

National Aeronautics and Space Administration

June 7, 2023

**National Academies: Joint Meeting of the
Aeronautics and Space Engineering Board
and Space Studies Board**

For All Humanity: **Progress and Plans for** **Deep Space Human** **Exploration**

Jim Free

**Associate Administrator
Exploration Systems Development**

NASA Headquarters, Washington, D.C.

 **@JimFree**

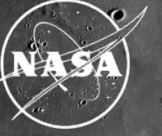
www.nasa.gov



ESDMD Goals

Meet the Agency's goals for human exploration by:

- Building a sustainable Artemis architecture that creates a lunar exploration plan and establishes a clear path to the human exploration of Mars
- Aligning with and supporting NASA's Moon to Mars objectives
- Moving toward a more affordable exploration crew transportation system that will enable a national launch capability
- Fostering high standards of program and project management
- Aligning Artemis programs to balance and optimize a funding profile with adjusted mission dates
- Collaborating with centers and committing to maintaining a highly-skilled and capable workforce
- Clearly communicating status and plans for all stakeholders





Artemis I

MISSION COMPLETE:

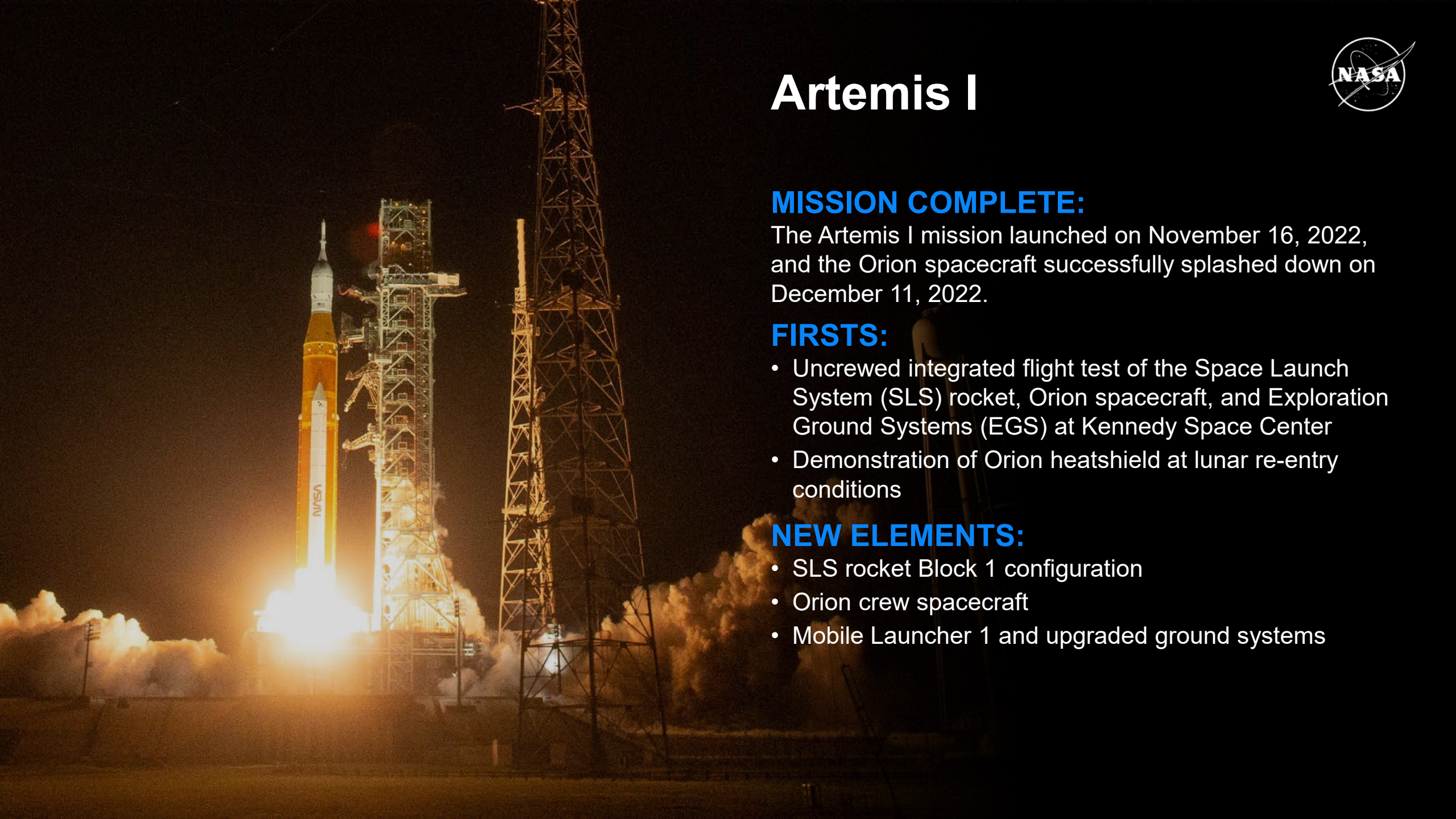
The Artemis I mission launched on November 16, 2022, and the Orion spacecraft successfully splashed down on December 11, 2022.

