May 15, 2023
NAC HEO Public Meeting

Exploration Systems Development Mission Directorate Status

Jim Free

Associate Administrator
Exploration Systems Development
Mission Directorate

NASA Headquarters, Washington, D.C.

Agenda

- ESDMD Organizational Refinements
- Budget Status
- Moon to Mars Architecture
- International Partnerships

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

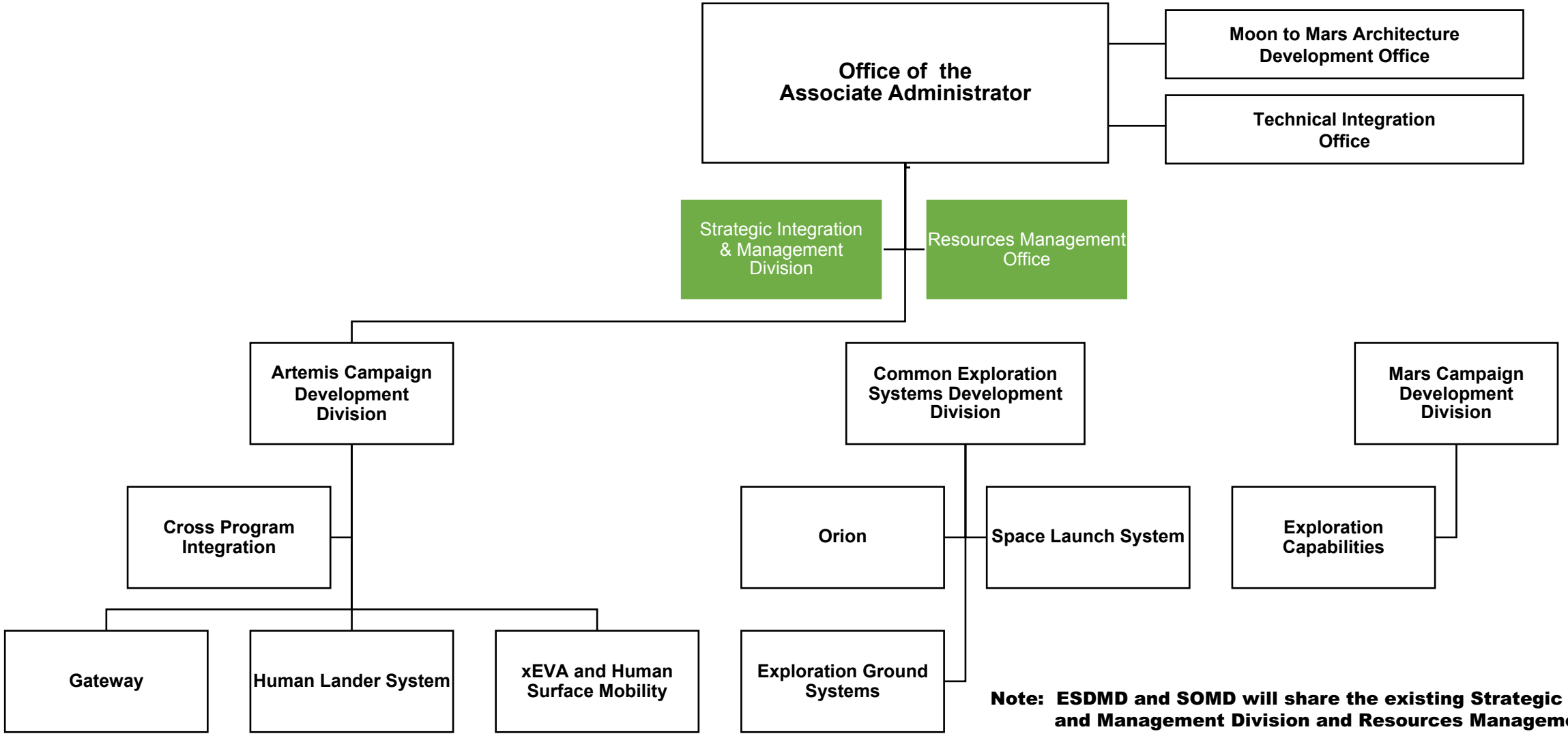
ESDMD and SOMD Organizational Refinements

- In response to the NASA Authorization Act 2022, Section 10811(3), ESDMD established a Moon-to-Mars (M2M) program to be responsible for end-to-end risk management associated with implementing lunar and Mars missions.

