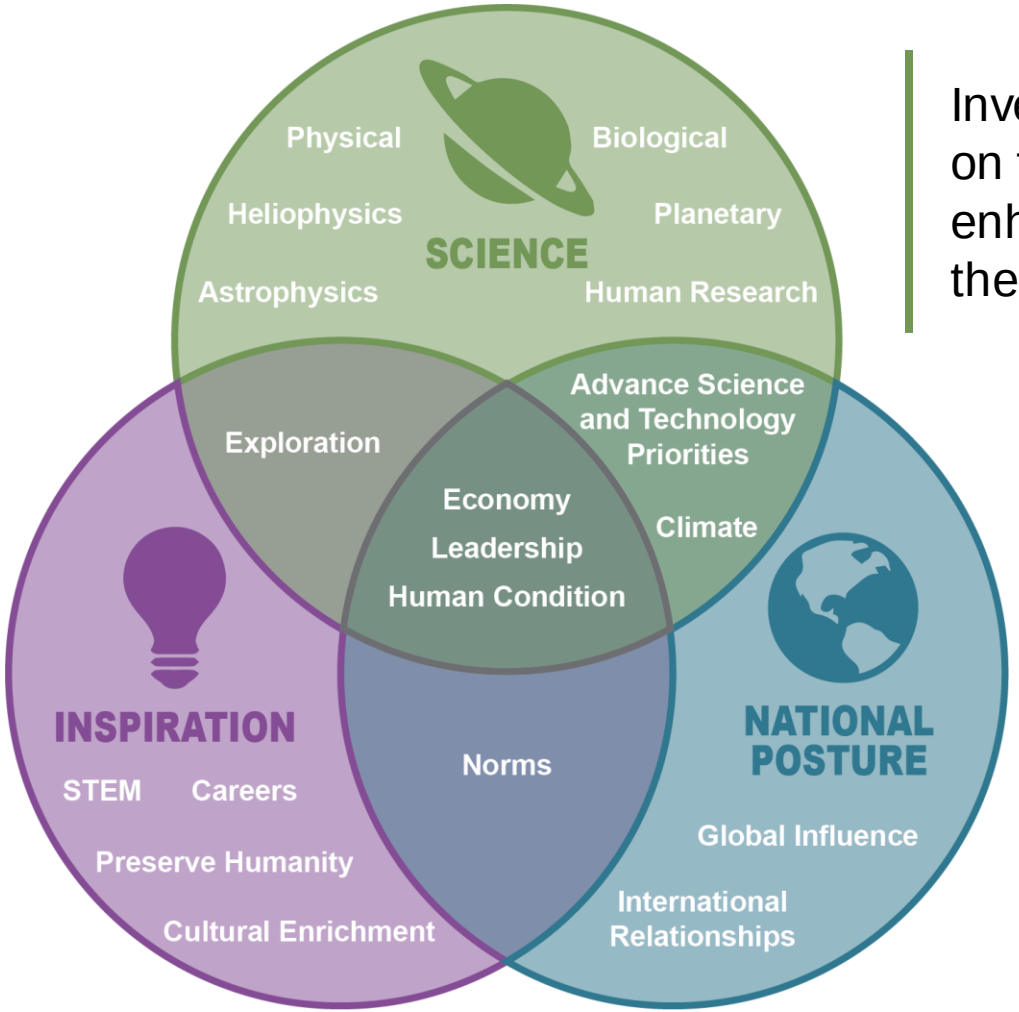
National Aeronautics and Space Administration

Moon to Mars Architecture Overview and Updates

Why Go?

Accepting audacious challenges motivates current and future generations to contribute to our voyage deeper into space.



Investigations in deep space, on the Moon, and on Mars will enhance our understanding of the universe and our place in it.

What is done, how it's accomplished, and who participates affect our world, quality of life, and humanity's future.

