National Aeronautics and Space Administration

Moon to Mars Architecture Overview

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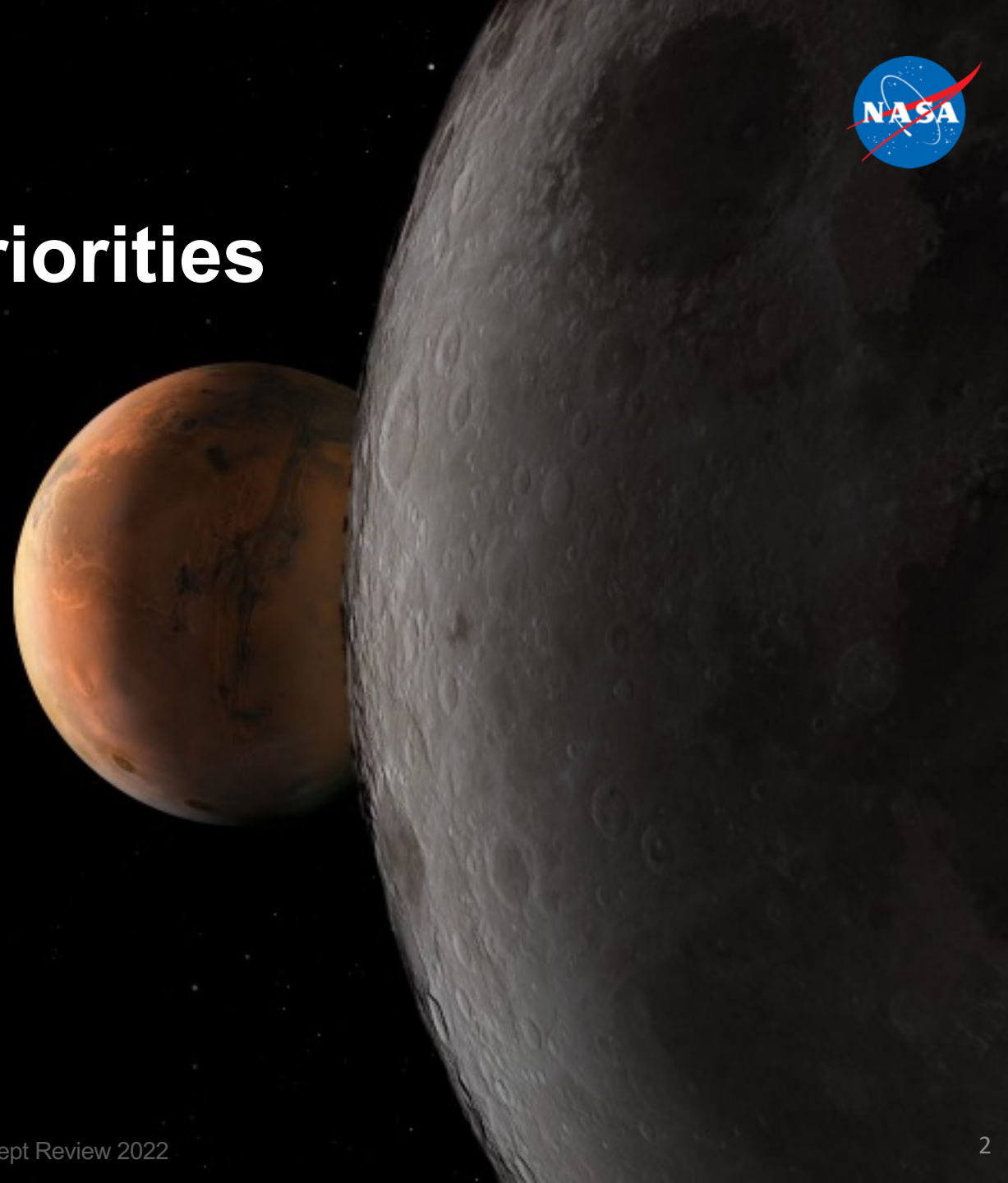
Deep Space Exploration Priorities

"…Human and robotic space exploration missions will land the first woman and person of color on the Moon, advance a robust cislunar ecosystem, continue to leverage human presence in low-Earth orbit to enable people to live and work safely in space, and prepare for future missions to Mars and beyond."