- To ensure the successful execution of Artemis missions, risk management, and maintain resiliency and flexibility for future missions and exploration requirements, NASA will no longer transition programs that complete their research and development phase in ESDMD to SOMD for their operational phase.

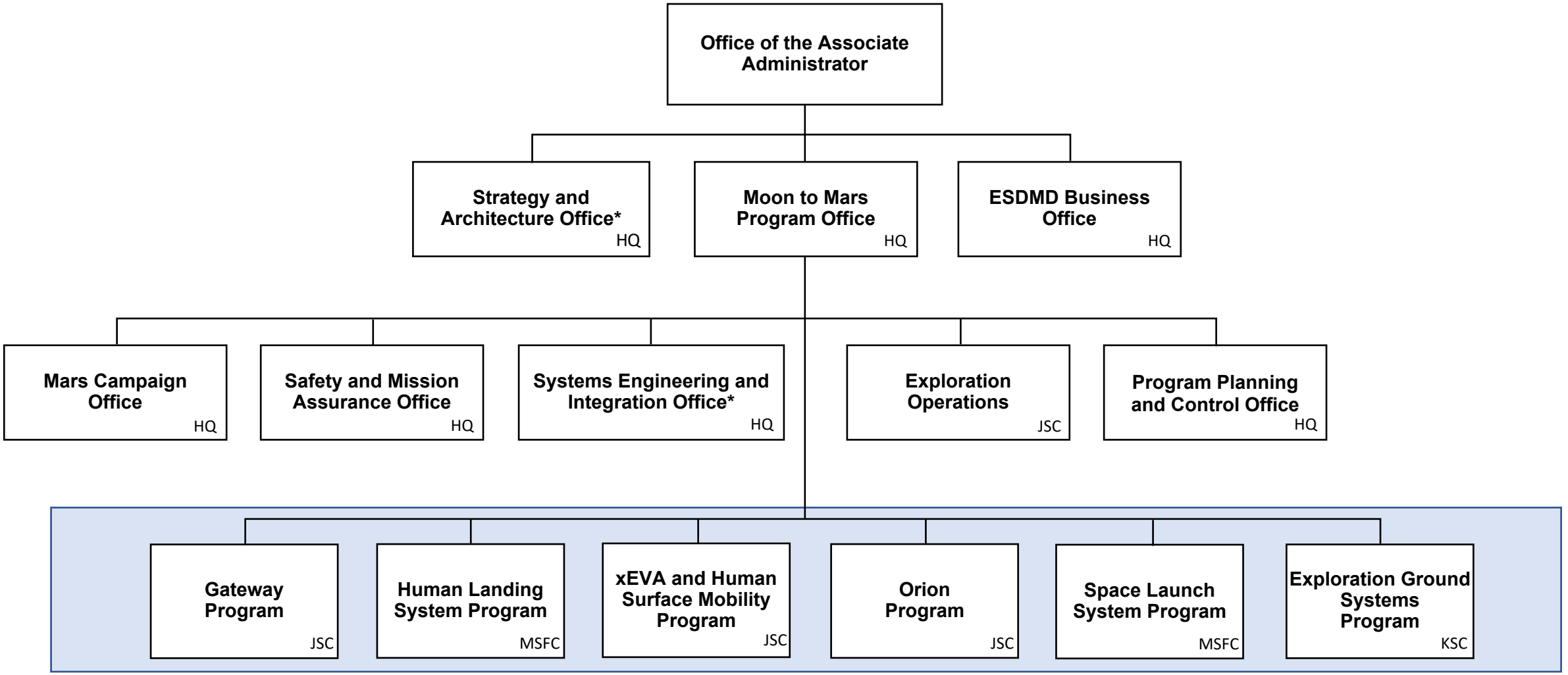
- On March 3, 2023, Senate Appropriations Committee approved the ESDMD/SOMD refinement, and the House Appropriations Committee approved.