Moon to Mars Objectives

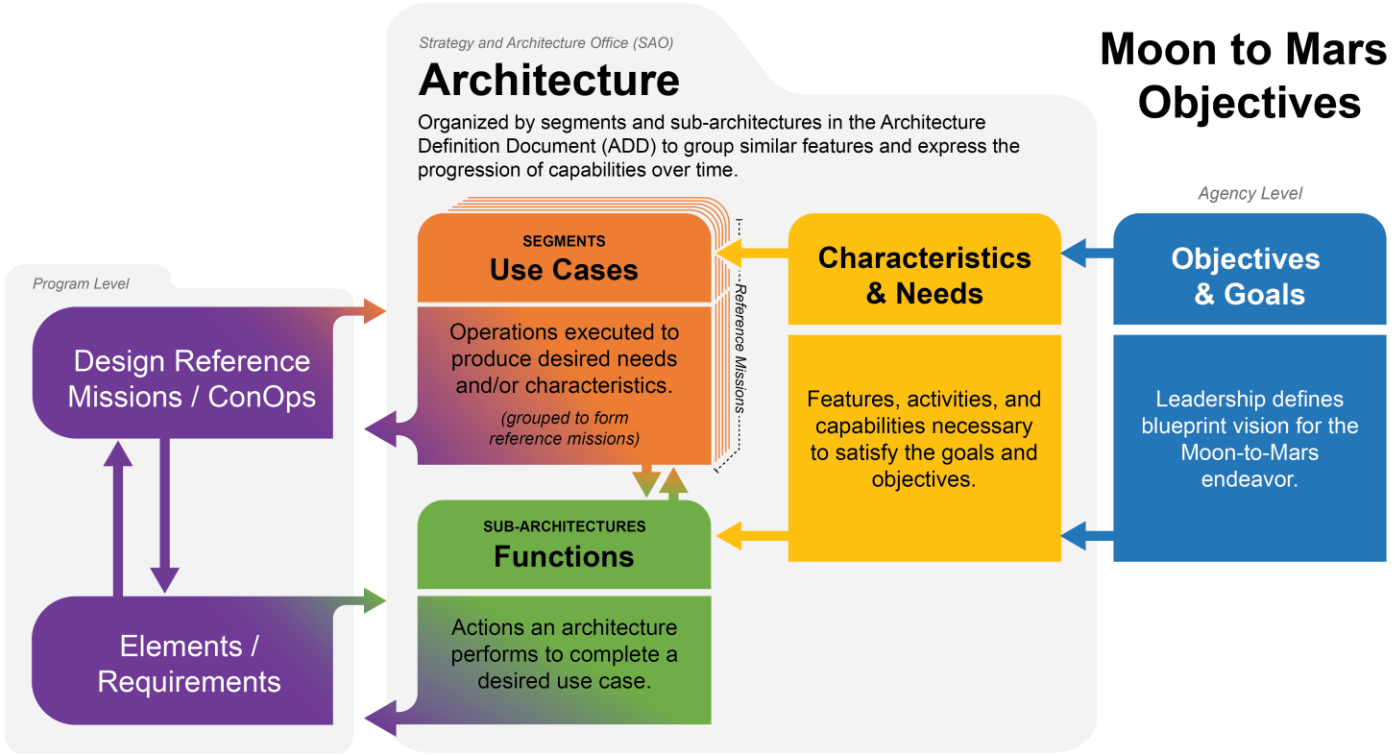
NASA's Moon to Mars Objectives document a systems engineering approach to crewed deep space exploration.

In contrast to a capabilities-based approach, an objectives-based approach focuses on the big picture, the "what" and "why," before prescribing the "how."

The methodology for the Moon to Mars Objectives is guided by five inter-related principles:

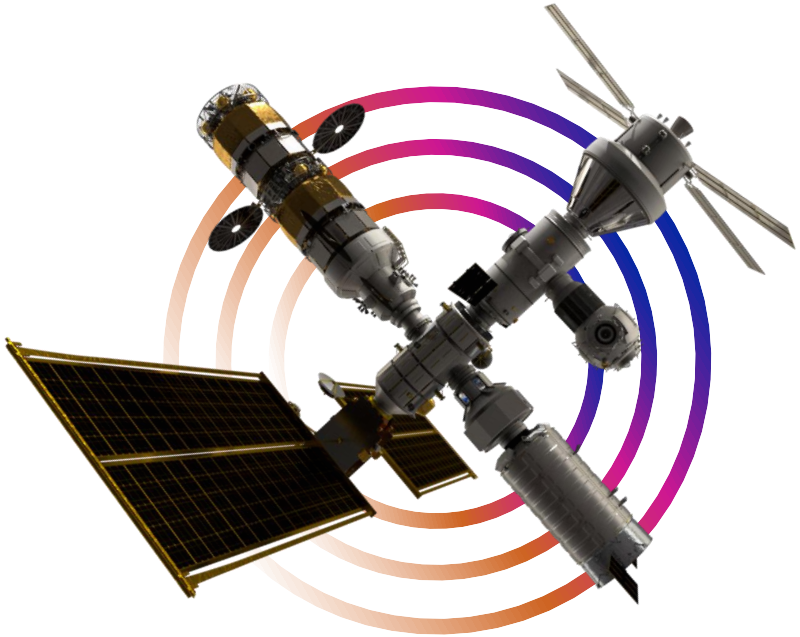
- **Objectives-based Approach**
- **Constancy of Purpose**
- **Enhanced Communication and Engagement**
- **Unity of Purpose**
- **Architect from the Right Execute from the Left**

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.

Architecture Components

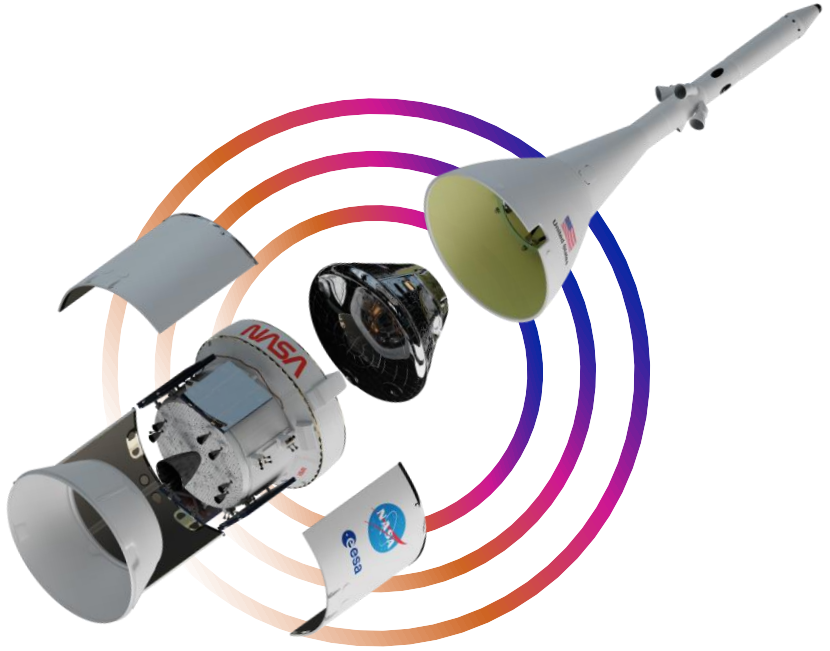


Segments

A portion of the architecture that integrates sub-architectures and progressively increases in complexity and objective satisfaction.

Sub-Architectures

A group of tightly coupled elements, functions, and capabilities that work together to accomplish one or more objectives.



Elements

A notional exploration system that enables a set of functions.

Architecture Segments

Human Lunar Return

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

Foundational Exploration

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

Sustained Lunar Evolution

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

Future Segments

Humans to Mars

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

Sub-architectures

Communications, Navigation, Positioning, and Timing Systems
enable transmission and reception of data, determination of location and orientation, and acquisition of precise time.

Habitation Systems
ensure the health and performance of astronauts in controlled environments.

Human Systems
execute human and robotic missions; this includes crew, ground personnel, and supporting systems.

Logistics Systems
package, handle, transport, stage, store, track, and transfer items and cargo.

Mobility Systems
move crew and cargo around the lunar and Martian surfaces.

Power Systems
generate, store, condition, and distribute electricity for architectural elements.

