National Aeronautics and Space Administration

NASA's

Moon to Mars Architecture

STIGUR

Space Technology Industry-Government-University Roundtable

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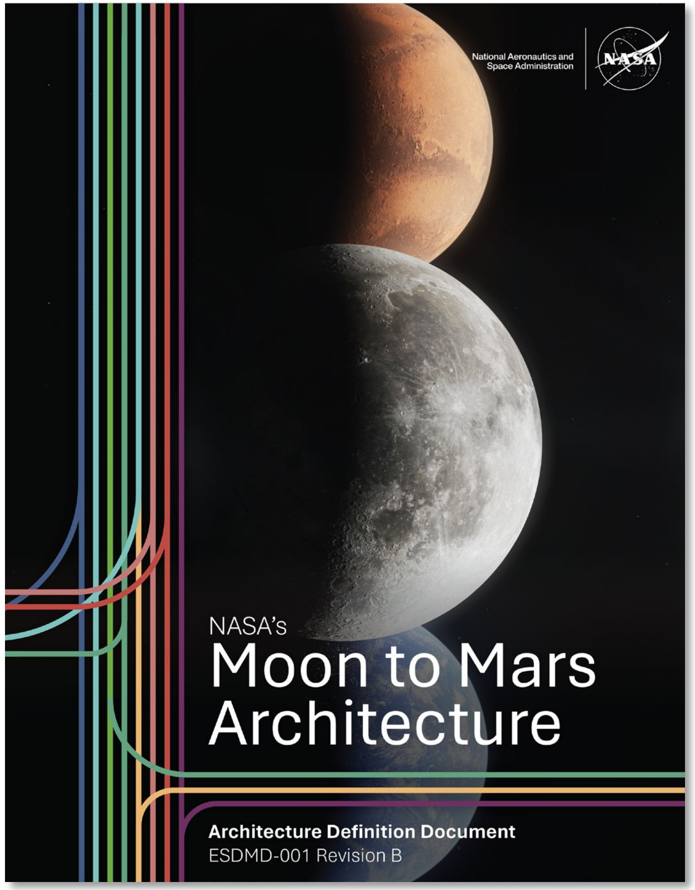
2024 Architecture Products



NASA's Architecture Definition Document Revision B

Architecture White Papers

Executive Overview

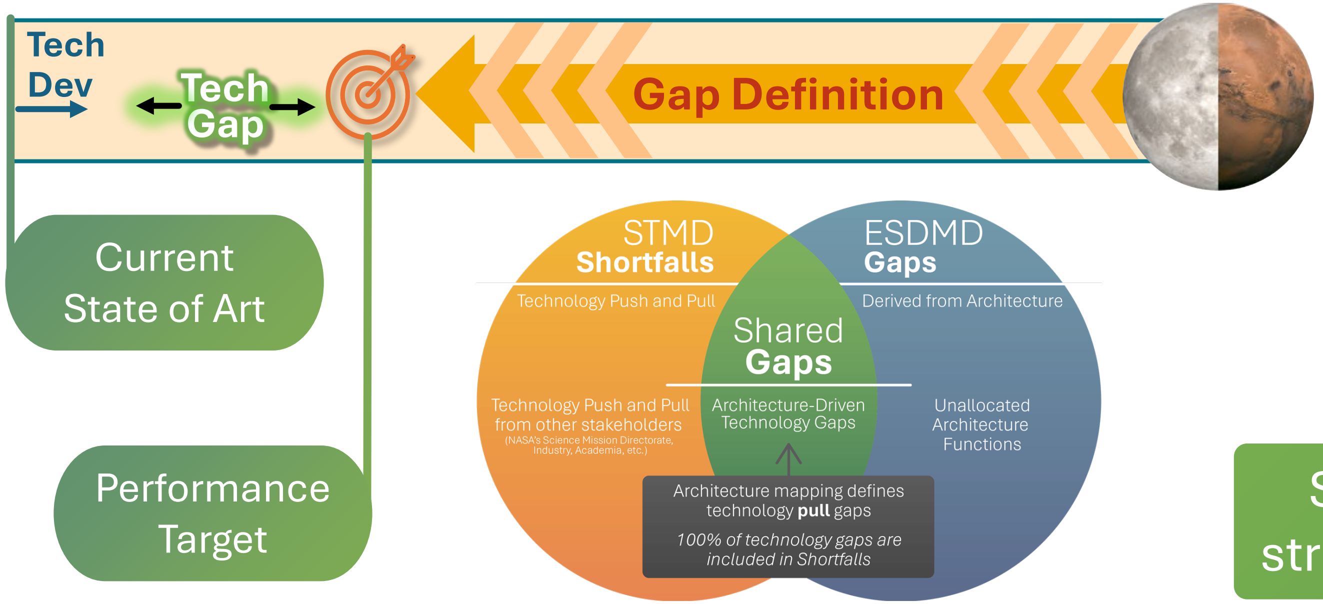
NASA documents its roadmap for deep space exploration in the Architecture Definition Document (ADD).
The agency updates the ADD yearly and publishes it alongside other public-facing products including white papers on relevant topics and an executive overview of the architecture.

