May 22, 2023
*M2M Architecture Industry Webinar*
**NASA Headquarters, Washington D.C.**

# NASA's Moon to Mars Architecture:
## *Avenues for Engagement*


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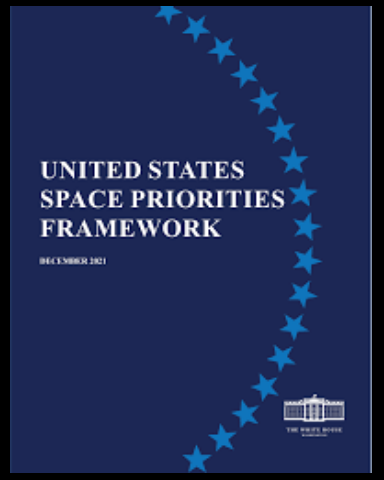
# Deep Space Exploration Priorities

"…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

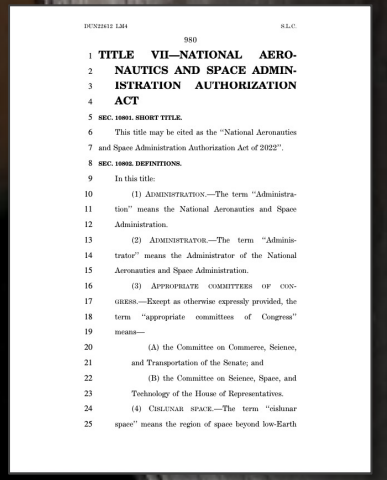

**Space Policy Directive-1**
December 2017


**National Space Council**
March 2019