Transportation Systems
convey crew and cargo to and from Earth to the Moon and Mars.

Utilization Systems
enable science and technology demonstrations.

NEW for 2023

Data Systems and Management
transfer, distribute, receive, validate, secure, decode, format, compile, and process data and commands.

In-situ Resource Utilization (ISRU) Systems
extract resources in space or on the Moon or Mars to generate products.

Infrastructure Support
includes facilities, systems, operations planning and control, equipment, and services needed on Earth, in space, and on planetary surfaces.

Autonomous Systems and Robotics
employ software and hardware to assist the crew and operate during uncrewed periods.

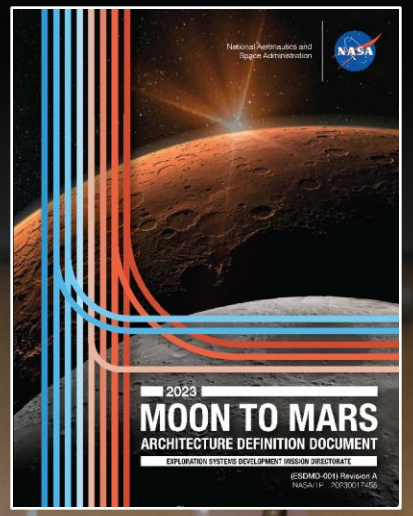
ACR23 Updates

ACR23 Products

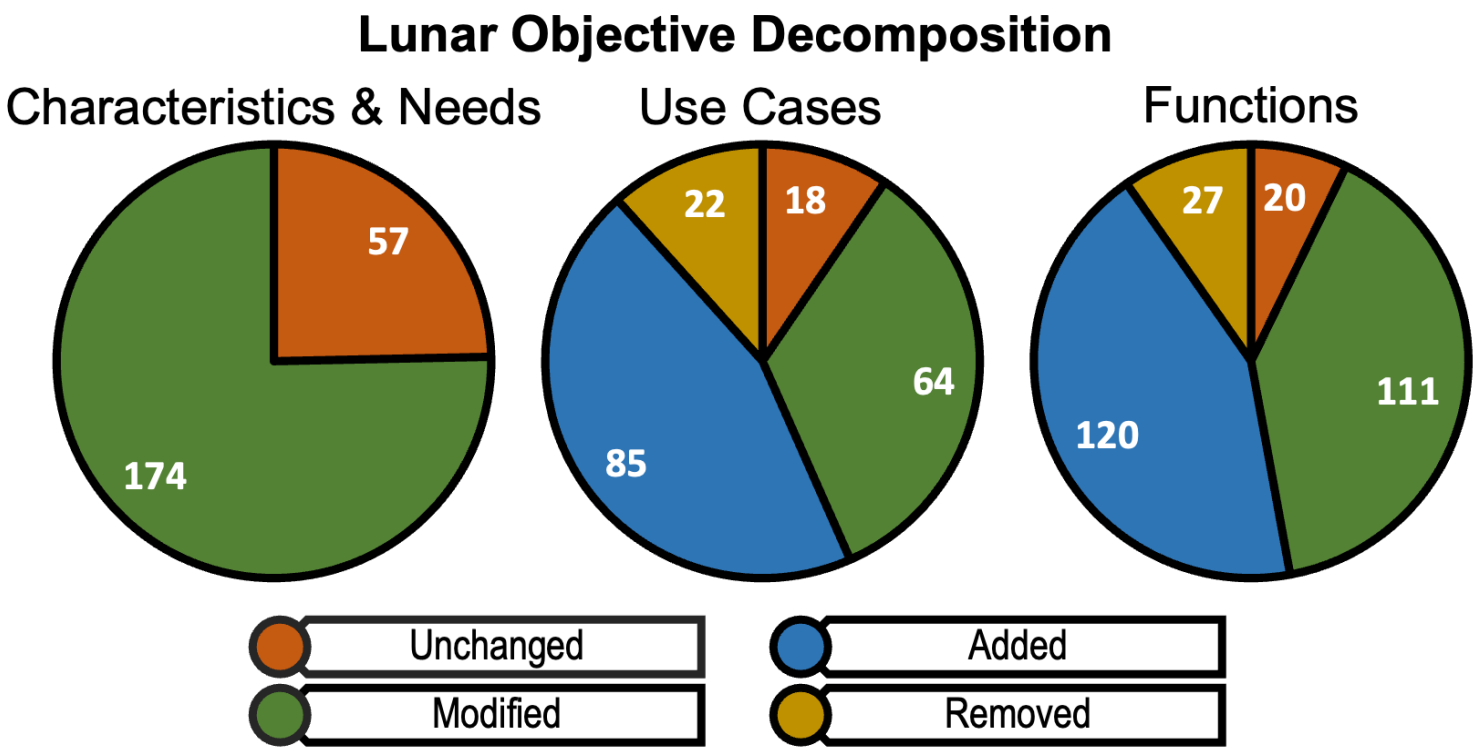
Architecture Definition Document - Revision A