— The White House U.S Space Priorities Framework, Dec 2021

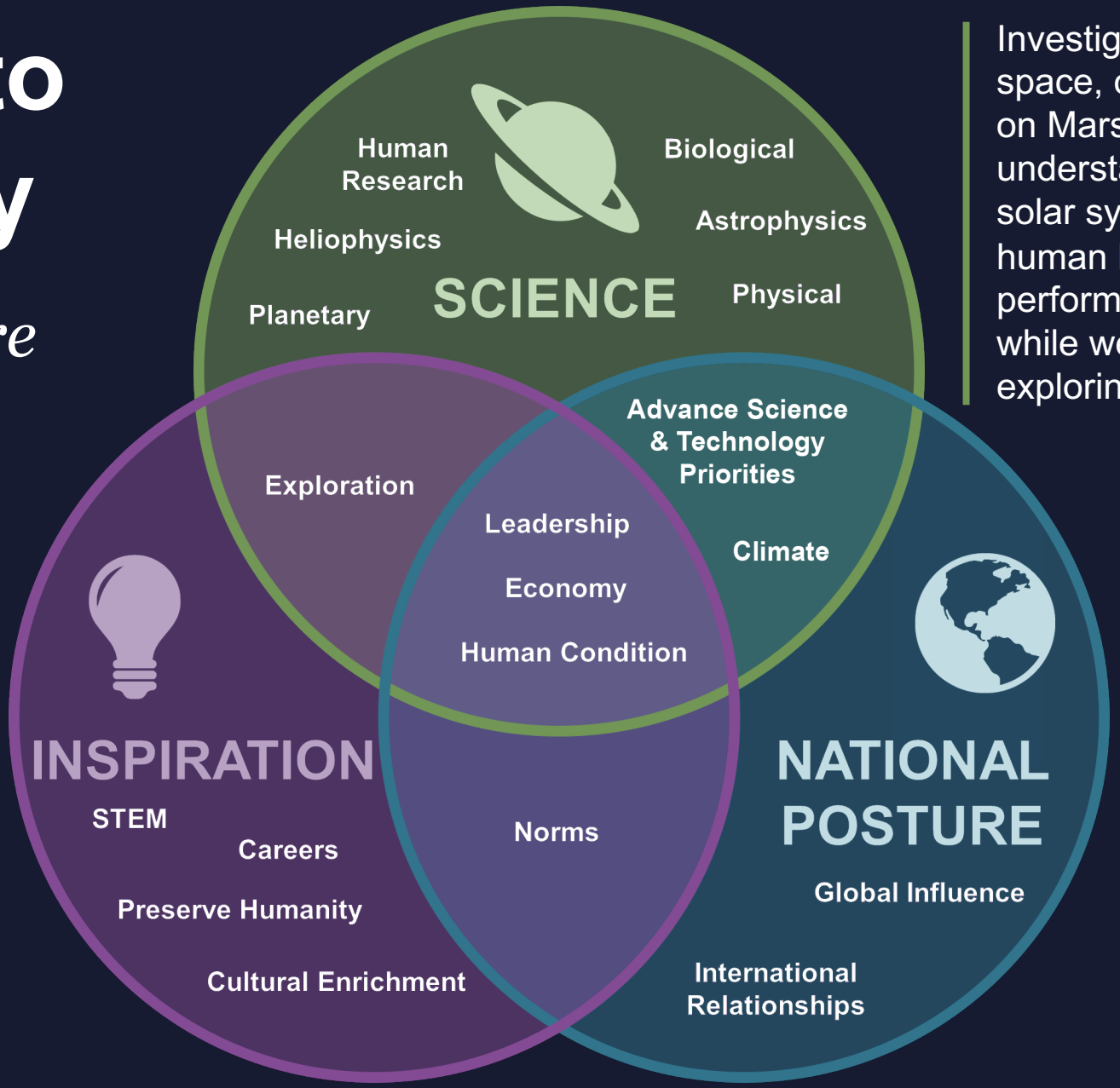
United States Space Priorities Framework
NASA 2022 Strategic Plan
2023 NASA Budget Request



Benefits to Humanity

Why We Explore

Investigations in deep space, on the Moon, and on Mars will enhance our understanding of the solar system, Earth, the human body, and how to perform new operations while we are out there exploring.



Accepting audacious challenges and succeeding through perseverance and tenacity in the face of adversity motivates current and future generations to dare mighty things.