FIRSTS:

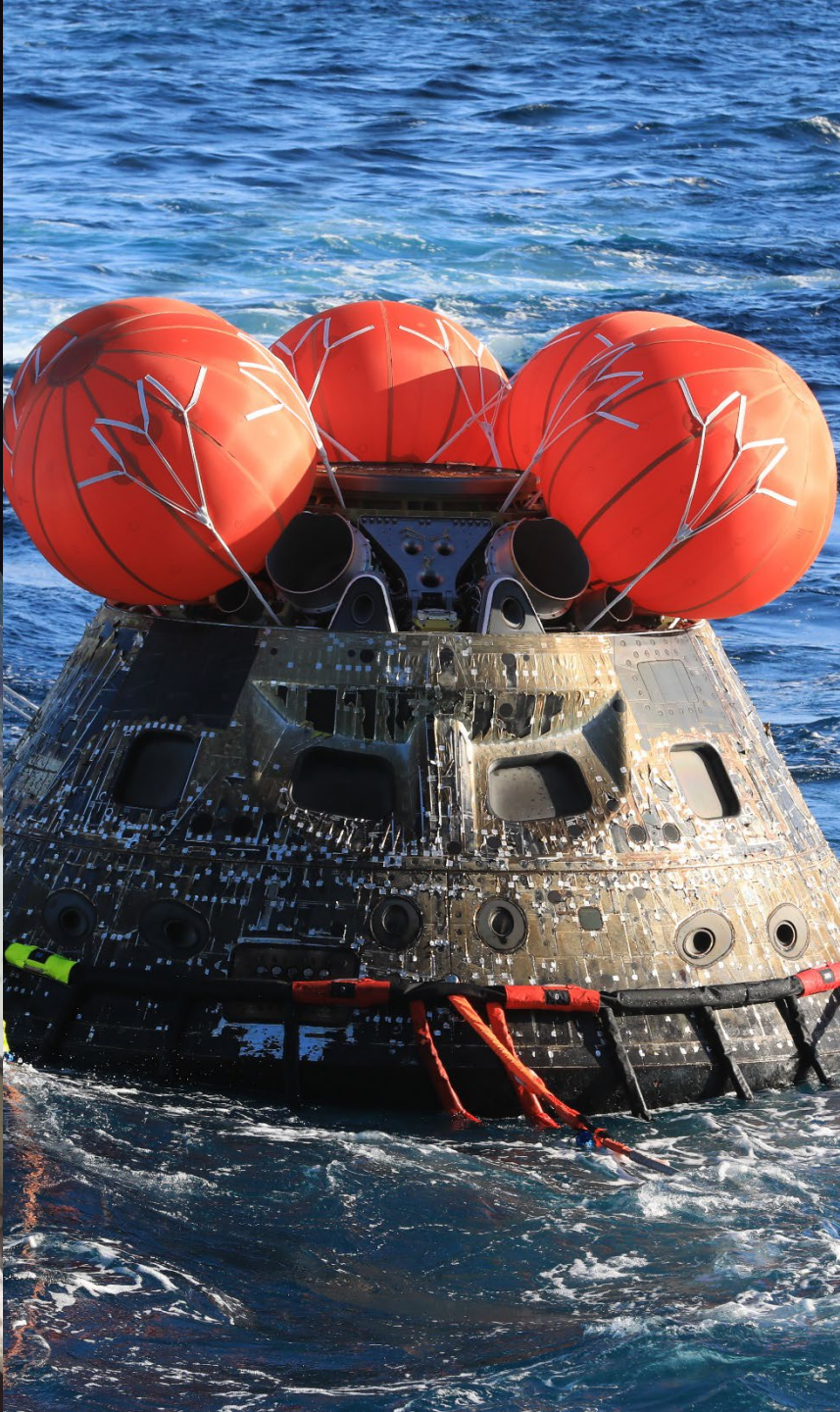
- Uncrewed integrated flight test of the Space Launch System (SLS) rocket, Orion spacecraft, and Exploration Ground Systems (EGS) at Kennedy Space Center
- Demonstration of Orion heatshield at lunar re-entry conditions

