Moon to Mars Architecture Process Overview

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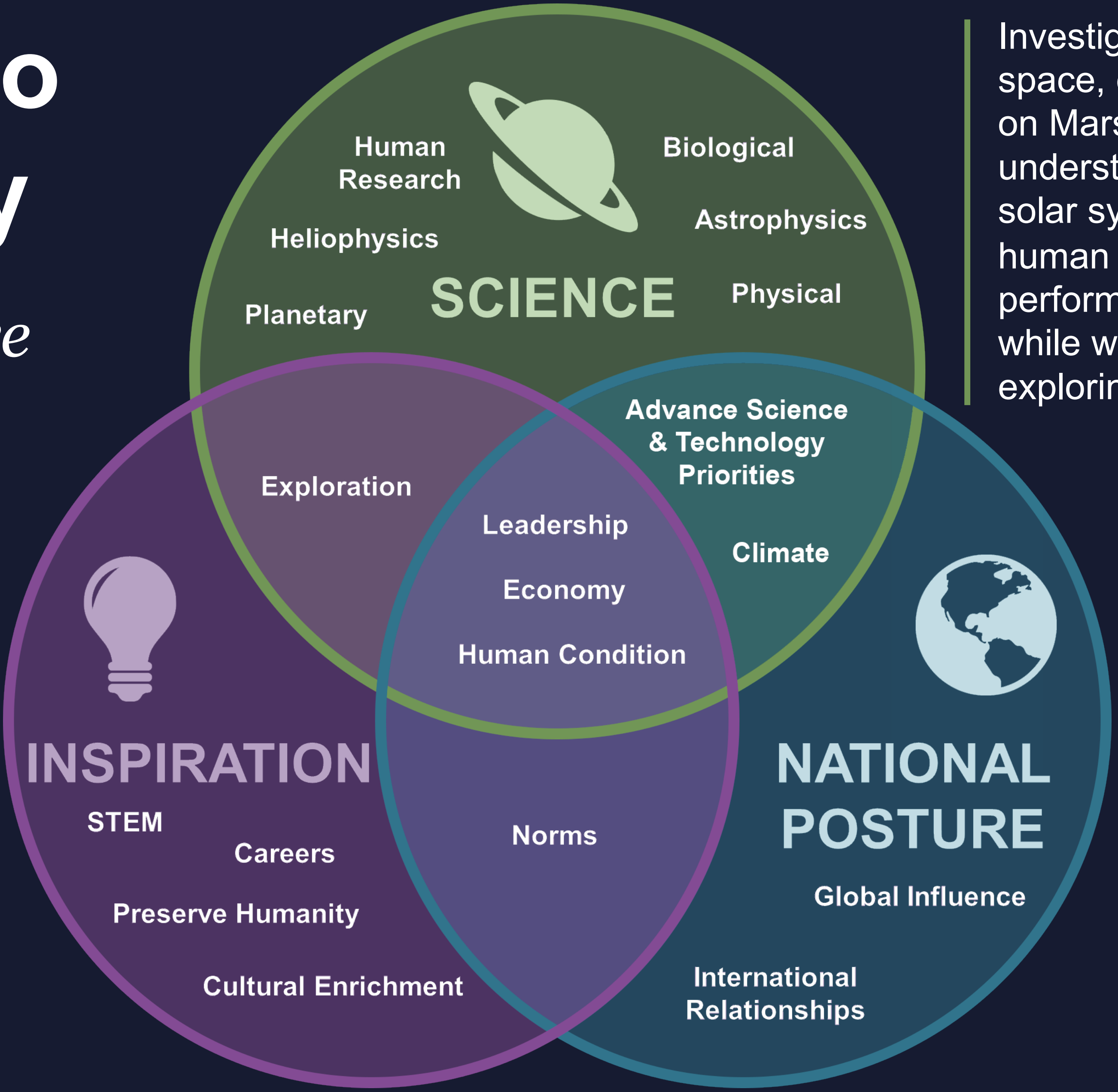
Benefits to Humanity

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.

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

WHEN WILL WE ACHIEVE LUNAR OBJECTIVES?

Multi-decadal campaign
Support annual cadence of crewed missions
Development of permanent infrastructure
Expansion of economic sphere to the Moon

WHO DOES THIS APPROACH INCLUDE?