What we choose to do, how we do those things, and who we do them with greatly impacts our place in the world today, our quality of life, and our possibilities for the future.

NASA's Moon to Mars Strategy and Objectives

A blueprint for future human exploration (Architecting from the Right)

ARCHITECTURE

Iterate and evolve through annual Architecture Concept Reviews

Goals and Objectives

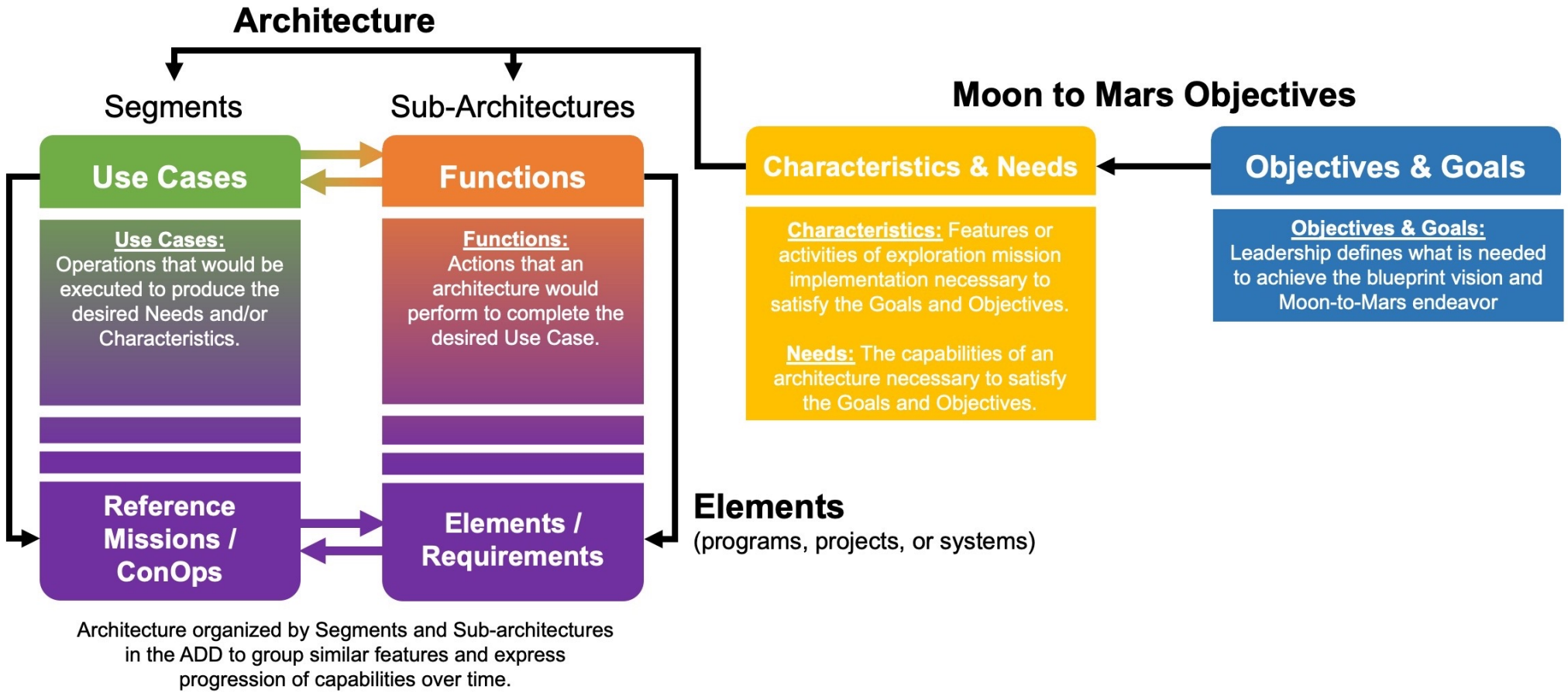
- **SCIENCE**
- **TRANSPORTATION AND HABITATION**
- **LUNAR AND MARS INFRASTRUCTURE**
- **OPERATIONS**

go.nasa.gov/3zzSNhp

Requested feedback on these objectives in summer 2022 from the following key stakeholders:

- NASA workforce: our greatest asset
- International partners: our key current and future, anticipated collaborators
- U.S. industry, academia, DOE, NIH, NSF, etc.: our national leaders in space research and capabilities