Expect 2025 Architecture Products in mid-December

NASA's Moon to Mars Architecture Website
nasa.gov/architecture

Architecture-Driven Technology Gaps

An **architecture-driven technology gap** is a capability that requires technology to be invented or significantly matured to enable the architecture



- Technology gaps are **solution-agnostic**; capture a need but do not prescribe a solution
- Demand signal used globally to inform technology investments that align to NASA's Moon to Mars Architecture
- Integrated with NASA technology development, providing technology pull from the architecture for Moon to Mars missions
- Gaps are prioritized based on four criteria: criticality, urgency, depth, and breadth

Systems engineering process & tools governed by strict principles to enable rigorous, repeatable results

White Paper:
Architecture-Driven Technology Gaps
https://go.nasa.gov/4goQ9iq

Feedback received highlights how architecture technology gaps definition is being used across NASA, industry, and international partners to prioritize investments in research & development

Example Technology Gap - Details

- Gap number, title, and description
- **Architecture impact and benefits** from architecture teams
- Current **state-of-the art** metrics sourced from technology development domain experts
- **Target performance metrics** sourced from architecture teams to specify needs
- **Traceability** to sub-architectures, segments, UC/Fs and decisions
- **Priority bin** based on Gap Overall Prioritization Rating sourced from architecture teams
- Related **Child Gaps** are more specific

Gap ID	Gap Title	Priority
ESDMD #0301	Systems to Survive and Operate through Extended Periods of Lunar Shadow	

Gap Description

Assets on the surface of the Moon will be subjected to large variations in natural and induced environments. The ability to survive and operate through these extreme variations is required to enable long-duration surface operations. New or improved power, thermal management, and actuation technologies are required and will need to work together to accomplish this goal for science experiments, mobility assets, habitats, and more.

Architecture-Driven Child Gaps

- 0301-01: Freeze-tolerant thermal components
- 0301-02: Extreme temperature-tolerant mechanisms and electronics
- 0301-03: Energy storage for extreme temperatures
- 0301-04: Heat rejection systems for the lunar thermal environment

Architecture Impact and Benefits

Without gap closure, the inability to survive extended periods of lunar shadow will impact the operating lifespan of surface assets. There may also be an inability to reuse surface assets if systems cannot survive shadowed periods.

Architecture Traceability

UC/Fs

- UC-H-105 L -- FN-H-201 L

Key Decision

Metrics

Current State of the Art

Small spacecraft have survived extended periods of lunar shadow with damage to subsystems and degraded capability. There is currently no state of the art for any human-scale elements successfully functioning through extended lunar shadow periods.

Performance Target

Survive continuous shadow for 150 (TBR) hours or more several times a year for 10 years.

Sub-Architecture(s)

Habitation Systems · Mobility Systems · Autonomous Systems and Robotics

Campaign Segment(s)

Foundational Exploration · Sustained Lunar Evolution

Higher Priority

Architecture-Driven Technology Gaps in ADD

nasa.gov/architecture

The Architecture Definition Document includes a prioritized list of technology gaps.