Exploration Systems Development Mission Directorate: Existing Organization



Note: ESDMD and SOMD will share the existing Strategic Integration and Management Division and Resources Management Office

Exploration Systems Development Mission Directorate: Approved Organization



*Strategy and Architecture and SE&I have direct integration with SMD and STMD

Program Financial Plan (PFP)

FY 2024 President's Budget provides $7.9B for Deep Space Exploration Systems account to continue pursuit of the nation's exploration goals, consistent with National Space Policy

Budget Authority ($ in millions)	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028
Deep Space Exploration Systems	**7,971.1**	**8,130.5**	**8,293.1**	**8,459.0**	**8,628.2**
Common Exploration Systems Development	**4,525.4**	**4,241.7**	**4,009.3**	**3,557.3**	**3,529.7**
Orion Program	1,225.0	1,093.7	1,093.7	1,094.2	1,115.1
Space Launch System	2,506.1	2,483.3	2,322.4	1,917.1	1,969.1
Exploration Ground Systems	794.2	664.7	593.2	546.0	445.5
Artemis Campaign Development	**3,234.8**	**3,674.4**	**4,068.9**	**4,686.2**	**4,879.6**
Gateway	914.2	853.0	744.2	768.8	777.3
Adv Cislunar and Surface Capabilities	60.3	102.0	433.0	563.8	969.9
xEVA and Human Surface Mobility Program	379.9	494.8	605.0	605.3	605.7
Human Landing System	1,880.5	2,224.7	2,286.7	2,748.3	2,526.6
Human Exp Requirements & Architecture	**49.1**	**50.0**	**50.5**	**51.0**	**51.1**
Moon & Mars Architecture	49.1	50.0	50.5	51.0	51.1
Mars Campaign Development	**161.8**	**164.4**	**164.4**	**164.5**	**167.8**
Exploration Capabilities	161.8	164.4	164.4	164.5	167.8
Construction of Facilities	**10.5**	**-**	**-**	**-**	**-**
Exploration CoF	10.5	-	-	-	-

FY 2024 Major Content Changes

Budget Authority ($ in M)	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	Total
Add FY 2028	**-**	**-**	**-**	**-**	**8,628.2**	**8,628.2**
Common Exploration Systems Development (CESD)	**939.5**	**1,104.3**	**1,131.3**	**1,137.2**	**-**	**4,312.4**
Orion - Exploration Operations to Orion Development	806.3	975.5	1,044.8	1,079.5	-	3,906.0
Exploration Ground Systems: Mobile Launcher-2	133.2	128.8	86.6	57.7	-	406.3
Artemis Campaign Development (ACD)	**152.5**	**199.0**	**173.7**	**185.3**	**-**	**710.4**
Lunar Surface	-	38.3	-	-	-	38.3
Artemis:	152.5	160.7	173.7	185.3	-	672.1
Human Landing System	*-*	*-*	*97.8*	*185.3*	*-*	283.0
Gateway	*152.5*	*160.7*	*75.9*	*-*	*-*	389.1
Transfer to CECR	**(10.5)**					

Totals may not add due to rounding

- **CESD**
  - Transfer of responsibility and funding for Orion production and sustainment operations from Space Operations Mission Directorate (SOMD) back to Exploration Systems Development Mission Directorate (ESDMD)
  - Additional funding to Mobile Launcher-2 development to support September 2028 Artemis IV mission
- **ACD**
  - Future Surface Systems continues to work risk reduction activities to avoid major schedule risk for future lunar Surface activities
  - HLS: Working with industry partners to support development of integrated landing systems that can transport crew to and from the lunar surface and maintain competition
  - Gateway: Funding for additional Power and Propulsion Element (PPE)/Habitation and Logistics Outpost (HALO) requirements