NEW ELEMENTS:

- SLS rocket Block 1 configuration
- Orion crew spacecraft
- Mobile Launcher 1 and upgraded ground systems



ARTEMIS I





Artemis II

FIRSTS:

- Crewed integrated flight test of the Space Launch System (SLS) rocket, Orion spacecraft, and Exploration Ground Systems (EGS) at Kennedy Space Center
- Demonstration of Orion life support systems
- Collection of human data in lunar orbit, transit to and from the Moon, and through reentry and splashdown

NEW ELEMENTS:

- Orion life support systems
- Launch Complex 39B emergency egress system for crew and new liquid hydrogen system

COMMON ELEMENTS:

- SLS rocket Block 1 configuration
- Orion crew spacecraft
- Mobile Launcher 1 and upgraded ground systems

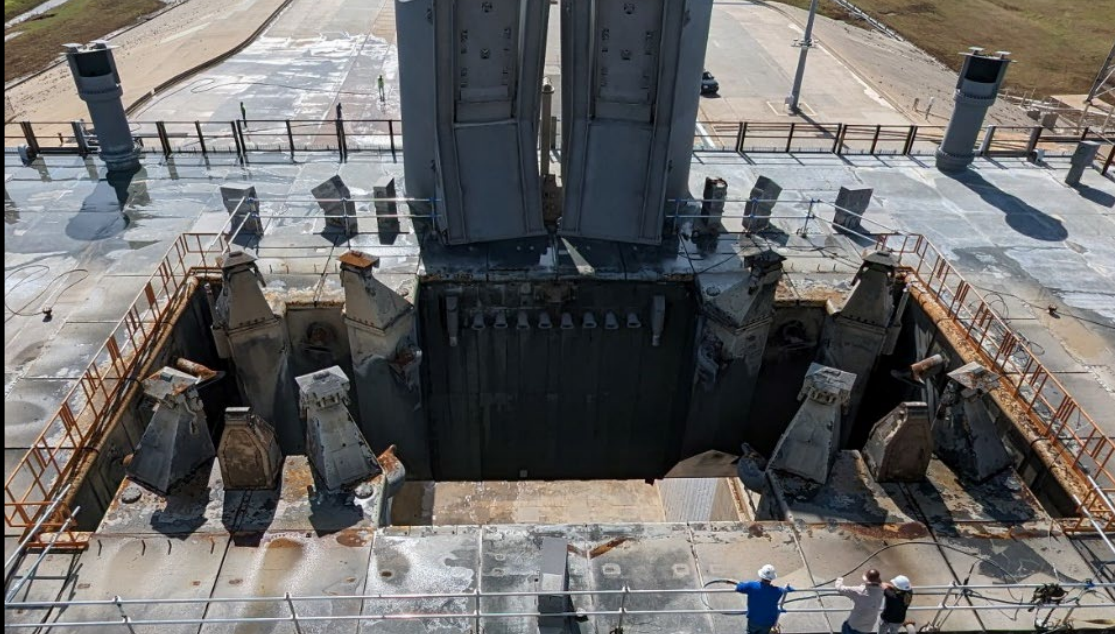
ARTEMIS II



**ARTEMIS II CREW MODULE
KENNEDY SPACE CENTER**



**ARTEMIS II SERVICE MODULE
KENNEDY SPACE CENTER**



**ARTEMIS II MOBILE LAUNCHER 1
REFURBISHMENT**



**ARTEMIS II BOOSTER MOTOR
SEGMENTS COMPLETE**



ARTEMIS II CORE STAGE ASSEMBLED



ARTEMIS II CMTA RECOVERY TESTING

THE ARTEMIS II CREW



The Artemis II crew represents thousands of people working tirelessly to bring us to the stars. This is their crew. This is our crew. This is humanity's crew.