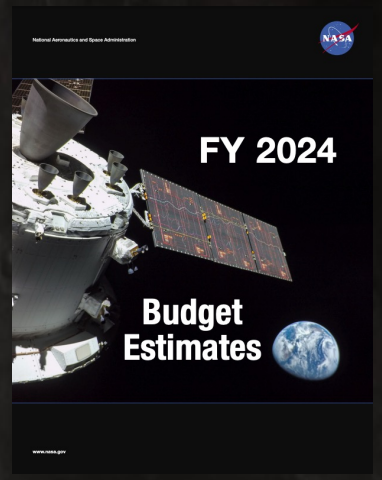



**Space Priorities Framework**
December 2021


**NASA Strategic Plan**
March 2022




**NASA Authorization Act**
July 2022

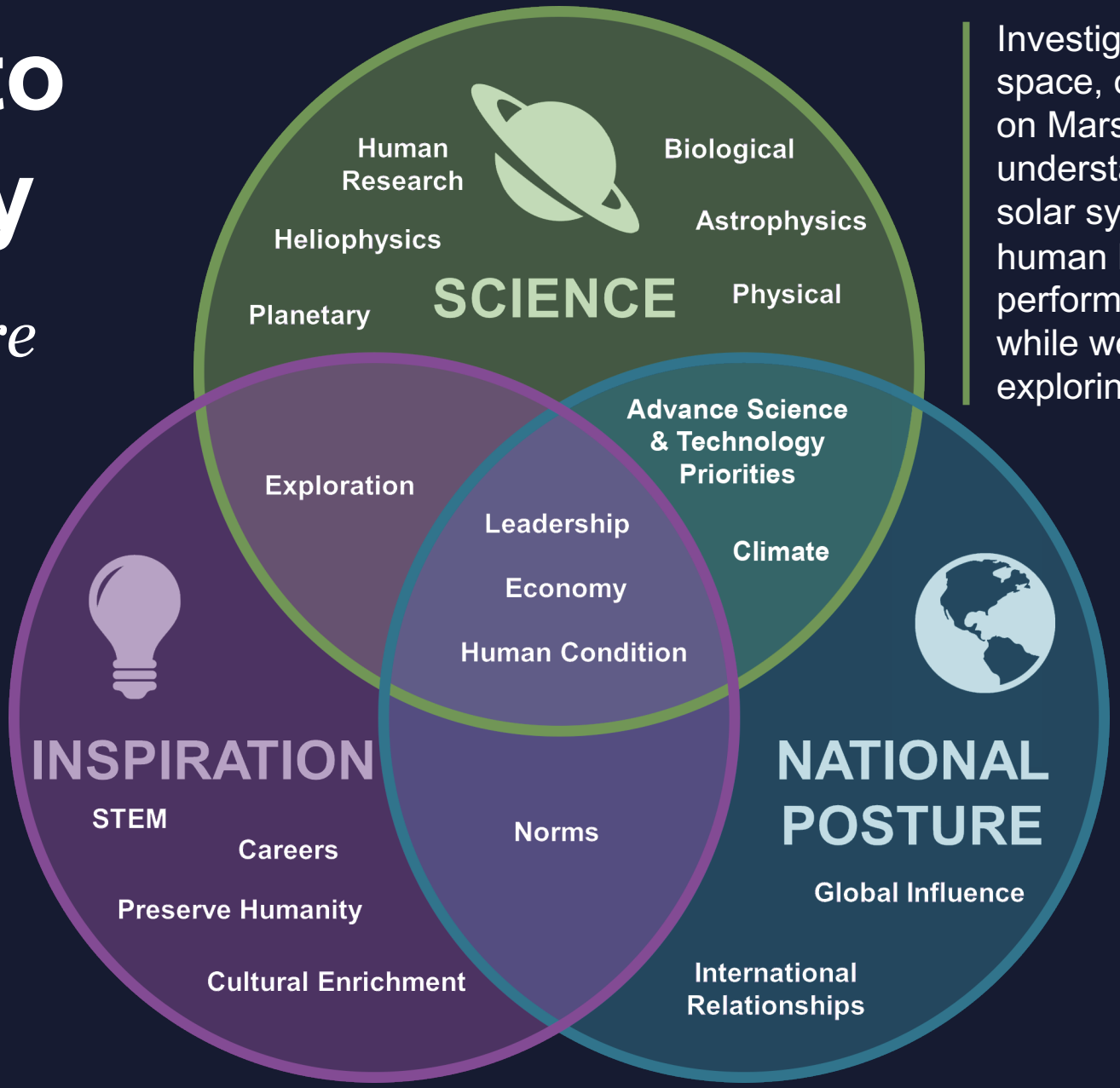



**President's Budget Request**
March 2023

# 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

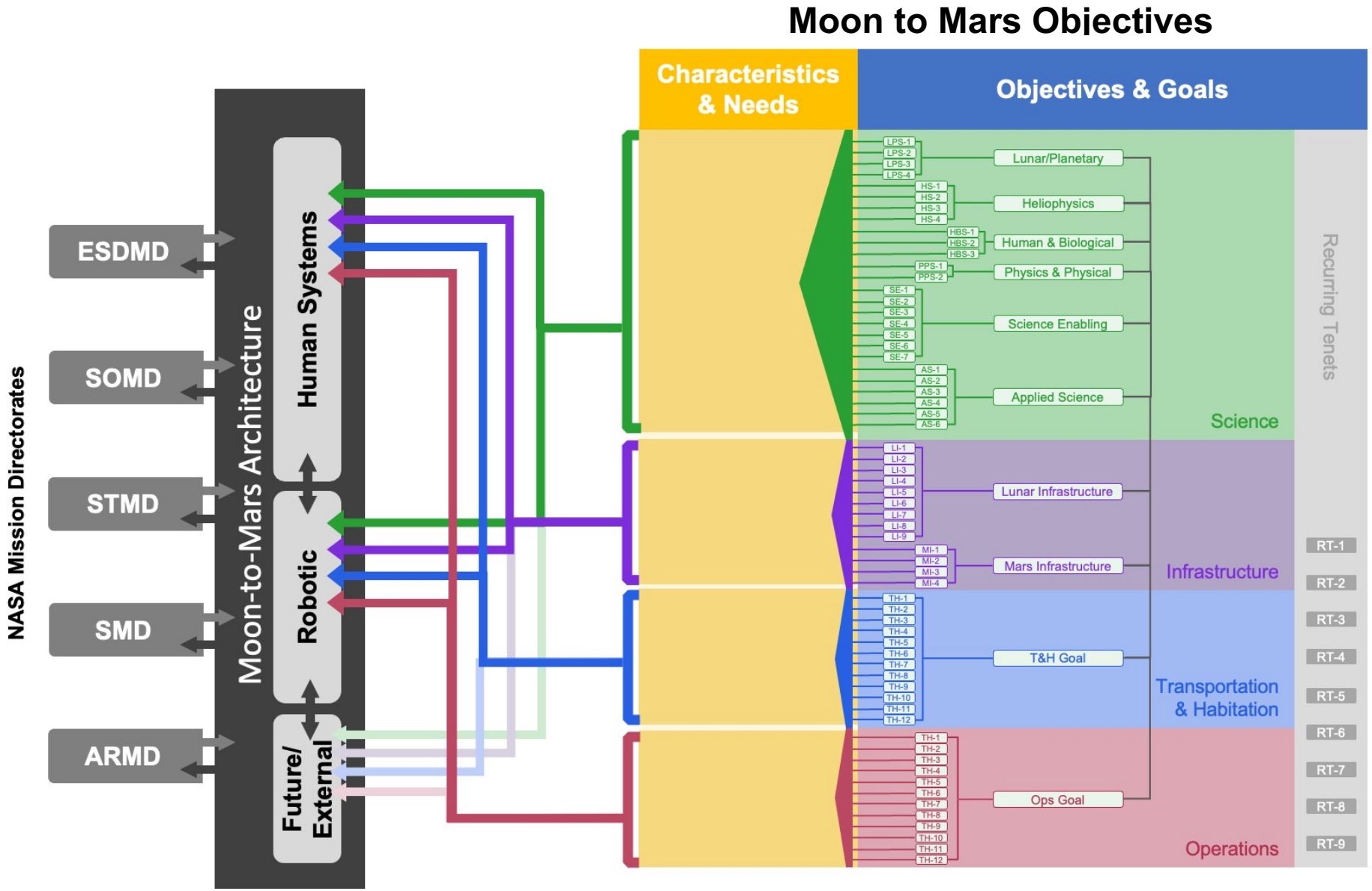
- **SCIENCE**
- **TRANSPORTATION AND HABITATION**
- **LUNAR AND MARS INFRASTRUCTURE**
- **OPERATIONS**