2024 Technology Gap Catalog

Gap ID	Gap Title	Priority Ranking	Priority Bin
0801	Lunar Dust Tolerant Systems and Dust Mitigation	1	1
0301	Systems to Survive and Operate through Extended Periods of Lunar Shadow	2	
0103	High-bandwidth, High-reliability Surface-to-Surface Communications	3	
1104	Mars Transportation Propulsion	4	
0201	Extreme Environment Avionics	5	
0805	Autonomous Surface Mobility and Navigation	6	2
0305	Food and Nutrition Capabilities for Missions with Long-duration Storage	7	
1103	Mars Entry, Descent, and Landing for Human Exploration	8	
0806	Payload Offloading, Handling, and Manipulation for Surface Assets	9	
0304	Habitat Environmental Monitors Capable of Supporting Deep Space Missions	10	
1107	Cryogenic Fluid Transfer	11	
1105	Mars Ascent Propulsion for Human Exploration	12	
0901	Scalable Lunar Surface Power Generation	13	
1001	High-performance Actuators, Sensors, and Interfaces	14	
0807	Docking and Berthing between Surface Elements on the Moon and Mars	15	
0303	Dormancy Recovery for Habitat Water Storage, Distribution, and Reclamation	16	3
0307	Radiation Monitoring and Modeling	17	
1003	Integrated System Fault/Anomaly Diagnosis, Decision Support, and Response	18	
0804	Robotic and Mobility Systems in Extreme Cold Environments	19	
0101	Lunar Surface Position, Navigation, and Timing Systems for Extreme Temperature, Radiation, Dust	20	
0702	Waste Management	21	
0302	Fire Safety Upgrades for Surviving Exploration Mission Environments	22	
0903	Power Management and Distribution between Surface Elements	23	
0808	Relocation of Large Assets on the Lunar Surface	24	
0202	High-Performance Onboard Computing	25	
0701	Packaging, Transport, and Use of Conditioned Supplies and Commodities	26	
1005	Safe Human-Robot Interaction and Teaming	27	

Gap ID	Gap Title	Priority Ranking	Priority Bin
0803	Extravehicular Activity (EVA) and Intravehicular Activity (IVA) Suit System Capabilities for Mars Missions	28	4
1101	Lunar Precision Landing and Hazard Avoidance for Human Exploration	29	
1004	Trustworthy Autonomy for Planning and Decision-making	30	
1002	Autonomous Monitoring for Exploration Missions	31	
0802	Mars Dust-Tolerant Systems and Dust Mitigation	32	
0501	Robotic and Human-Robot Inspection, Maintenance, and Repair	33	
1102	Mars Precision Landing and Hazard Avoidance for Human Exploration	34	5
1201	In-Situ Sample Storage and Processing	35	
0402	Sensorimotor Countermeasures to Support Extended Habitation in Space	36	
0401	Crew Exercise Countermeasures to Support Extended Habitation in Space	37	
0403	Physiological Countermeasures for Extended Habitation in Space	37	
0404	Behavioral Countermeasures for Extended Habitation in Space	37	
0406	Spacesuit Physiology for Deep Space Missions	40	
1202	Planetary Protection Technologies for Human Exploration	41	
0405	Exploration Medical Capabilities for Deep Space Missions	42	
1106	Cryogenic Fluid Storage	43	
0308	Radiation Countermeasures	44	
0902	Scalable Mars Surface Power Generation	45	
0104	Earth-Independent Surface Positioning, Navigation, and Timing for Deep Space Missions	46	
0306	Advanced Structures and Materials to Enable Mass-Efficient Habitats	47	6
0602	In-Situ Resource Identification, Characterization, and Mapping	48	
0503	In-Space & Surface Transfer of Earth Storable Propellants	49	
0102	High-bandwidth, High-reliability Deep Space Communications	50	
0606	Mars ISRU to Support Human Exploration	51	
0605	Lunar Regolith Excavation, Manipulation, and Transportation	52	
0601	Oxygen Extraction from Lunar Regolith	53	
0603	Water Recovery from Lunar Regolith/Ice	53	
0604	Metal Extraction from Lunar Regolith	55	
0502	In-situ Manufacturing of Spares, Repairs, and New Parts	56	

Architecture-Driven Technology Gaps in ADD

nasa.gov/architecture

Technology gaps prioritized according to Moon to Mars Architecture benefit and reassessed yearly for updates.

