to the established architecture

- **Constancy of Purpose**

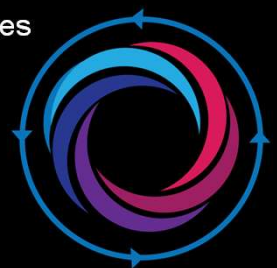
- Stick with the Plan: once documented, the goal, top-level objectives, and overall plan should be clear and remain consistent over time

- **Unity of Purpose**

- Everyone (inside and outside the Agency) should understand and be able to articulate the vision, goals, and objectives

- **Enhanced Communication & Engagement**

- The lifeblood that drives the reinforcing cycle of the other principles, and promotes political resilience
- Raise public awareness and support for M2M through robust outreach and engagement efforts
- Collaborate with international partners, industry, and academia to achieve common goals and objectives
- Engage NASA workforce continuously to promote understanding of the plan, sustain awareness of respective roles, and solicit feedback



M2M Objectives Roll-up

- **63 Top-Level Objectives across 10 Top-Level Goals**

- 26 Science (6 Goals)
- 13 Infrastructure (2 Goals)
- 12 Transportation & Habitation (1 Goal)
- 12 Operations (1 Goal)

- **9 Recurring Tenets (RT)**

- Common themes across objectives

- RT-1: International Collaboration
- RT-2: Industry Collaboration
- RT-3: Crew Return
- RT-4: Crew Time
- RT-5: Maintainability and Reuse
- RT-6: Responsible Use
- RT-7: Interoperability
- RT-8: Leverage Low Earth Orbit
- RT-9: Commerce and Space Development

Science Objectives (1 of 4)
Lunar/Planetary Science (LPS) Goal: Address high priority planetary science questions that are best accomplished by on-orbit human explorers on and around the Moon and Mars, aided by surface and orbiting robotic systems.

Heliohydric Science (HS) Goal: Address high priority heliohydric science and space weather questions that are best accomplished using a combination of human explorers and robotic systems at the Moon, at Mars, and in deep space.

Recurring Tenets
Common human access objectives



Recurring Tenets

Common themes across objectives



- RT-1: **International Collaboration:** partner with international community to achieve common goals and objectives
- RT-2: **Industry Collaboration:** partner with U.S. industry to achieve common goals and objectives
- RT-3: **Crew Return:** return crews safely to Earth while mitigating adverse impacts to crew health
- RT-4: **Crew Time:** maximize crew time available for science and engineering activities within planned mission durations
- RT-5: **Maintainability and Reuse:** when practical, design systems for maintainability, reuse, and/or recycling to support the long-term sustainability of operations and increase Earth independence
- RT-6: **Responsible Use:** conduct all activities for the exploration and use of outer space for peaceful purposes consistent with international obligations, and principles for responsible behavior in space
- RT-7: **Interoperability:** enable interoperability and commonality (technical, operations and process standards) among systems, elements, and crews throughout the campaign
- RT-8: **Leverage Low Earth Orbit:** leverage infrastructure in Low Earth Orbit to support M2M activities
- RT-9: **Commerce and Space Development:** foster the expansion of the economic sphere beyond Earth orbit to support U.S. industry and innovation

Superscripts indicate applicability to Lunar (L), Martian (M), or both (LM)



Science Objectives (1 of 4)

Lunar/Planetary Science (LPS) Goal:

Address high priority planetary science questions that are best accomplished by on-site human explorers on and around the Moon and Mars, aided by surface and orbiting robotic systems.

Heliophysics Science (HS) Goal:

Address high priority heliophysics science and space weather questions that are best accomplished using a combination of human explorers and robotic systems at the Moon, at Mars, and in deep space.



Science Objectives (2 of 4)

Human and Biological Science (HBS) Goal:

Advance understanding of how biology responds to the environments of the Moon, Mars, and deep space to advance fundamental knowledge, support safe, productive human space missions and reduce risks for future exploration.