NASA
U.S. Government
Industry
International Partners
Academia
Public

WHAT FOUNDATIONAL CAPABILITIES ARE NEEDED?

Long-duration microgravity systems
Partial gravity destination platforms
Low Earth Orbit assets and infrastructure

WHERE SHOULD SYSTEMS BE?

Ensure access to the lunar South Pole
Capability for non-polar expeditions

HOW WILL WE GET THERE AND RETURN?

Lunar Microgravity staging in NRHO
Earth ⟷ NRHO ⟷ Lunar surface
Surface mobility

WHY EXPLORE?

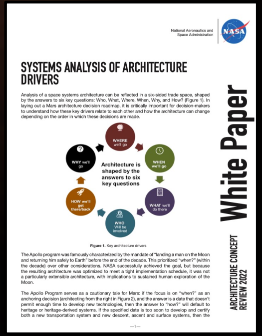
—SCIENCE—
Understand the universe
Direct observations

—INSPIRATION—
"Artemis Generation"
Overcome challenges
Succeed with hard work

—NATIONAL POSTURE—
Enrich lives on Earth
Technology development
International partnerships

ACR 22 White Papers

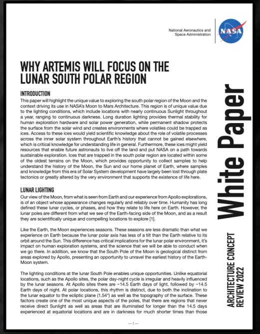
Systems Analysis of Architecture Drivers


SYSTEMS ANALYSIS OF ARCHITECTURE DRIVERS

White Paper

ARCHITECTURE CONCEPT REVIEW 2022

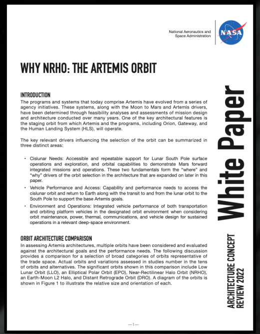
Why Artemis Will Focus on the Lunar South Polar Region


WHY ARTEMIS WILL FOCUS ON THE LUNAR SOUTH POLAR REGION

White Paper

ARCHITECTURE CONCEPT REVIEW 2022

Why NRHO: The Artemis Orbit


WHY NRHO: THE ARTEMIS ORBIT

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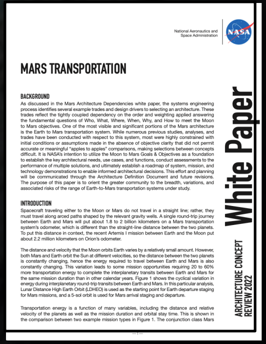
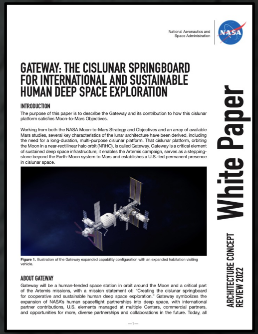
Mars Transportation