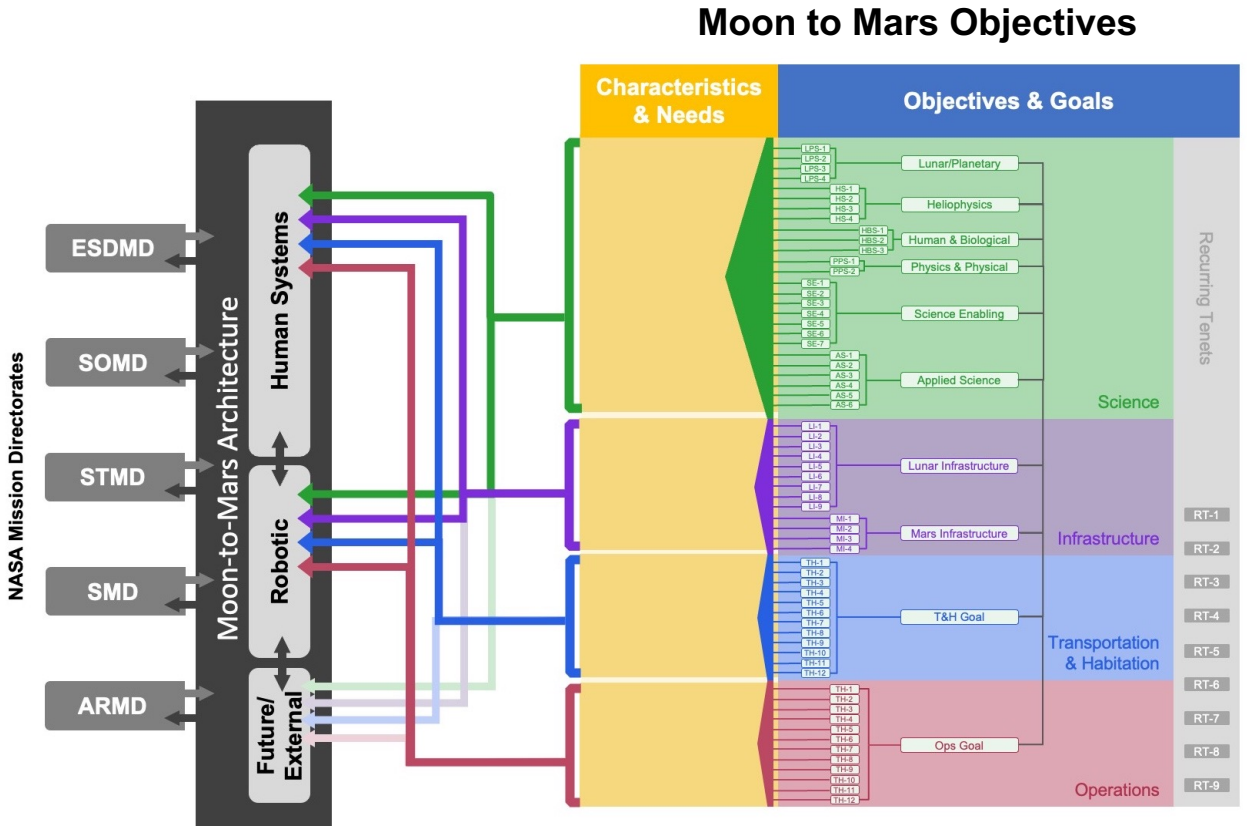
Architecting from the Right



The Architecture process requires a decomposition of Moon to Mars Objectives to element functions and mission use cases to complete the process of "architecting from the right." This establishes the relationship of executing programs and projects to the driving goals and objectives.

Integrating Human and Supporting Robotic Science Needs

- ACR22 and associated products were focused on the agency's human Moon to Mars architecture
  - Included SOMD systems, SMD robotic missions, STMD technology demonstrations, and ARMD activities that support the human architecture
- The Moon to Mars Architecture Definition Document (ADD) includes use cases, functions, and reference missions for uncrewed periods of operations in lunar orbit and on the surface



Architecture Concept Review

The purpose of an Architecture Concept Review (ACR) is to help unify the agency, promote advocacy for the architecture, and generate inputs from across NASA.