go.nasa.gov/3zzSNhp

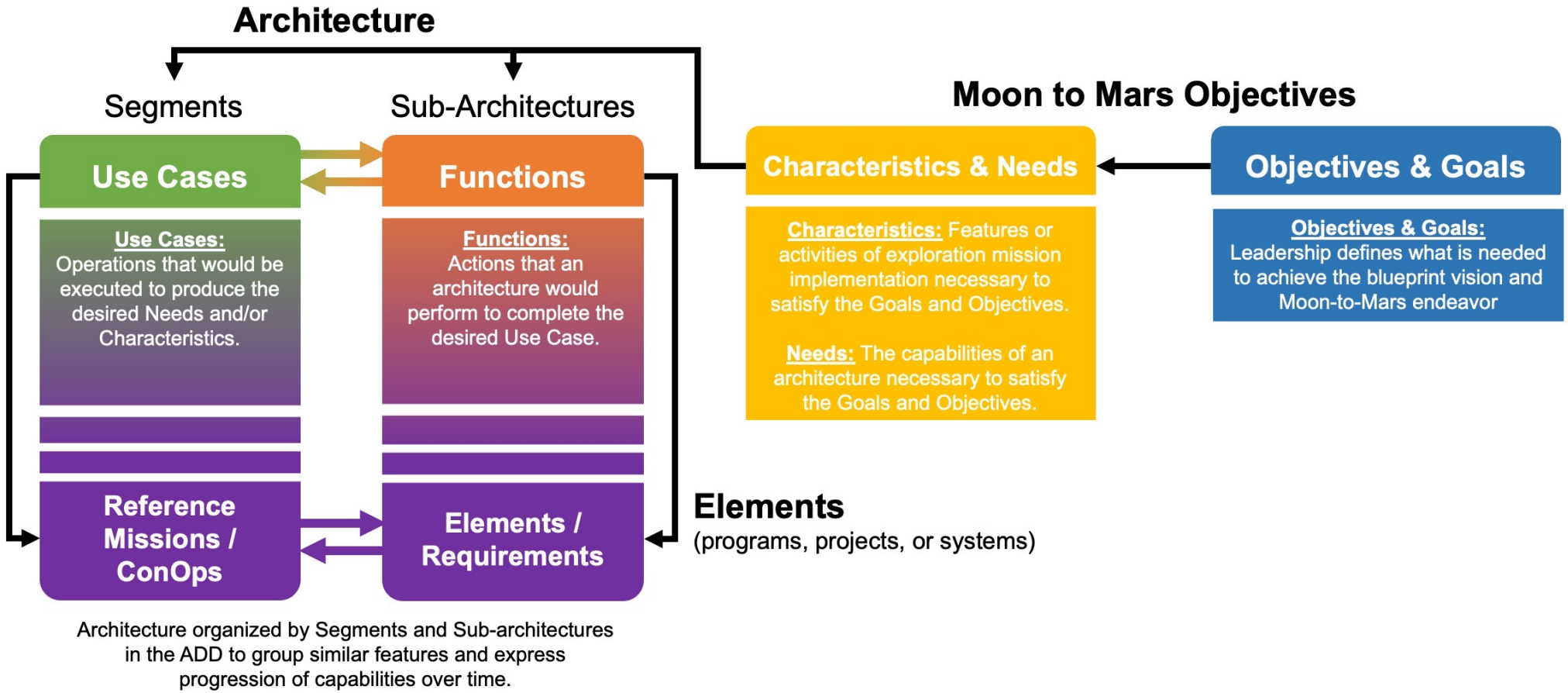
Requested feedback on these objectives in summer 2022 from the following key stakeholders:

- 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



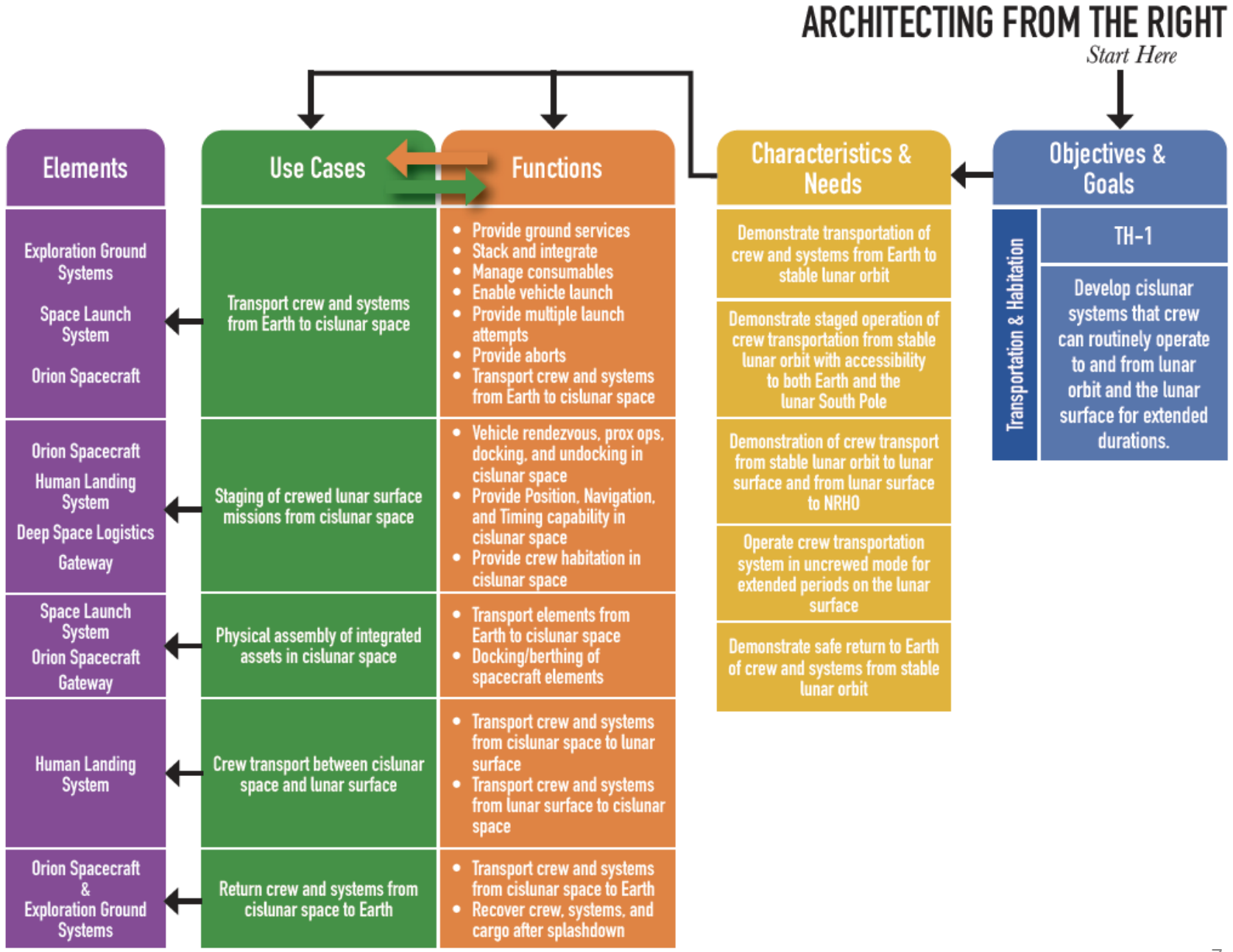
# Architecting from the Right



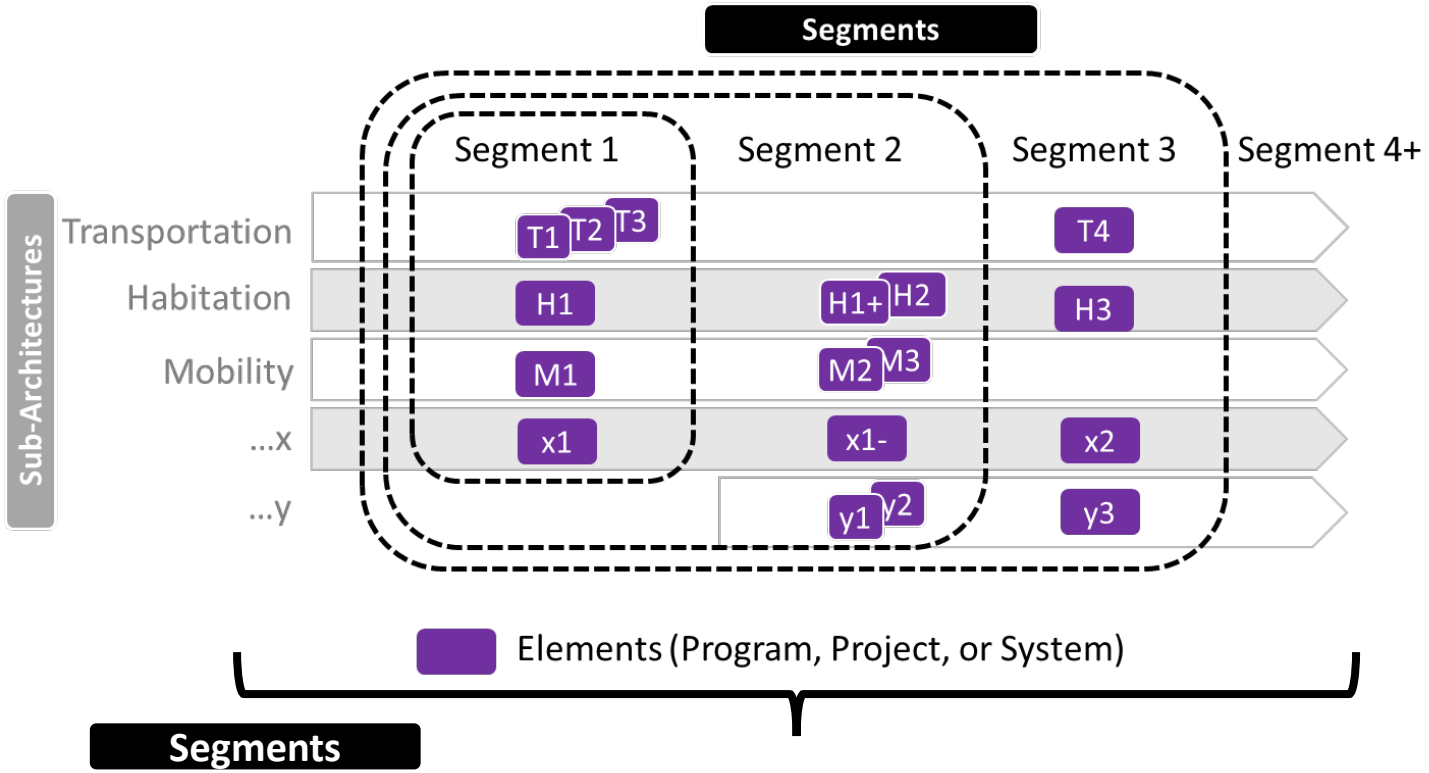

The Architecture process requires a decomposition of Moon to Mars Objectives to element functions and mission use cases to complete the process of "architecting from the right." This establishes the relationship of executing programs and projects to the driving goals and objectives.

# Example Objective Decomposition

Example of the full distillation of the objectives into lunar-specific Use Cases, Functions, and Elements for the *Human Lunar Return* segment using one of 12 Transportation and Habitation Objectives.



# Architecture Framework




**Sub-Architectures**

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

Ex: Transportation Systems: Contain common functions (e.g. RPOD) & need to ensure end-to-end allocation for crew transport from Earth to destinations to safe return