MARS TRANSPORTATION

White Paper

ARCHITECTURE CONCEPT REVIEW 2022

Gateway: The Cislunar Springboard


GATEWAY: THE CISLUNAR SPRINGBOARD FOR INTERNATIONAL AND SUSTAINABLE HUMAN DEEP SPACE EXPLORATION

White Paper

ARCHITECTURE CONCEPT REVIEW 2022

Mars Forward Capabilities to Be Tested at the Moon


MARS FORWARD CAPABILITIES TO BE TESTED AT THE MOON

White Paper

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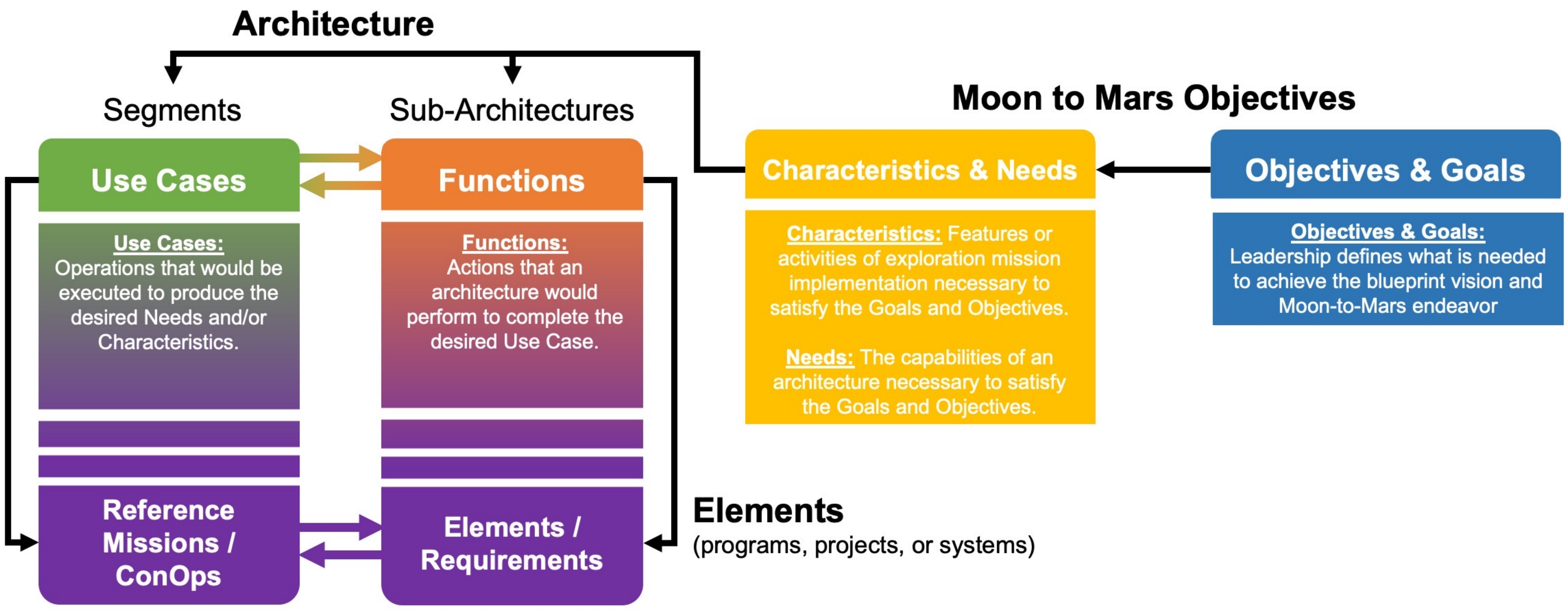
Key Components of the Approach

Component	Rationale	Implementation
Traceability	Decomposition of Blueprint Objectives to executing Architecture elements	Characteristics & Needs Use Cases/ Functions
Architecture Framework	Organizational construct to ensure system/element relationships are understood and gaps can be identified	Sub-Architectures Campaign Segments
Process & Products	Clear communication and review integration paths for stakeholders	ADD Strategic Analysis Cycle Arch. Concept Reviews