Physics and Physical Science (PPS) Goal:

Address high priority physics and physical science questions that are best accomplished by using unique attributes of the lunar environment.

Science Objectives (3 of 4)



Science-Enabling (SE) Goal:

Develop integrated human and robotic methods and advanced techniques that enable high-priority scientific questions to be addressed around and on the Moon and Mars.

Science Objectives (4 of 4)



Applied Science (AS) Goal:

Conduct science on the Moon, in cislunar space, and around and on Mars using integrated human and robotic methods and advanced techniques, to inform design and development of exploration systems and enable safe operations.



Infrastructure Objectives (1 of 2)

Lunar Infrastructure (LI) Goal:

Create an interoperable global lunar utilization infrastructure where U.S. industry and international partners can maintain continuous robotic and human presence on the lunar surface for a robust lunar economy without NASA as the sole user, while accomplishing science objectives and testing for Mars.



Infrastructure Objectives (2 of 2)

Mars Infrastructure (MI) Goal:

Create essential infrastructure to support initial human Mars exploration campaign.

Transportation and Habitation Objectives



Transportation and Habitation Goal:

Develop and demonstrate an integrated system of systems to conduct a campaign of human exploration missions to the Moon and Mars, while living and working on the lunar and Martian surface, with safe return to Earth.

Operations Objectives



Operations Goal:

Conduct human missions on the surface and around the Moon followed by missions to Mars. Using a gradual build-up approach, these missions will demonstrate technologies and operations to live and work on a planetary surface other than Earth, with a safe return to Earth at the completion of the missions.



Looking Ahead

Continual Documentation

Documentation of refined objectives for distribution including rationale

Enhanced Communication and Engagement

Continued discussions with International, Industry, Academia, Workforce, and Stakeholders

Architecture Concept Review

Closeout of the objectives integration effort and gap analysis will be the 2022 NASA Internal Architecture Concept Review with results shared externally