Moon to Mars Architecture Executive Overview

13 White Papers



Decomposition Updates

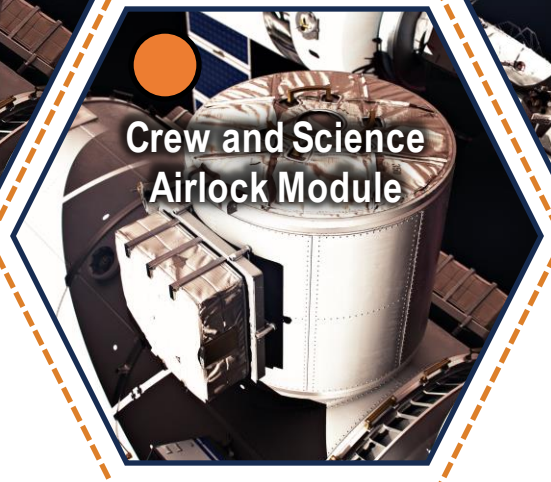


ADD Rev-A includes refined and expanded Moon to Mars objective decomposition, sub-architectures, and elements

Added, refined, removed, or modified characteristics and needs, use cases, and functions for lunar objectives

179 characteristics and needs added for Mars objectives

New Elements



- Canadian Space Agency
- European Space Agency
- United Arab Emirates

The United Arab Emirates Implementing Arrangement was signed shortly after ACR23. The collaboration will be included in ADD Rev-B during ACR24.

White Papers

- Surface EVA Architectural Drivers
- Lunar Logistics Drivers and Needs
- Lunar Communications and Navigation Architecture
- Lunar Site Selection
- Analytical Capabilities In-situ vs. Returned
- Safe and Precise Landing at Lunar Sites
- Mars Communication Disruption and Delay
- Mars Mission Abort Considerations
- Mars Surface Power Generation
- Mars Priority Decisions
- Round Trip Mars Mission Mass Challenges
- Human Health and Performance for Mars Missions
- Exploration Lessons Learned from the Space Station