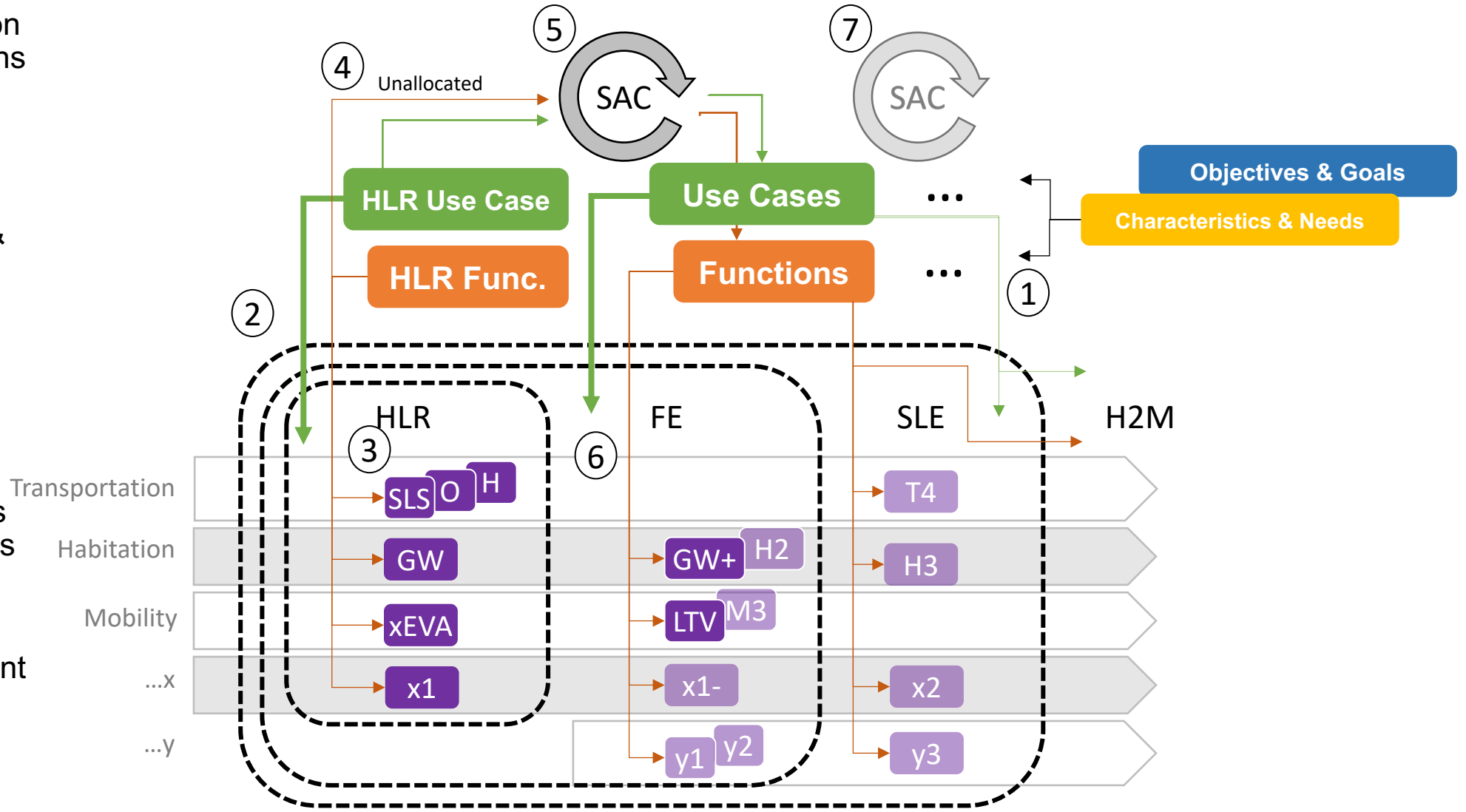
**Segments**

**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.**

Ex: Human Lunar Return integrated use case similar to current Artemis IV operations

# Architecture Iteration Process

1. Objectives decomposition to Use Cases & Functions
2. Element allocations and traceability performed to initial Segment (HLR)
3. Program requirements & ConOps implement allocated architecture needs
4. Unallocated functions (gaps) re-enter SAC process
5. SAC trades and analysis identify element solutions or definition of new program/projects
6. Definition of next segment and included elements begins
7. Repeat



# 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.

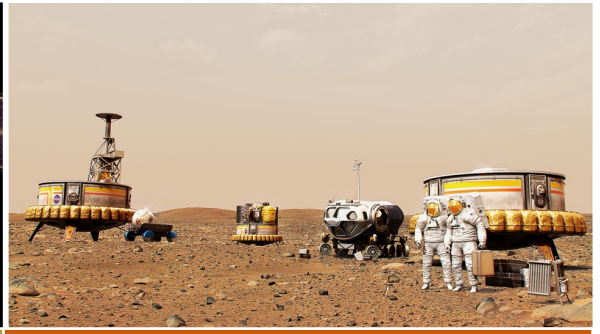
**Focus for ACR 22**

**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**

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**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