Looking Forward

Updates to gap definition and priorities occur annually in our strategic analysis cycle

- As architecture evolves (new functions, decisions, priorities)
- As technologies are developed (gap closure)
- Coordinated with NASA technology development organizations

In December, NASA plans to publish a preliminary list of **architecture-driven data gaps** in revision C of the Architecture Definition Document

These data gaps communicate a specific demand signal for data products the agency needs that could be provided by industry, academia, or international partners.

Architecture Website
nasa.gov/architecture

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NASA's

Moon to Mars Architecture

Questions?

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Strategy and Architecture Office
Exploration Systems Development Mission Directorate

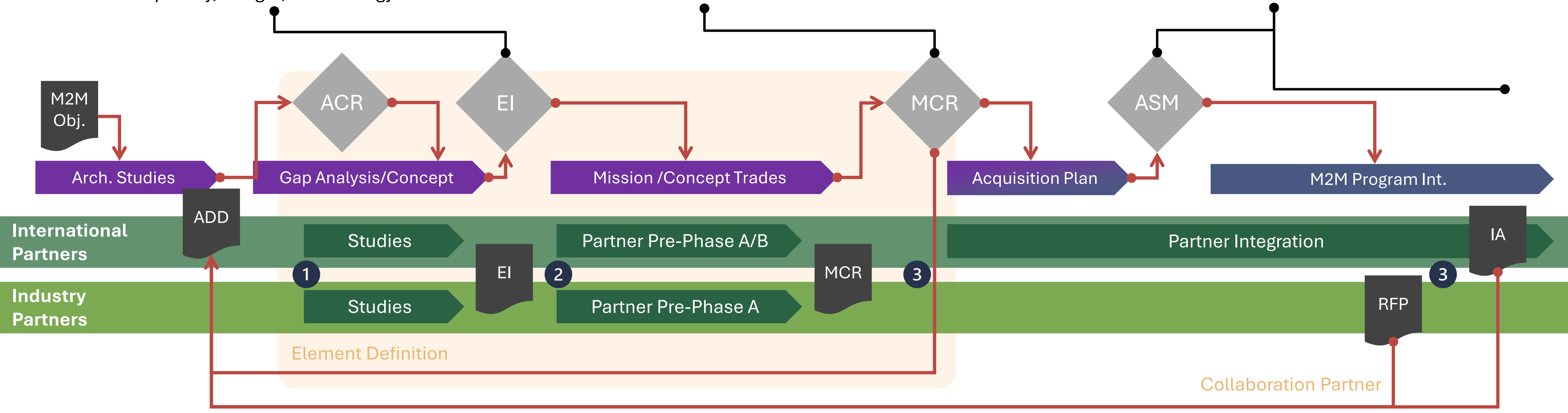
Partner Pre-formulation Process

Exploration Systems Development Mission Directorate

Element Initiation (EI)
Overt decision to proceed with maturation of concept assessed for priority, budget, and strategy

Mission Concept Review (MCR)
Evaluates feasibility of proposed mission concept(s) and its fulfillment of architecture needs and objectives.

Acquisition Strategy Meeting:
Transition from SAO to M2MPO for implementation, completion of project roles and responsibilities leading to Implementing Arrangement (IA) or contracting process (e.g., RFP)



Document(s)

NASA Milestone

1. Feasibility studies and collaboration identify potential concept.
2. Mission refinement to optimize for strategic value and functional achievement, using study mechanisms to better inform planning.
3. Feedback incorporated into architecture products as milestones occur.

Collaboration Partner

Strategy and Architecture Office (SAO)

Moon to Mars Program Office (M2MPO)