- The specific purpose of the Architecture Concept Review 22 (ACR22) was to:
  - Concur on the newly established yearly ACR process
  - Concur on disposition of key issues from ESDMD-001 Moon to Mars (M2M) Architecture Definition Document (ADD) Change Request
  - Concur on priority tasks for future ACRs

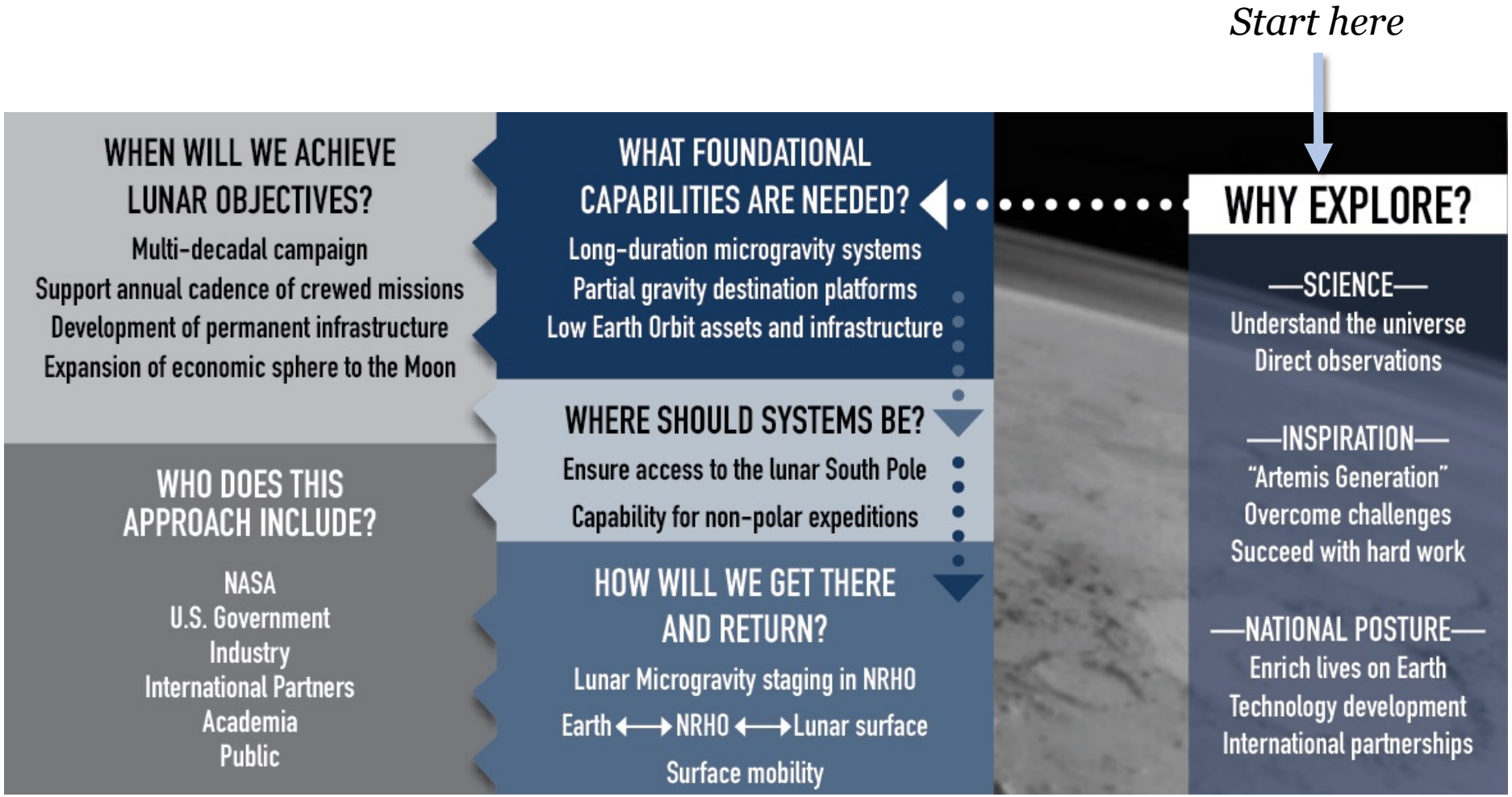
ARCHITECTURE CONCEPT REVIEW (ACR22)
Participation included representation from Mission Directorates, Agency Leadership, NASA Centers, Tech Authorities, ESDMD Leadership, Program Managers, and the Architecture Team

Future ACRs will be conducted annually in November to continue refining the architecture based on evolving policy, budget, partner contributions, and development schedules. Annual ACRs shifted to align with the NASA budget cycle.