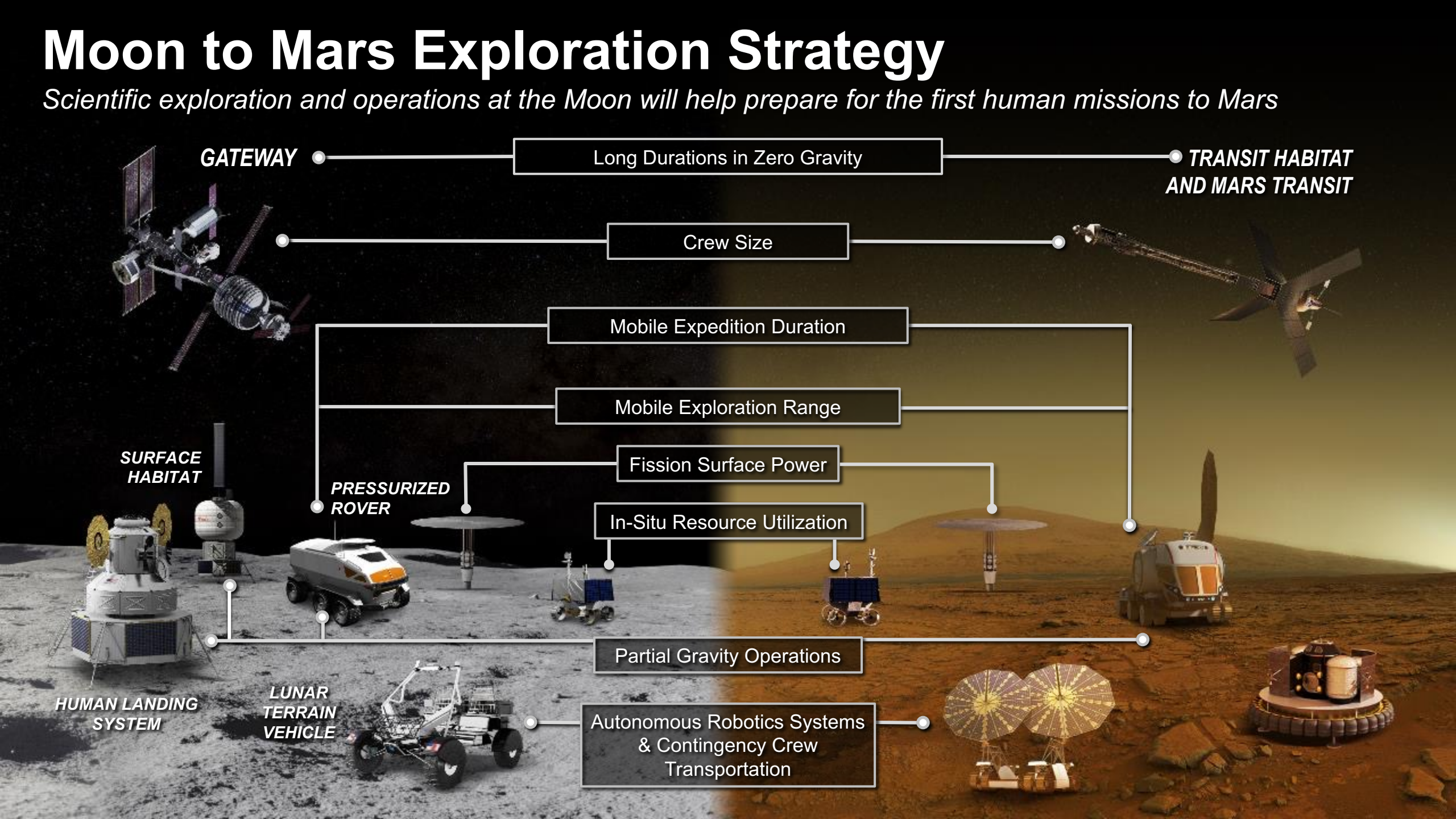
HUMAN LANDING SYSTEM

COMM, POSITIONING, NAV, TIMING (CPNT)