Architecting from the Right

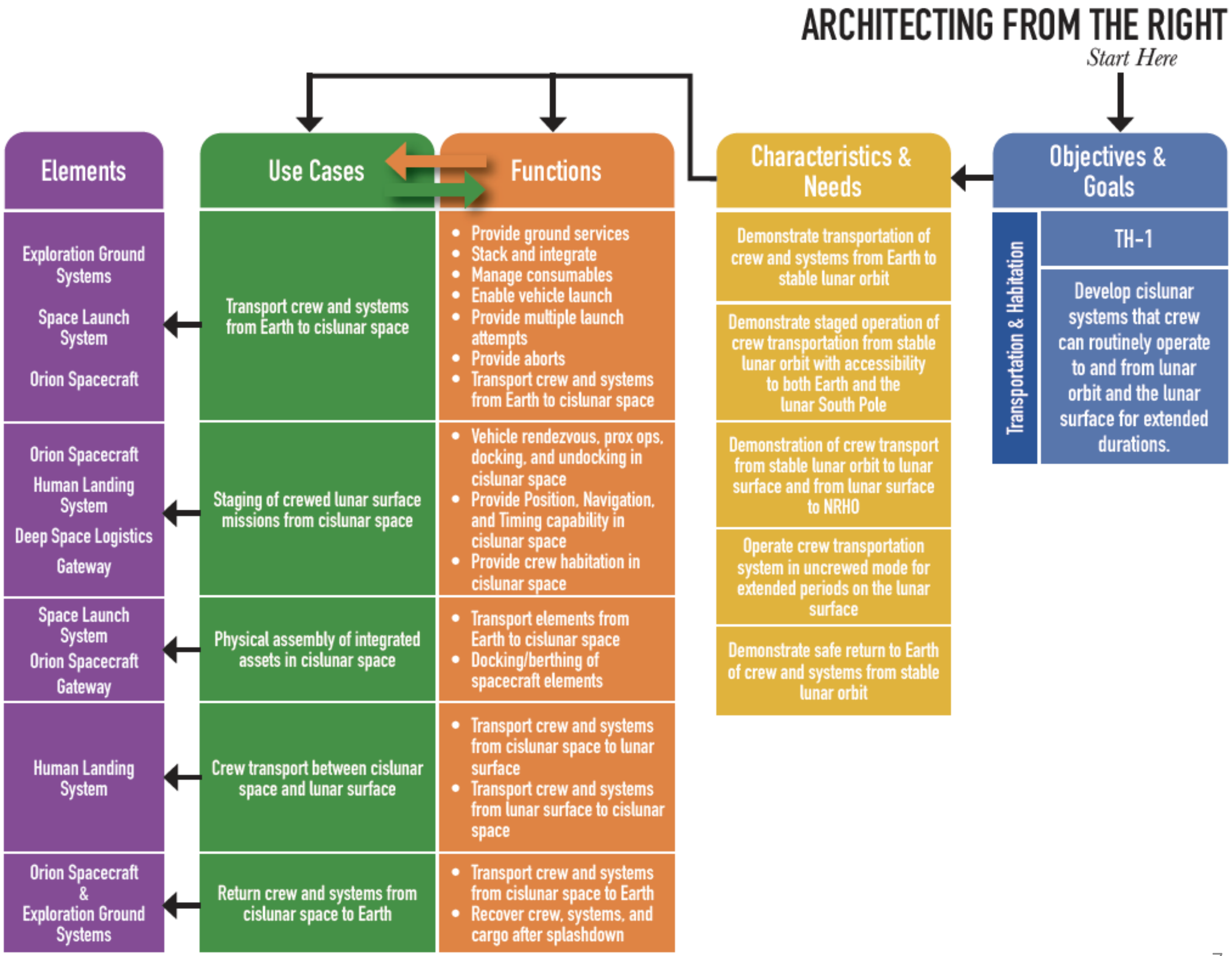


Architecture organized by Segments and Sub-architectures in the ADD to group similar features and express progression of capabilities over time.