FY 2024 President's Budget Request
Moon to Mars Manifest

CY	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
ESDMD	MISSION COMPLETE **Artemis I** (Nov. - Dec. 2022) Uncrewed Test Flight: SLS Block 1 / Orion / ML1 10 CubeSats Deployed		**Artemis II** (Nov. 2024) Crewed Test Flight SLS Block 1 / Orion / ML1 *HLS Uncrewed Lunar Demo*	**Artemis III** (Dec. 2025) Crewed Flight SLS Block 1 / Orion / ML1 HLS Crewed Lunar Demo xEVA Surface Suits *Gateway PPE/HALO Launch*	*Gateway PPE/HALO Arrival in NRHO*		**Artemis IV** (Sept. 2028) Crewed Flight SLS Block 1B / Orion / ML2 I-Hab to Gateway DSL to Gateway Sustaining HLS Crewed Lunar Demo xEVA Surface Suits *TBD Sustaining HLS Uncrewed Lunar Demo*	**Artemis V** (Sept. 2029) Crewed Flight SLS Block 1B / Orion / ML2 ESPRIT to Gateway DSL to Gateway Gateway External Robotics System TBD Sustaining HLS Crewed Lunar Demo xEVA Surface Suits LTV	**Artemis VI** (Sept. 2030) Crewed Flight SLS Block 1B / Orion / ML2 Airlock to Gateway DSL to Gateway TBD Sustaining HLS Services xEVA Surface Suits	**Artemis VII** (Sept. 2031) Crewed Flight SLS Block 1B / Orion / ML2 Gateway operations DSL to Gateway TBD Sustaining HLS Services xEVA Surface Suits Pressurized Rover
SOMD	DSN Upgrades (DLEU) **Completed** DSS-26 [Goldstone]	**Completed** DSS-36 [Canberra]	DSS-24 [Goldstone] DSS-56 [Madrid]	DSS-34 [Canberra] Lunar Communications Relay and Navigation Services (LCRNS) Increment Alpha	DLEU Overall Completion DSS-54 [Madrid]	Lunar Exploration Ground Sites 1-3 Increment Beta	Increment Charlie	Ongoing Science, Human Research Program, and Technology Development in LEO (ISS transition to CLD)		
SMD CLPS Flights Outlined	LRO Mars 2020:	TO 2-AB TO 2-IM	ESCAPADE TO 20A: VIPER TO 19D TO CP-11:	Artemis III Surface Science Instruments HERMES ready for integration ESA Lunar Pathfinder delivered for launch TO CP-12 TO CS-3	LRO continued ops TO CP-21 TO CP-22 TO CP-31	Mars Sample Return (MSR): Earth-Return Orbiter (ESA) TO CP-32 TO CP-41	Artemis IV Surface Science Instruments MSR Lander: Sample Retrieval Lander; Mars Ascent Vehicle TO CP-42 TO CP-51	Artemis V Surface Science Instruments Artemis LTV Science Instruments TO CP-52 TO CP-61 TO CP-62	Artemis VI Surface Science Instruments MSR: Mars Ascent Vehicle launch Mars 2020 Sample Delivery	Artemis VII Surface Science Instruments
STMD	MOXIE; MEDA LAUNCHED CAPSTONE LAUNCHED LOFTID	TO PRIME-1: Lunar Trailblazer; PRIME-1 Drill; Nokia LTE/4G Comm; IM Deployable Hopper CFM SpaceX TP Flight Demo	Surface Robotic Scouts (CADRE) Preliminary DRACO NTP Engine Design NEP Concept Vehicle Design PPE SEP qual. environ. complete CFM Eta Space TP Flight Demo	CFM Lockheed Martin TP Flight Demo CFM ULA TP Flight Demo	PSI Mini-Suite	TO CT-1: Lunar Surface Power Demo (i.e. RFC, VSAT, Wireless Charging); Lunar Surface Scaled Construction Demo 1; ISRU Pilot Excavator; ISRU Subscale Demo		SEP qual. complete	TO CT-2: Lunar Surface Scaled Construction Demo 2; Autonomous Robotics Demo; Deployable Hopper 2; ISRU Subscale Demo 2 Fission Surface Power demo delivered for launch	