COMMERCIAL LUNAR PAYLOAD SERVICES

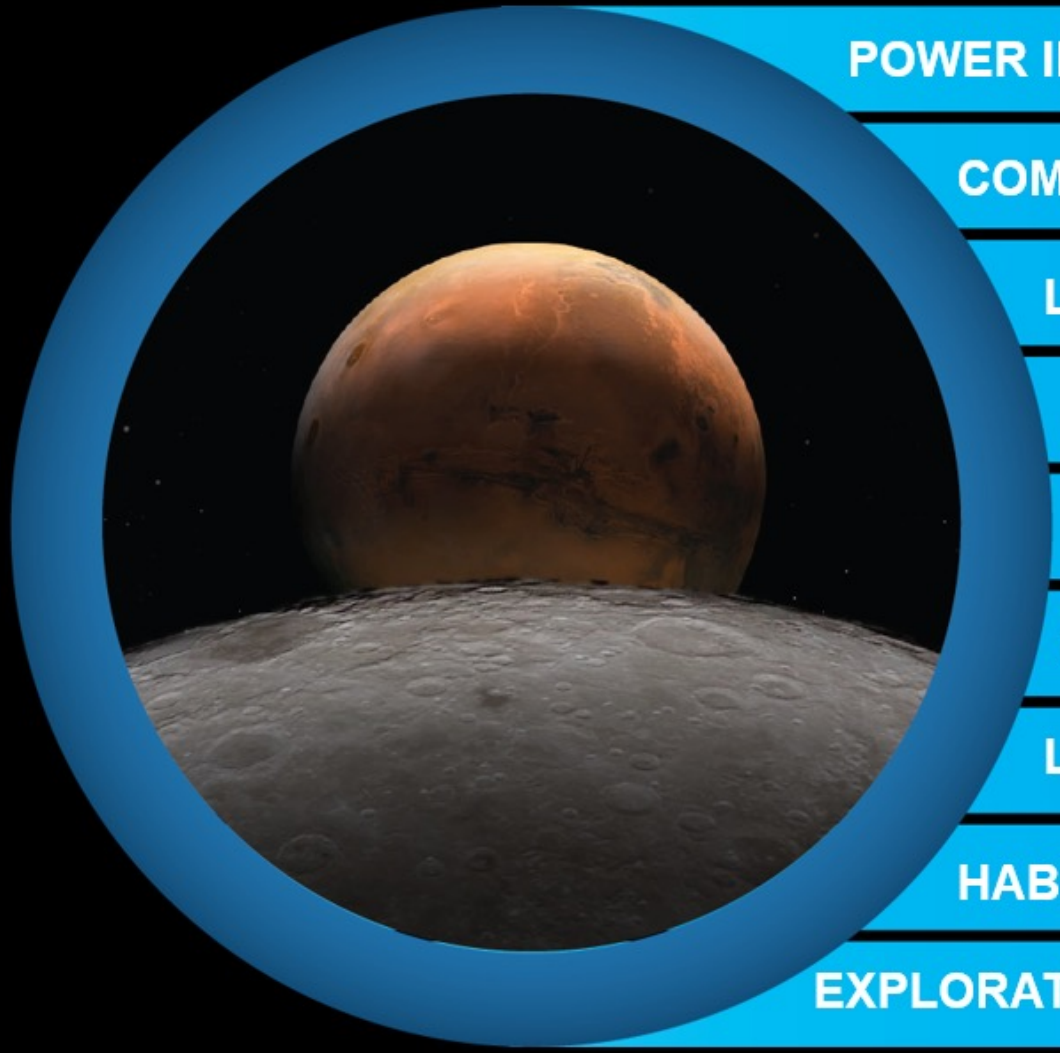
# Moon to Mars Exploration Strategy

*Scientific exploration and operations at the Moon will help prepare for the first human missions to Mars*



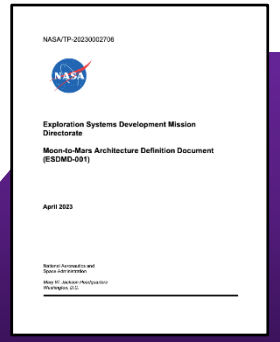
# Areas for Collaboration

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



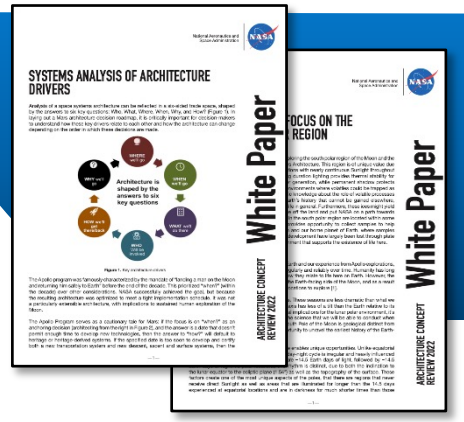
- POWER INFRASTRUCTURE AND DISTRIBUTION
- COMMUNICATION AND NAVIGATION
- LUNAR ENVIRONMENT MITIGATION
- ROBOTICS AND MOBILITY
- LOGISTICS
- UTILIZATION OPERATIONS
- LUNAR SAMPLING AND CURATION
- HABITATION AND CREW HEALTH SYSTEMS
- EXPLORATION SYSTEMS AND OPERATIONS ANALOG TESTING

# 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

# Engagement and Feedback

- The Moon-to-Mars architecture will be continually refined based on the development of our current programs, inputs from U.S. commercial and academic space communities, international partners, other stakeholders, and ongoing work to increase detail on the architecture products.
- A NASA-led in-person workshop is planned for June 27th – 28th. It will be geared toward soliciting feedback via small group discussions from U.S. commercial and academia on the Moon-to-Mars architecture processes and documentation. The location of the workshop will be in the greater D.C. area.
- Stakeholders can also provide feedback through nasa.gov/MoontoMarsArchitecture and during existing interactions, including conference meetings and partner discussions.

# Questions and Answers


www.nasa.gov/MoonToMarsArchitecture

National Aeronautics and Space Administration