Jeremy Hansen

Mission Specialist
Canadian Space Agency Astronaut

Reid Wiseman

Commander
NASA Astronaut

Victor Glover

Pilot
NASA Astronaut

Christina Hammock Koch

Mission Specialist
NASA Astronaut



Artemis III

FIRSTS:

- Human landing in South Pole region
- Orion to human landing system direct mission
- Use of Near Rectilinear Halo Orbit (NRHO)
- Four astronauts to lunar orbit
- Two astronauts to lunar surface to collect scientific samples and data

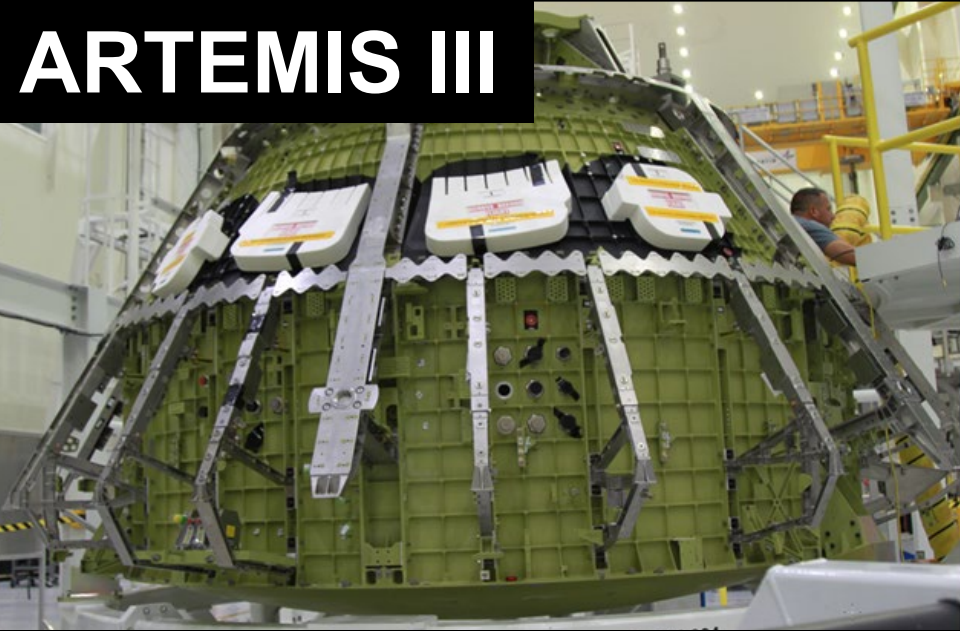
NEW ELEMENTS:

- Use of Orion full up rendezvous, proximity operations, and docking systems
- SpaceX Starship human landing system
- Axiom advanced spacesuits and support systems

COMMON ELEMENTS:

- SLS rocket Block 1 configuration
- Orion crew spacecraft
- Mobile Launcher 1 and upgraded ground systems

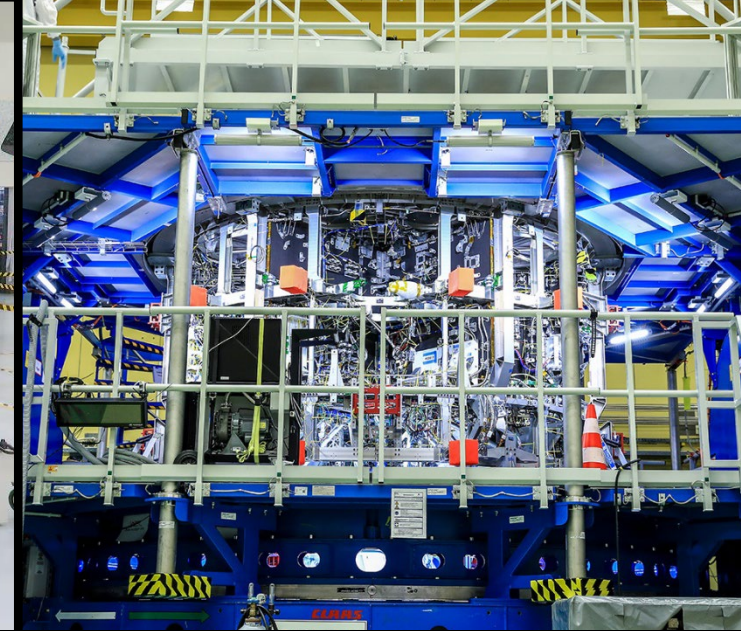
ARTEMIS III



ARTEMIS III CREW MODULE



ARTEMIS III ORION HEAT SHIELD KENNEDY SPACE CENTER



ARTEMIS III ORION SERVICE MODULE INTEGRATION IN BREMEN (Image: Airbus)