Icons are representative only, and may not reflect final configurations, not to scale | Icons represent the calendar year in which an event occurs | Based on FY 2024 President's budget request

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

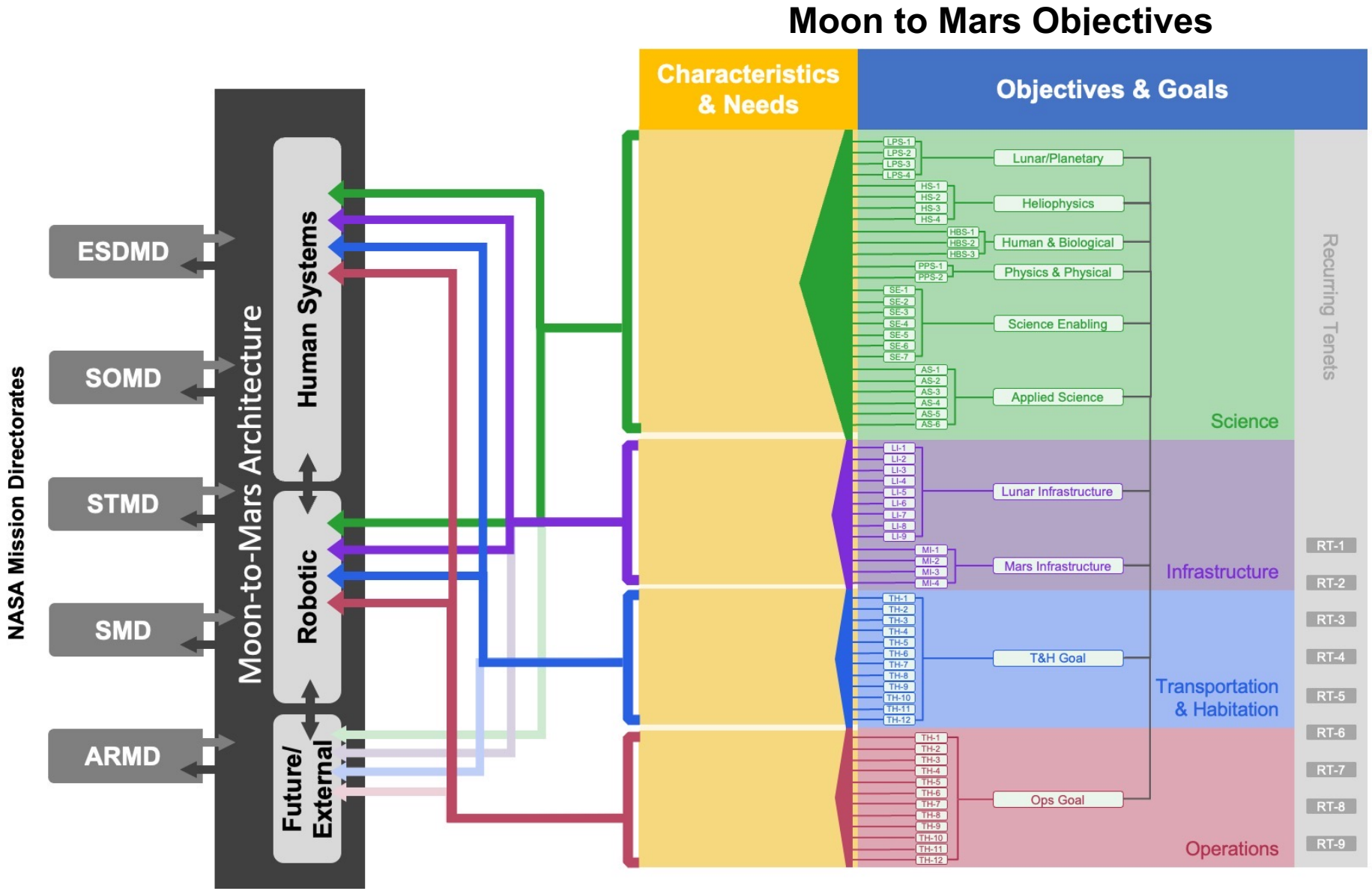
- SCIENCE
- TRANSPORTATION AND HABITATION
- LUNAR AND MARS INFRASTRUCTURE
- OPERATIONS