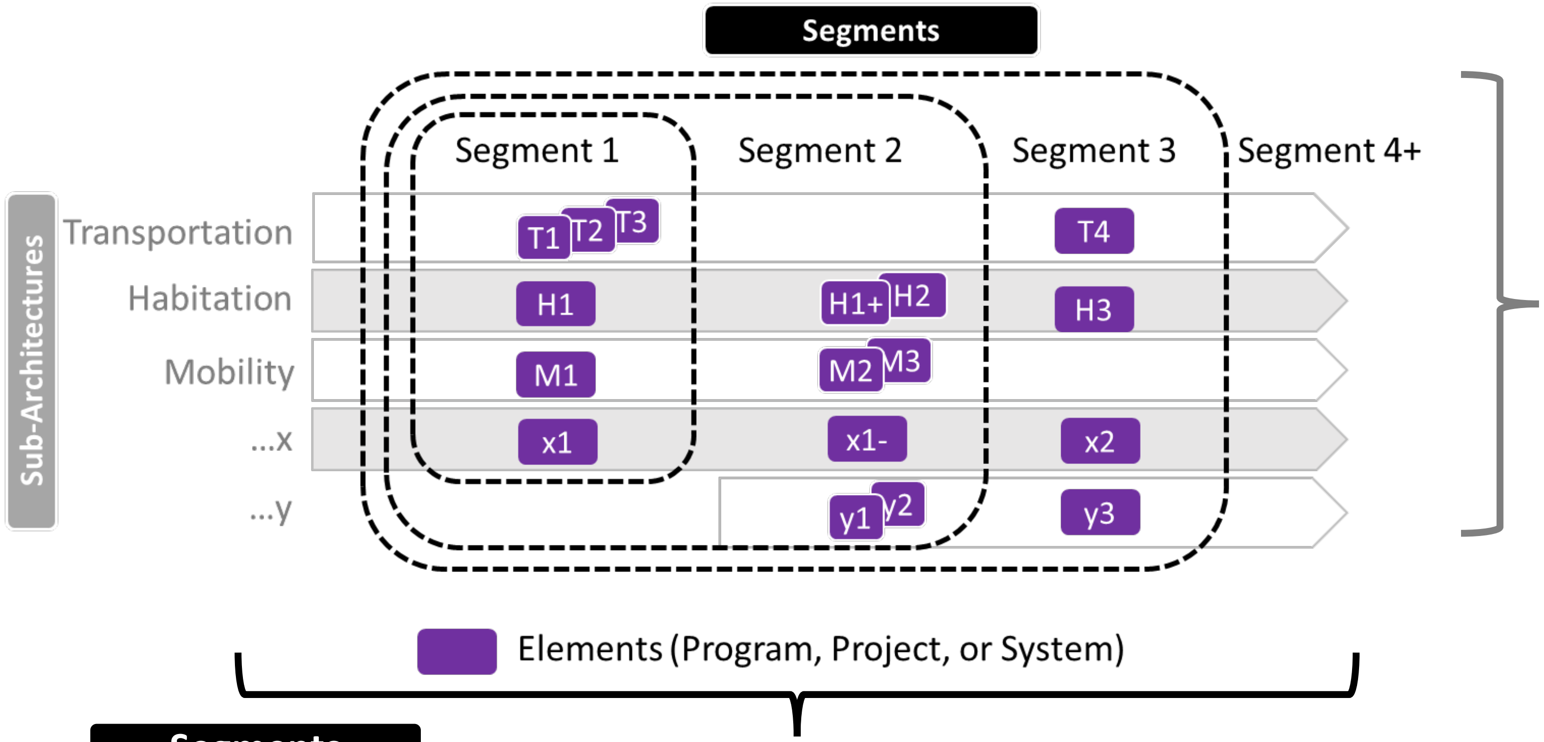
The Architecture process requires a decomposition of Moon to Mars Objectives to element functions and mission use cases to complete the process of “architecting from the right.” This establishes the relationship of executing programs and projects to the driving goals and objectives.