Who, What, When, Where, Why, and How?

When addressing the classic six questions, each drives different architectural decisions, but all must be answered to arrive at a complete exploration strategy.

In the case at the right, the driving question is "Why," which informs the What, Where, How, When, and Who.



Executing from the Left: Segments and Sub-architectures

Segment: A portion of the architecture, identified by one or more notional missions or integrated use cases, illustrating the interaction, relationships, and connections of the sub-architectures through progressively increasing operational complexity and objective satisfaction.

Human Lunar Return

Initial capabilities, systems, and operations necessary to re-establish human presence and initial utilization (science, etc.) on and around the Moon.

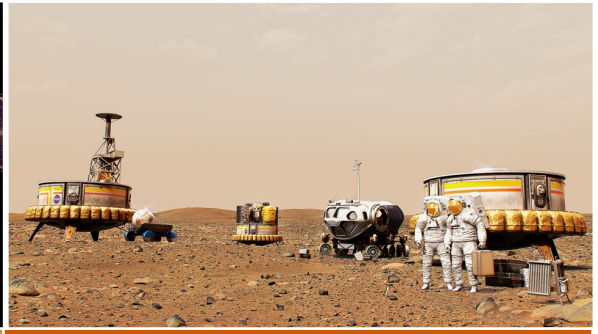
Focus for ACR 22

Foundational Exploration

Expansion of lunar capabilities, systems, and operations supporting complex orbital and surface missions to conduct utilization (science, etc.) and Mars forward precursor missions.

Sustained Lunar Evolution

Enabling capabilities, systems, and operations to support regional and global utilization (science, etc.), economic opportunity, and a steady cadence of human presence on and around the Moon.



Humans to Mars

Initial capabilities, systems, and operations necessary to establish human presence and initial utilization (science, etc.) on Mars and continued exploration.

Focus for ACR 23

Sub-architecture: A group of tightly-coupled systems, functions, and capabilities that perform together to accomplish architecture objectives.

Communication, Positioning, Navigation, and Timing • Habitation • Human Systems • Logistics • Mobility Systems • Power • Transportation • Utilization Systems

Human Lunar Return Segment

EXPLORATION GROUND SYSTEMS

ORION SPACECRAFT

SPACE LAUNCH SYSTEM

GATEWAY

DEEP SPACE LOGISTICS

xEVA Systems

HUMAN LANDING SYSTEM

COMM, POSITIONING, NAV, TIMING (CPNT)