STARSHIP FIRST INTEGRATED FLIGHT TEST (Image: SpaceX)



SLS LIQUID HYDROGEN TANK



THERMAL PROTECTION APPLIED TO LVSA



THE ARTEMIS III SPACESUIT PROTOTYPE, THE AXEMU



Artemis IV

FIRSTS:

- Crewed mission to Gateway space station
- Launch and delivery of a space station module to lunar orbit on a crewed flight
- Crew transfer from Orion to human landing system (HLS) via Gateway

NEW ELEMENTS:

- Space Launch System rocket Block 1B configuration
- Mobile Launcher 2 with supporting ground systems
- SpaceX Sustaining Starship HLS
- Gateway modules: Power and Propulsion Element, Habitation and Logistics Outpost, International Habitat

COMMON ELEMENTS:

- Common SLS elements
- Orion crew spacecraft
- Spacesuits and support systems



ARTEMIS IV



ARTEMIS IV SPACE LAUNCH SYSTEM ENGINE SECTION



ARTEMIS IV CREW MODULE PRESSURE VESSEL
AT KENNEDY SPACE CENTER



ARTEMIS IV EUROPEAN SERVICE MODULE IN BREMEN,
GERMANY



FIRST SHIPMENT OF STEEL TRUSSES FOR MOBILE LAUNCHER 2

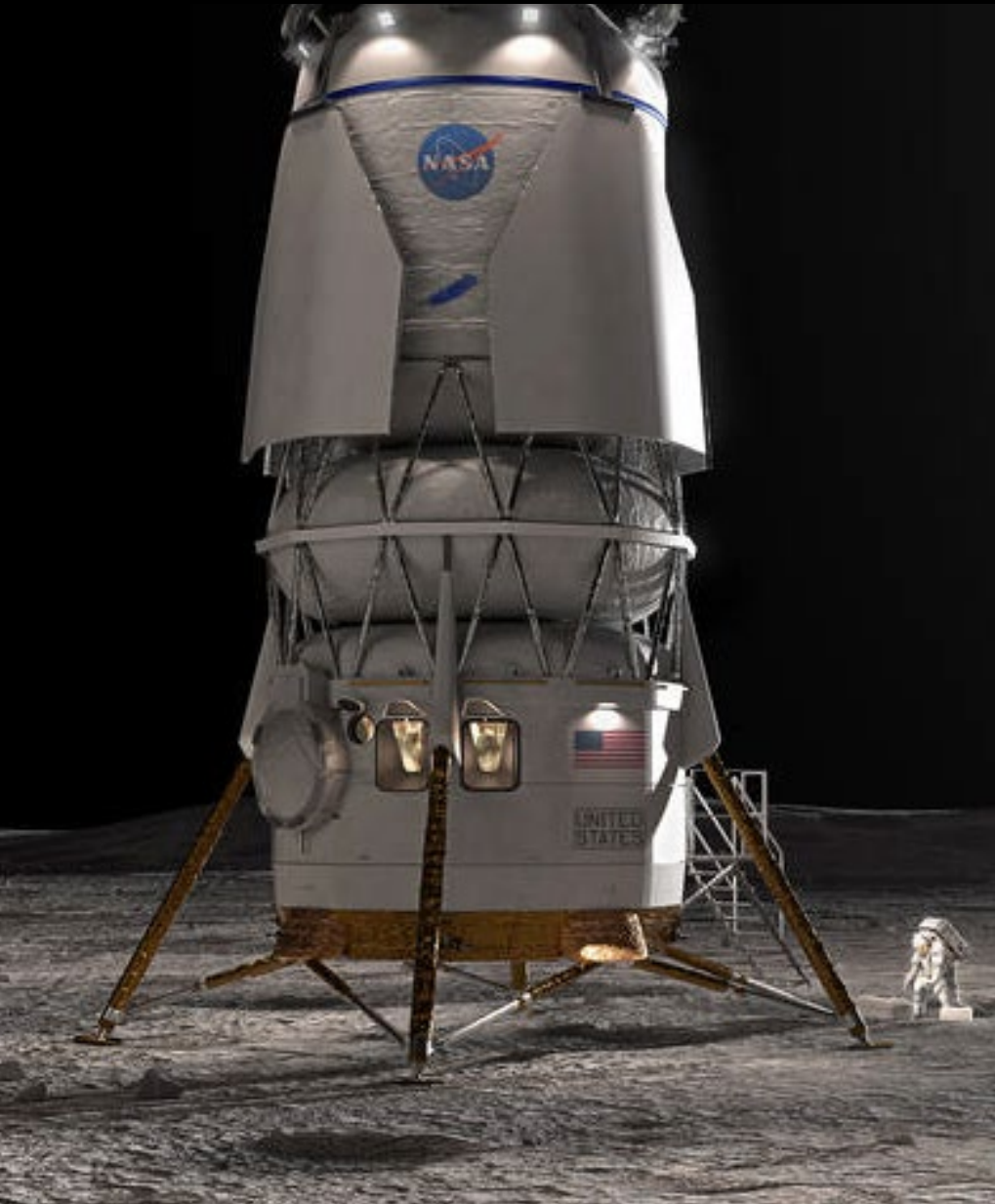


GATEWAY HALO MOCK-UP AT JOHNSON
SPACE CENTER



INITIAL WELDS ON GATEWAY I-HAB PRIMARY
STRUCTURE

FUTURE ARTEMIS MISSIONS



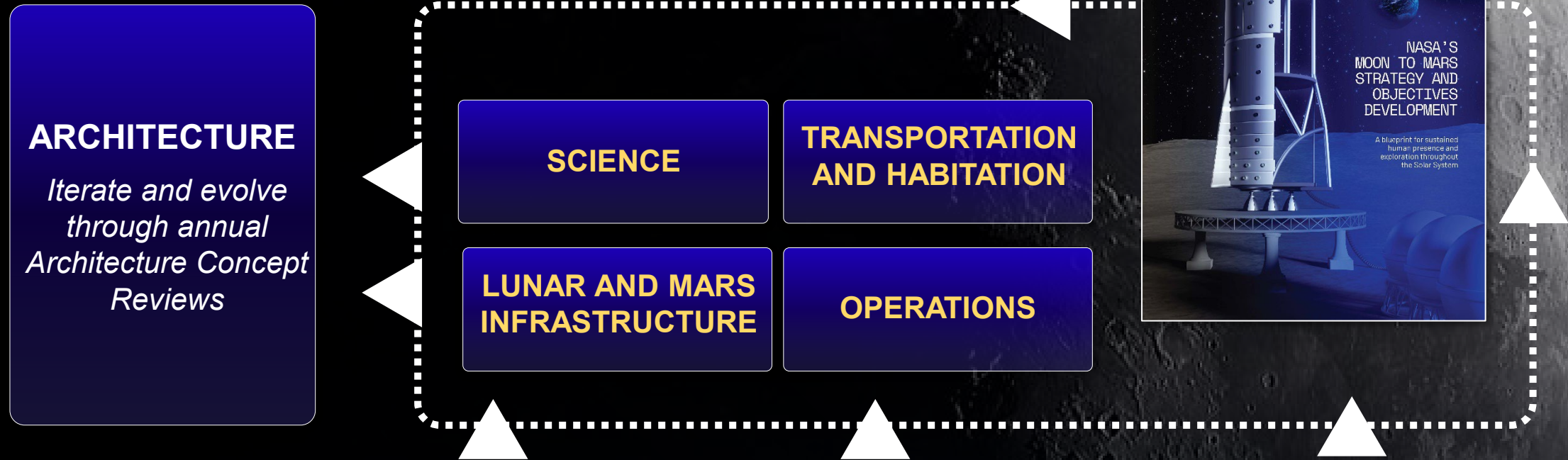
BLUE ORIGIN'S BLUE MOON HUMAN LANDING SYSTEM
(Credit: Blue Origin)



LUNAR TERRAIN VEHICLE RENDER

NASA's Moon to Mars Strategy and Objectives

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



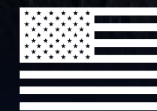
Requested feedback on these objectives in summer 2022 from the following key stakeholders:



NASA workforce:
our greatest asset

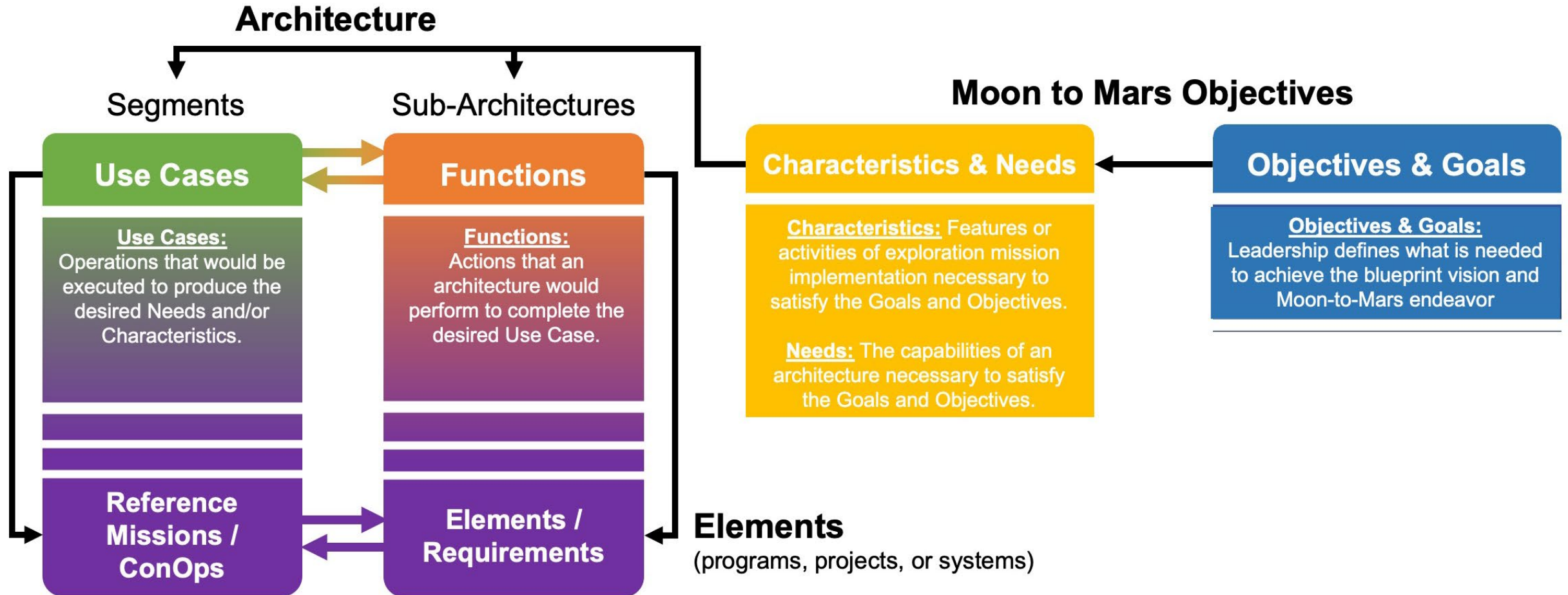


International partners: our key
current and future, anticipated
collaborators



U.S. industry, academia, DOE, NIH,
NSF, etc.: our national leaders in
space research and capabilities