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

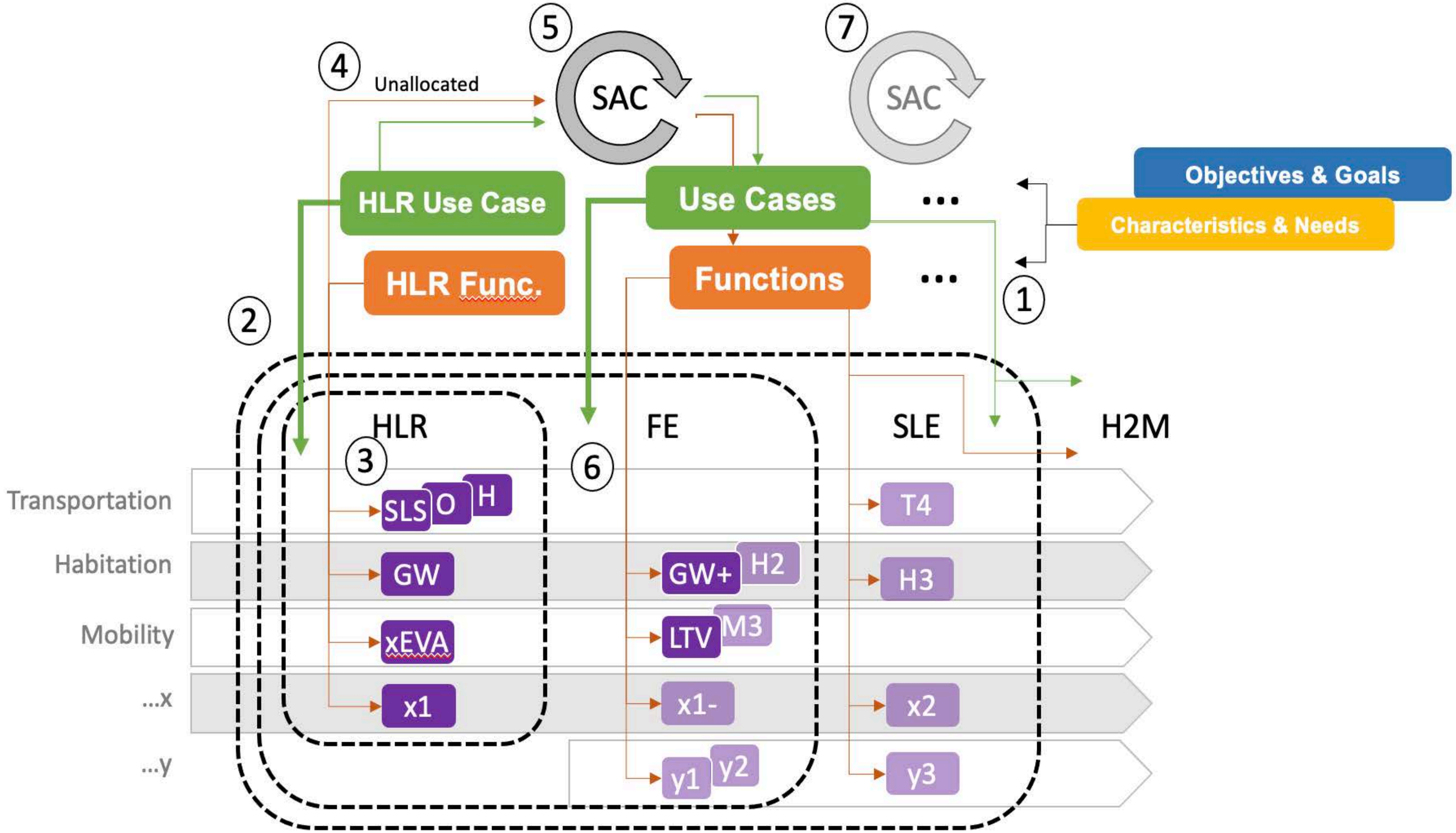
A portion of the architecture, identified by one or more notional missions or integrated use cases, illustrating the interaction, relationships, and connections of the sub-architectures through progressively increasing operational complexity and objective satisfaction.

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

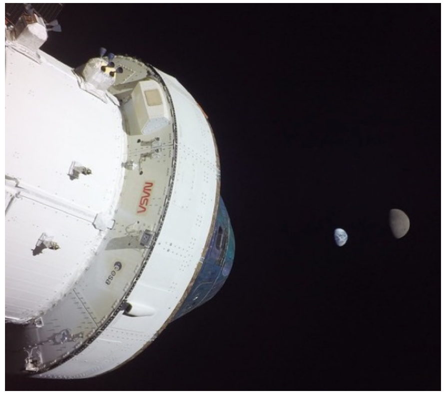


Initial Sub-Architectures

Communication, Positioning, Navigation, and Timing	A group of services that enable the sending or receiving of information, ability to accurately and precisely determine location and orientation, capability to determine current and desired position, and the ability to acquire and maintain accurate and precise time from a standard.
Habitation	A group of capabilities that provide controlled environments to ensure crew health and comfort.
Human Systems	The overall capabilities of onboard and ground personnel and systems required to develop and execute safe and successful crewed and uncrewed missions
Logistics	Systems and capabilities needed for packaging, handling, staging and transfer of logistics goods, including equipment, materials, supplies, and Environmental Control and Life Support System consumables.
Mobility Systems	A group of capabilities and functions that enables the robotic-assisted mobility of crew and/or cargo on and around the surface of the destination including extravehicular activity systems.
Power	Capabilities that support the function of providing electrical energy to architectural elements. These capabilities include components and hardware for power generation, power conditioning and distribution, and energy storage.
Transportation	Capabilities that provide the transportation functions for all phases of the lunar and Mars missions for both crew and cargo including in-space, entry, descent, landing, and lunar and Mars ascent.
Utilization Systems	A group of capabilities whose primary function is to accomplish utilization which includes science and technology demonstrations.