COMMERCIAL LUNAR PAYLOAD SERVICES

MOON TO MARS CAMPAIGN SEGMENTS

ELEMENTS SHOWN BEYOND *HUMAN LUNAR RETURN* ARE NOTIONAL

LEO AND EARTH ANALOGS

SUSTAINED LUNAR EVOLUTION

HUMAN LUNAR RETURN

FOUNDATIONAL EXPLORATION

HUMANS TO MARS *MODEST FIRST MISSION OF THE TRADE SPACE SHOWN*

SLS BLOCK 1

ORION

NEAR-TERM ARTEMIS MISSIONS

SLS BLOCK 1B

SLS BLOCK 2

ISS AND COMMERCIAL LEO PLATFORMS

COMMERCIAL CARGO

GATEWAY

Increased Crew Size & Longer Durations in Micro-gravity

TRANSIT HABITAT AND MARS TRANSIT

COMMUNICATIONS RELAYS

SURFACE HABITAT

HUMAN LANDING SYSTEM

LOGISTICS LANDER

Nuclear Surface Power

MARS ASCENT VEHICLE

Habitation Systems

PRESSURIZED ROVER

Partial Gravity Operations

Mobile Expedition Duration / Mobile Exploration Range

PRESSURIZED ROVER

LUNAR TERRAIN VEHICLE

In-Situ Resource Utilization

Autonomous Robotics Systems & Contingency Crew Transportation

MARS TERRAIN VEHICLE

Sustained Lunar Evolution

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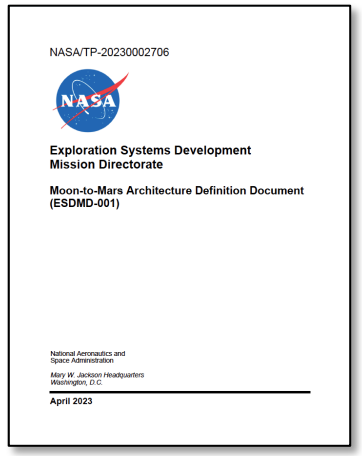
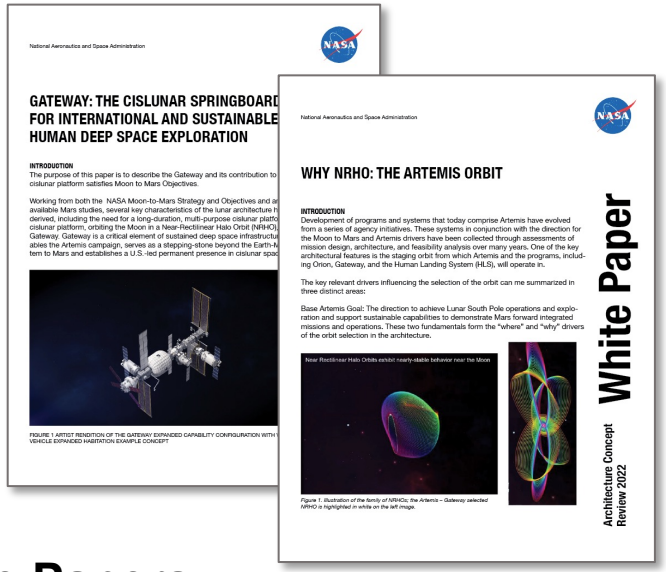
ACR Public Products
Available at www.nasa.gov/MoonToMarsArchitecture



Architecture Definition Document
- **Length:** 150 pages
- **Purpose:** detailed documentation of a snapshot of the human spaceflight architecture and exploration strategy
- **Audience:** highly technical – NASA, industry, international partners, committee staffers
- **Publication**: NASA Technical Reports Server
- **Update cadence:** Annual ACRs

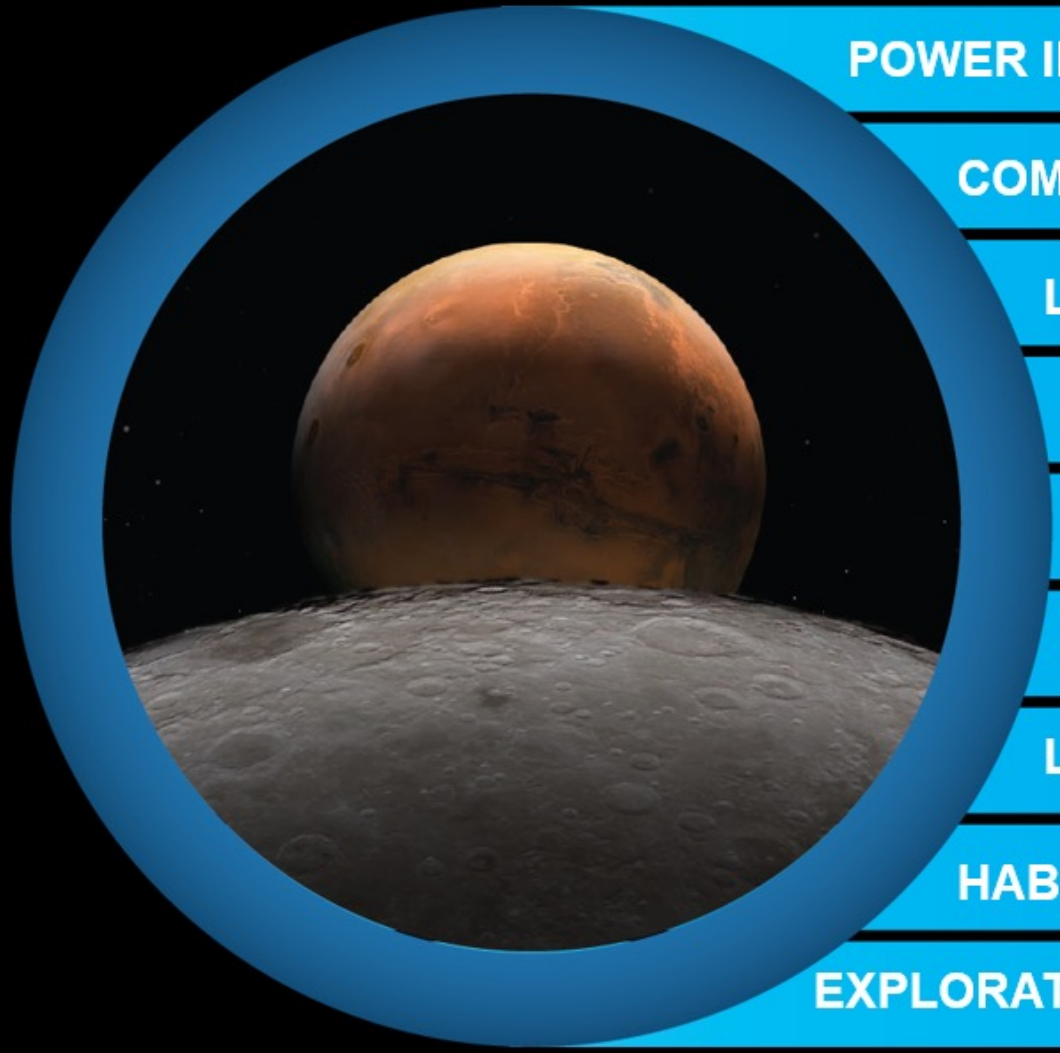
Moon to Mars Architecture "Glossy"
- **Length:** 18 pages
- **Audience:** technically informed – Advisory, legislative, investigative, auditing organizations
- **Purpose:** high-level documentation of M2M architecture and exploration strategy
- **Publication:** nasa.gov
- **Update cadence:** as needed