go.nasa.gov/3zzSNhp

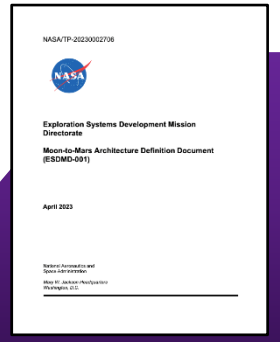
Requested feedback on these objectives in summer 2022 from the following key stakeholders:

- 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

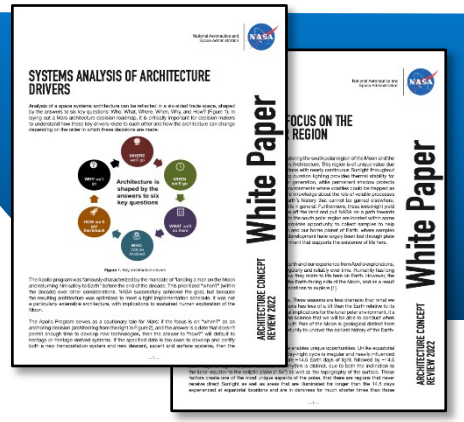


Downloadable Products



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

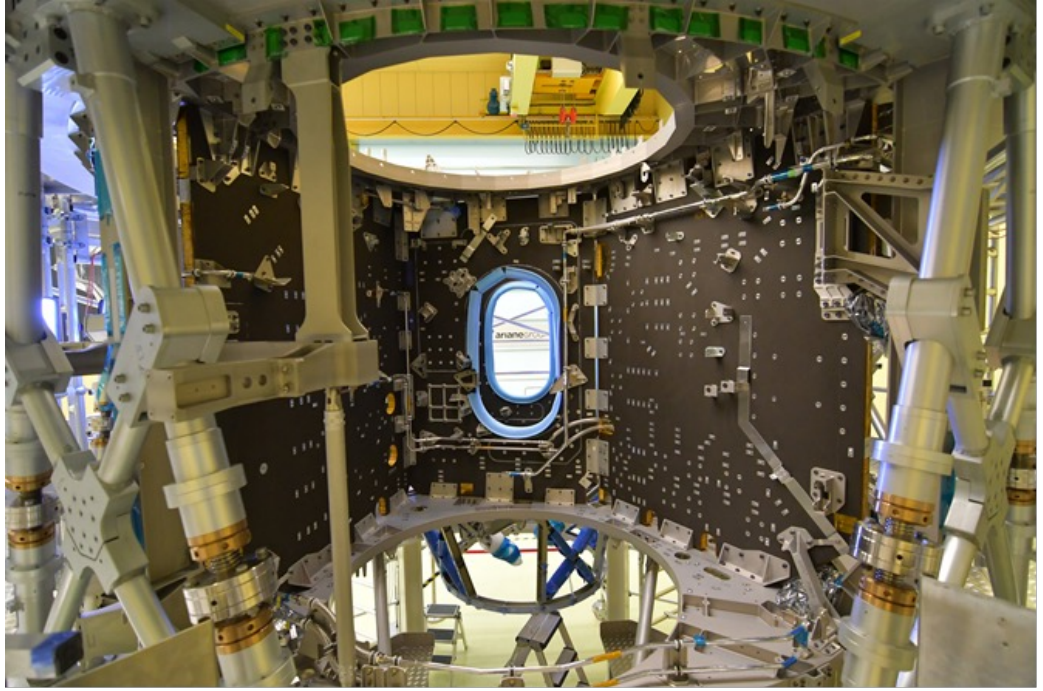
Stakeholders provide input during existing interactions including: conference meetings, partner discussions, bi-laterals, etc.