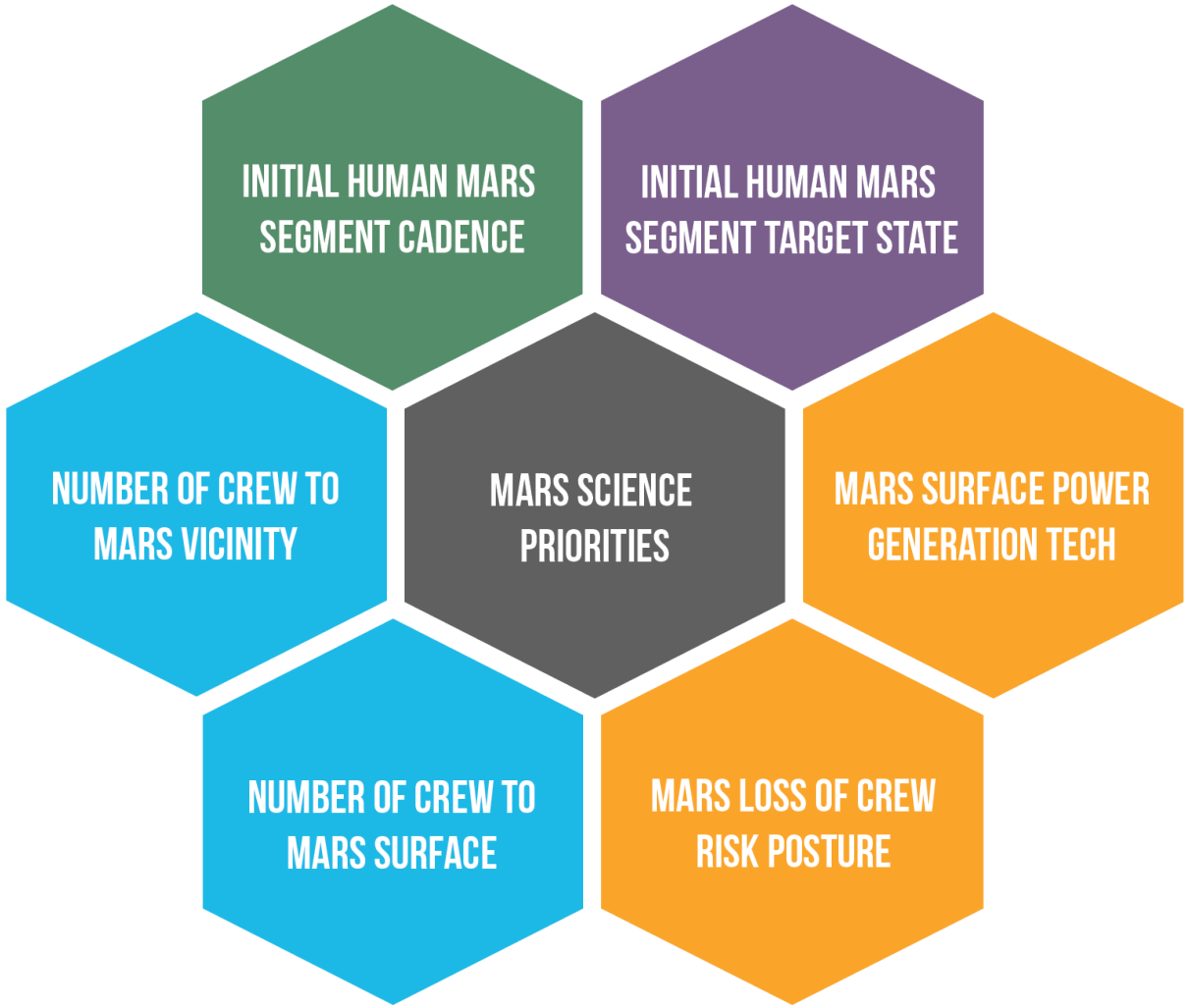
Suggestion from 2023 Architecture Workshops

White paper added after ACR23 Concurrence

Mars Priority Decisions

NASA catalogued nearly 90 needed decisions for an initial crewed Mars mission and developed a decision roadmap. That process resulted in seven interrelated decisions needed to begin planning.

In 2024, NASA has begun analyses needed to allow for informed decision-making by agency leadership.



Architecture Concept Review Process

An Evolutionary Architecture Process

Formulating an Architecture and Exploration Strategy Based on Objectives

TRACEABILITY

Decomposition of Blueprint Objectives to executing Architecture elements

ARCHITECTURE FRAMEWORK

Organizational construct to ensure system/element relationships are understood and gaps can be identified

PROCESS AND PRODUCTS

Clear communication and review integration paths for stakeholders

Forward Work

The 2024 Strategic Analysis Cycle (SAC24) will focus on:

- Addressing Human Lunar Return and Foundational Exploration segment gaps, including lunar logistics, large cargo return, conceptual reference missions, and cargo offloading/relocation.
- Performing strategic analysis for segment sub-architectures, including surface communication, large-scale mobility, power systems, in-situ resource utilization (ISRU), and ingress/egress strategies.
- Developing decision packages for initial seven Mars exploration decisions and continuing progress on other Mars trade studies.