White Papers
- **Length:** 4-6 pages each
- **Purpose:** document architecture study details on frequently discussed topics
- **Audience:** technically informed – industry, international partners, staffers
- **Publication**: nasa.gov
- **Update cadence:** ACRs and as needed

Areas for Collaboration

The Moon to Mars architecture is flexible, and there are opportunities to contribute, creating opportunity.



- POWER INFRASTRUCTURE AND DISTRIBUTION
- COMMUNICATION AND NAVIGATION
- LUNAR ENVIRONMENT MITIGATION
- ROBOTICS AND MOBILITY
- LOGISTICS
- UTILIZATION OPERATIONS
- LUNAR SAMPLING AND CURATION
- HABITATION AND CREW HEALTH SYSTEMS
- EXPLORATION SYSTEMS AND OPERATIONS ANALOG TESTING

Opportunities to Engage

Provide input during existing interactions including: conference meetings, partner discussions, bi-laterals, etc.

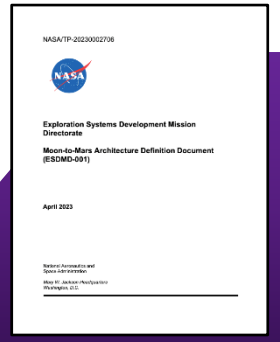
Attend the NASA-led workshops geared toward soliciting feedback on processes and documentation to be held summer of 2023.

Engage with partner professional society workshop opportunities (under development).

Review architecture products at www.nasa.gov/MoonToMarsArchitecture and reach out via e-mails provided.

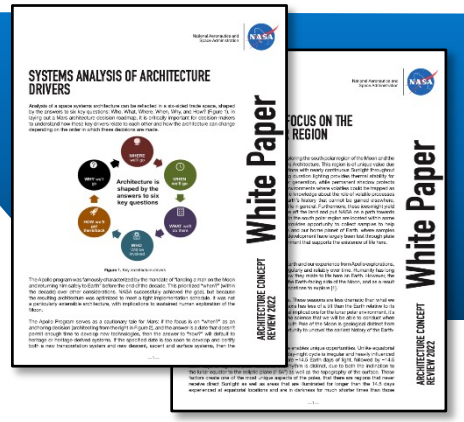
We’re on our way!

Architecture Concept Review Products



Architecture Definition Document
Detailed documentation of a snapshot of NASA's human spaceflight architecture and exploration strategy

Moon to Mars Architecture Summary
High-level overview of NASA's Moon to Mars architecture and exploration strategy



White Papers
Six papers on architecture study details for frequently discussed topics

www.nasa.gov/MoonToMarsArchitecture