- Traceability of element relationships across multiple contributing architecture sources (Mission Directorates, Intl. Partners, etc.)
- Evolvable through trades & assessments
  - Human Systems: added to address several ADD comments & will refine in ACR23
  - Potential for more to be refined with integrated discussion (e.g. Command & Data Handling, ISRU & construction scope, ground systems incl. EGS) (SAC23 Task)
- Utilization is defined as the use of the platform, campaign and/or mission to conduct science, research, test and evaluation, public outreach, education, and industrialization.

Reference Missions - HLR


3.1.3.1 Crewed Initial Lunar Surface Reference Mission

- Transporting crew and systems from Earth to cislunar space
- Staging crewed lunar surface missions from cislunar space
- Assembling integrated assets in cislunar space
- Transporting crew and systems between cislunar space and the lunar surface
- Returning crew and systems from cislunar space to Earth
- Crew operations on the lunar surface
- Frequent crew EVA on the surface
- Crew conducting utilization activities on the surface.
- Additional science, utilization, crew health and performance, and operations are also envisioned

3.1.3.2 Crewed Gateway and Lunar Surface Reference Mission

- Crew conducts utilization activities in cislunar space
- Enable ground personnel and science teams to directly engage with crew on the surface and in lunar orbit - augmenting the crew's effectiveness at conducting science activities
- Enables crew and/or robotic emplacement and set-up of science instrumentation in lunar orbit with long-term remote operation
- Autonomous/semi-autonomous mission operations in cislunar space

Foundational Exploration Segment Overview

Formally allocate functions at element Mission Concept Review (MCR), include in ADD at the following ACR

3.2.3.1 Sortie Reference Mission with Unpressurized Mobility

- Crew excursions
- Robotic assistance of crew exploration
- Locating samples and resources, and retrieval of samples
- Crewed/robotic collection of samples from PSRs
- Deployment of power generation, storage, and distribution systems

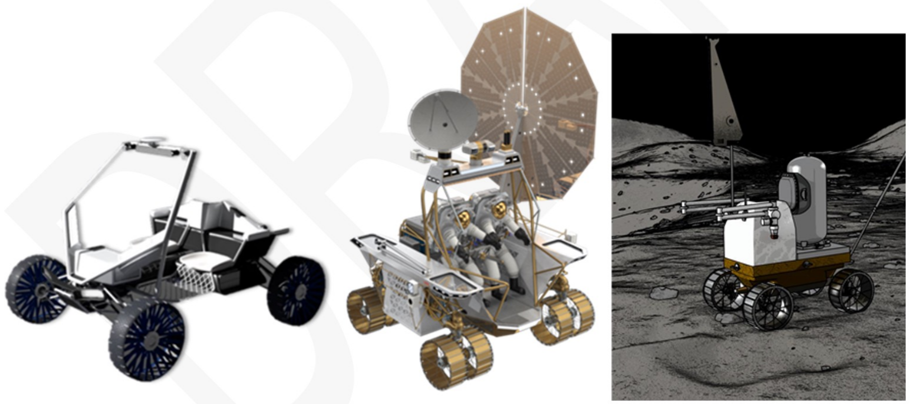


Figure 3.2-1 Example Concepts for Unpressurized Mobility

3.2.3.2 Sortie Reference Mission with Pressurized Mobility

- Scientific and industrial utilization
- Developing surface habitation systems
- Perform Mars risk reduction activities
- Pressurized mobility systems
- Crew IVA research
- Expanded durations for crew operations on the lunar surface
- Crew excursions to locations distributed around the landing sit
- EVA egress/ingress
- Crew relocation and exploration in a shirtsleeve environment.

3.2.4.2 Pressurized Mobility

Figure 3.2-2 Example Concepts for Pressurized Mobility

Additional missions will be refined and updated thru the SAC process:

- 3.2.3.3 Robotic Uncrewed Operations
- 3.2.3.4 Cislunar Operations at Gateway
- 3.2.3.5 Extended Surface Habitation Operations
- 3.2.3.6 Non-Polar Lunar Sortie Reference Mission

NASA