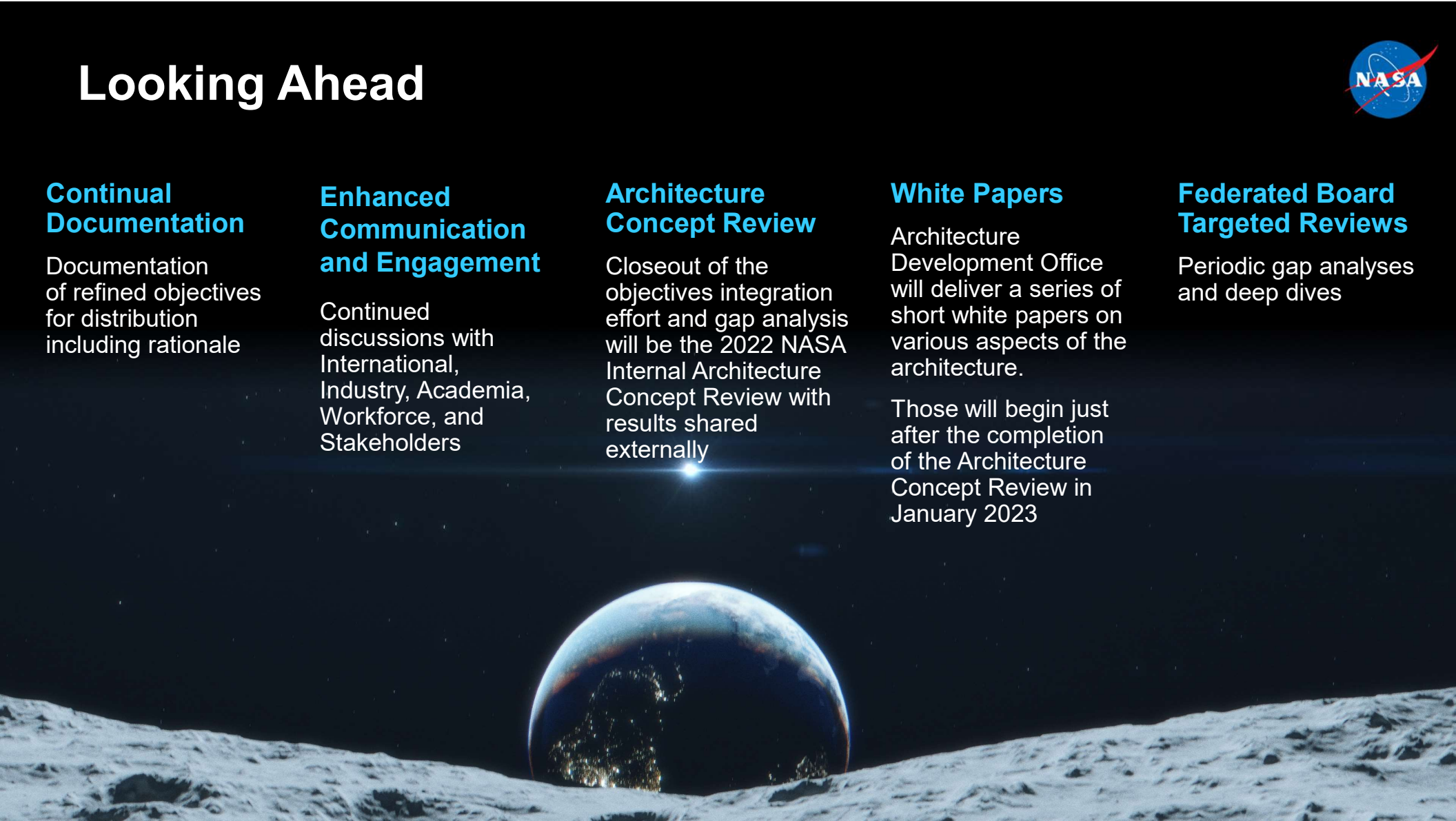
White Papers

Architecture Development Office will deliver a series of short white papers on various aspects of the architecture.

Those will begin just after the completion of the Architecture Concept Review in January 2023

Federated Board Targeted Reviews

Periodic gap analyses and deep dives





We came in peace.



We return for all humanity.

[Final Moon to Mars
Objectives](#)



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BACK UP

M2M Objectives Glossary of Terms



Architecture: A set of functional capabilities, their translation into elements, their interrelations and operations. The architecture enables the implementation of various mission scenarios that achieve a set of given goals and objectives.

Campaign: A series of interrelated missions that together achieve agency goals and objectives.

Continuous presence: Steady cadence of human/robotic missions in subject orbit/surface with the desired endpoint of 365/24/7 operations.

Demonstrate: deploy an initial capability to enable system maturation and future industry growth in alignment with architecture objectives.

Develop: design, build, and deploy a system, ready to be operated by the user, to fully meet architectural objectives.

Explore: Excursion-based expeditions focused on science and technology tasks.

Global: Infrastructure and capabilities that support human and robotic operations and utilization across the subject planetary surface.

Incremental: Building compounding operational capabilities within the constraints of schedule, cost, risk, and access.

M2M Objectives Glossary of Terms



Live: The ability to conduct activities beyond tasks on a schedule. Engage in hobbies, maintain contact with friends and family, and maintain healthy work-life balance.

Mission: A major activity required to accomplish an Agency goal or to effectively pursue a scientific, technological, or engineering opportunity directly related to an Agency goal. Mission needs are independent of any particular system or technological solution.

Mobility: Powered surface travel that extends the exploration range beyond what is possible for astronauts to cover on foot. Spans robotic and crewed systems, and can be accomplished on and above the surface.

Routine: Recurring subject operations performed as part of a regular procedure rather than for a unique reason.

Scalability: Initial systems designed such that minimal recurring DDT&E is needed to increase the scale of a design to meet end state requirements.

Utilization: Use of the platform, campaign and/or mission to conduct science, research, test and evaluation, public outreach, education, and industrialization.

Validate: Confirming that a system satisfies its intended use in the intended environment (Did we build the right system?).