NASA-led workshops planned summer of 2023, which are geared toward soliciting feedback on processes and documentation.

Partner professional society workshops provide additional opportunities for engagement.

International Partners

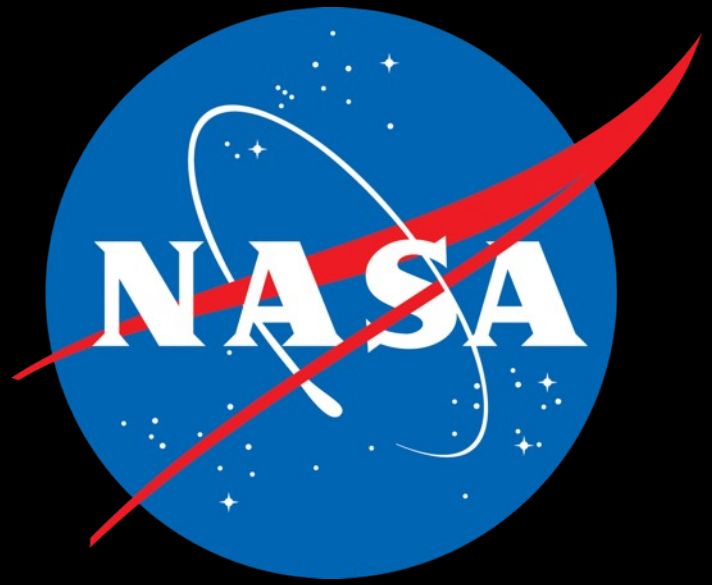
- In development
  - European Services Modules in production through Artemis VI
  - International Habitation Module
  - Canadarm3
  - ESPRIT
  - HTV-XG
- Study agreements
  - Pressurized lunar rover
  - Surface habitation
  - Lunar cargo lander
  - Lunar utility rover
- Future work



Pictured top left: European Service Module-5 at the Airbus integration hall in Bremen, Germany. *Credit: ESA*

Pictured top right: The first element of the I-HAB primary structure welded. *Credit: Thales Alenia Space*

Picture bottom: Orion European Service Modules for Artemis III, IV, and V in production in the cleanroom at Airbus facilities.



National Aeronautics and Space Administration

Artemis I Initial Observations

- **Orion:**
  - Performance was nominal or better than expected
    - Orion documented 71 Items for Investigation (IFIs)
    - European Service Module (ESM) performed near nominally
    - Unexpected heatshield char spallation
    - Unexpected Power Control and Distribution Units latch anomaly
- **EGS:**
  - Umbilicals performed nominally
  - Liftoff damage to ML/Tower and some unexpected debris items
    - 54 launch debris items identified from post launch imagery reviews
- **SLS:**
  - Booster and core stage performance was nominal throughout flight
  - RS25 engine performance was nominal
    - Main Engine Cut Off target performance was outstanding – inertial velocity within 7 ft/sec of predicted
  - RL10 engine operated as expected, including the longest ever burn duration of 1084 seconds
- **SCaN:** 68 comm and network related items to be investigated
- **Currently identified 74 Candidate In-Flight Anomalies**

Current Post-Artemis I Work

- Avionics boxes extracted for reuse on Artemis II and installed on Artemis II.
- Heat shield removed on February 9. Further testing and evaluation underway
- Capsule to be sent to Armstrong Test Facility for environmental testing
- Significant damage to launch pad and systems being assessed

Pictured right: Engineers first opening of Orion hatch from inside the KSC Multi-Payload Processing Facility