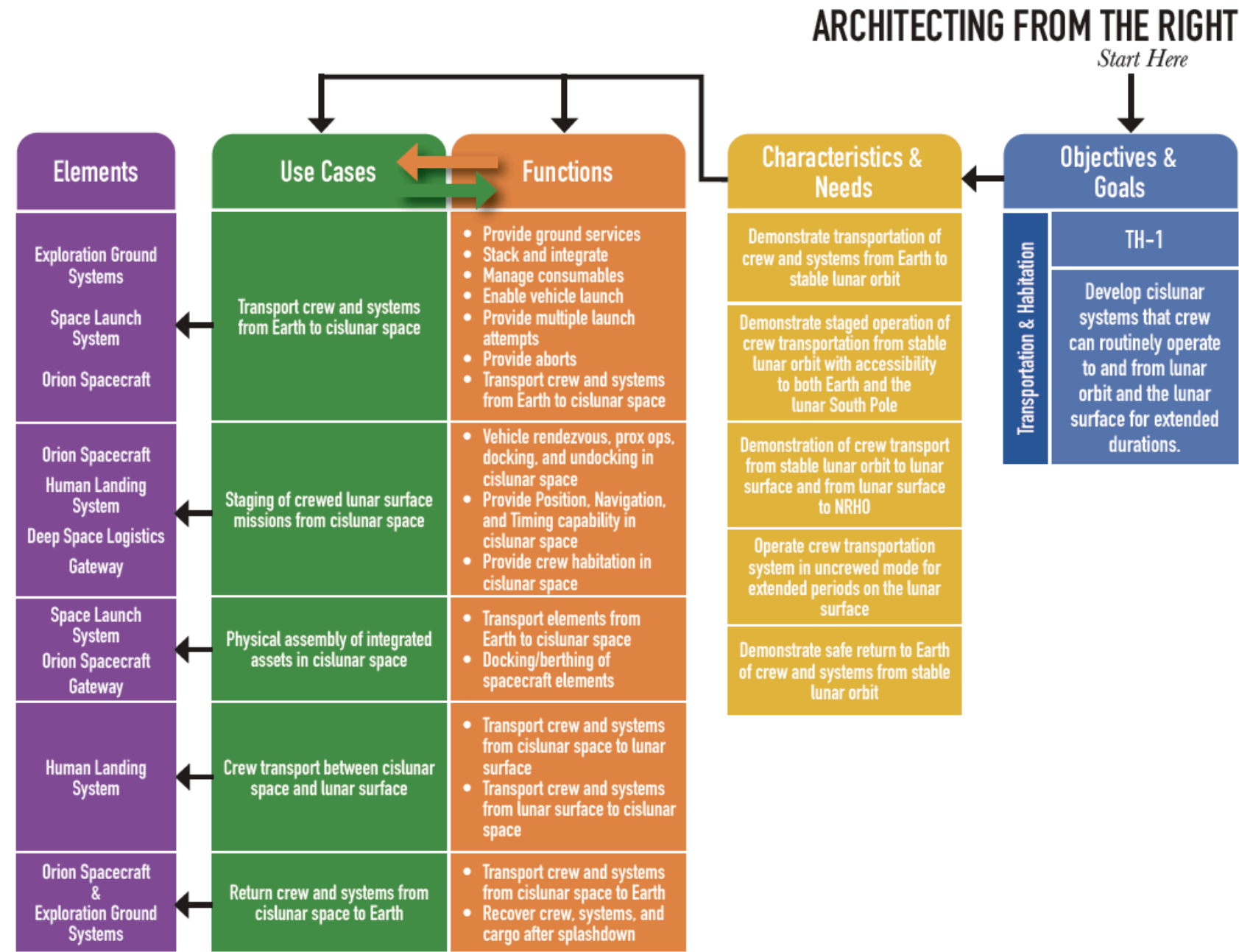
Architecting from the Right



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

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.



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



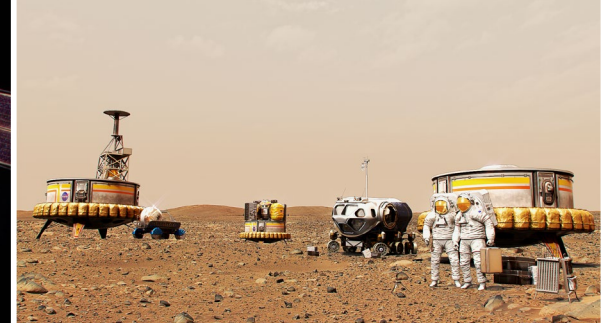
Foundational Exploration

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

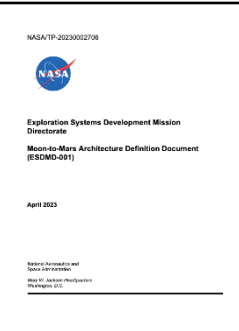
Sub-architecture: A group of tightly-coupled systems, functions, and capabilities that perform together to accomplish architecture objectives.

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

Architecture Products



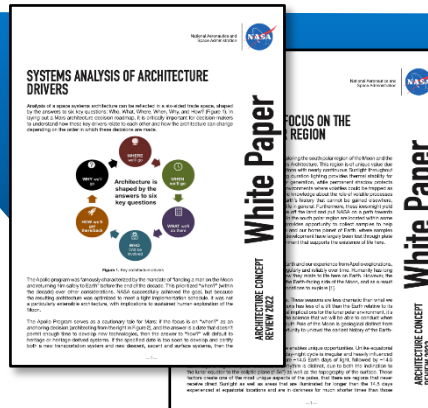
Architecture Definition Document
Detailed documentation of a snapshot of NASA's human spaceflight architecture and exploration strategy



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

We came in peace.

We return for all humanity.

