National Aeronautics and Space Administration

ESDMD-001 Moon to Mars (M2M) Architecture Definition Document (ADD) Revision A Updates

JAXA Technical Interchange Meeting

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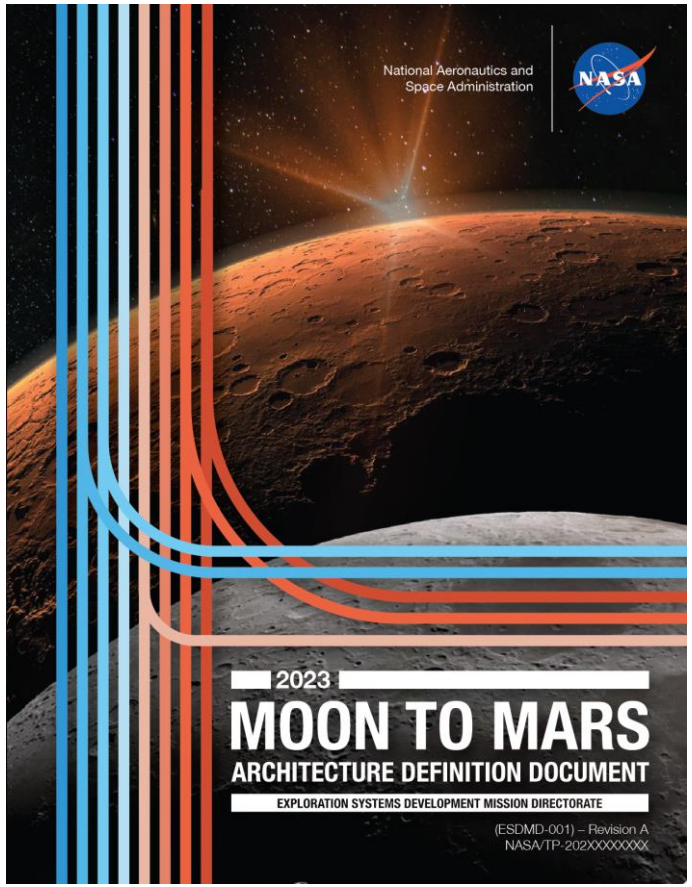
STRATEGY AND ARCHITECTURE OFFICE
EXPLORATION SYSTEMS DEVELOPMENT MISSION DIRECTORATE

Agenda

- ADD Purpose
- M2M Workshops
- Key Findings Since ACR22
- What's New for ADD Rev A
- White Papers for ACR23

Moon to Mars (M2M) Architecture Definition Document (ADD)



Purpose:

Reference document that presents the current state of the human spaceflight architecture and exploration strategy

- Current version of ADD published April 1st, 2023 (NASA/TP-20230002706)
- Documents NASA's M2M human exploration strategy
- Includes relationship to NASA's Exploration policy and M2M Objectives
- Decomposes the M2M Objectives into functions and use cases that can be allocated to implementable programs and projects
- Includes current partnerships presence in the architecture and identifies architectural gaps and opportunities for further collaboration

The M2M ADD is <u>not</u>:

- A requirements document
- A mission definition document
- A mission planning document or manifest
- A procurement strategy
- A final document – plan to be updated yearly

Visit www.nasa.gov/MoonToMarsArchitecture/ for details and additional content

Moon to Mars Workshops

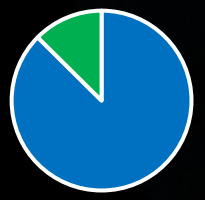
Workshops held throughout summer 2023 to review outcomes from ACR22 and solicit feedback from the space community.

- **International Partners Workshop**

17 Organizations Represented

48 Attendees Representing

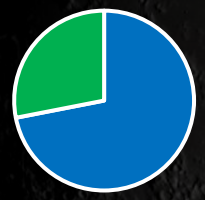
- **Industry and Academia Workshop**



146 Attendees

125 Industry

18 Academia



58 Organizations

46 Industry

12 Academia

- **Interagency Workshop**

21 Agencies Represented

78 Attendees Representing

Key Findings Since ACR22

- **ADD Approach:**
  - Overall positive feedback, appreciation of systems engineering rigor & communication of plan
  - Need to standardize and level decomposition content
    - Established syntax structure, revised commonality C&Ns + UC/F, leveled across objective areas
  - Some verbs and nouns don't translate for international partners easily
    - Modified to use common words and/or added to glossary where necessary
  - Identified needs for additional content and sub-architectures
    - Addressed in SAC23 work and added content in revised ADD
  - Need to continue socialization of process and adaptation to evolutionary approach
- **High interest, response, and positive feedback on white papers**
  - Overall extremely well received, desire for more, and interest in collaboration/supplementation
- **Eagerness to engage and communicate across IP, industry, academia, and inter-gov**
- **Notable observation in all-of-Agency participation at workshops**
  - Highlighted panels and sessions with multiple MD participation and collaboration
- **Several IP and Industry partners directly linked their strategies, responses, and structuring internal work to trace to/from or take next steps directly from ADD**

What's New for ADD Revision A

- **M2M ADD Revision A will include updates based on Architecture Concept Review 2023 (ACR23)**

- **Addition of Mature Elements** *(Elements will be documented once they pass internal NASA Mission Concept Review (MCR) Milestone and international agreements on project cooperation are concluded)*
  - Lunar Terrain Vehicle (LTV)
  - Pressurized Rover (PR)
  - Human-class Delivery Lander (HDL)
  - Gateway Extra-Vehicular Robotic System (GERS) – *Provided by Canadian Space Agency (CSA)*
  - Gateway European System Providing Refueling, Infrastructure and Telecommunications (ESPRIT) Refueling Module (ERM) – *Provided by European Space Agency (ESA)*
  - Gateway Airlock Module

What's New for ADD Revision Cont.

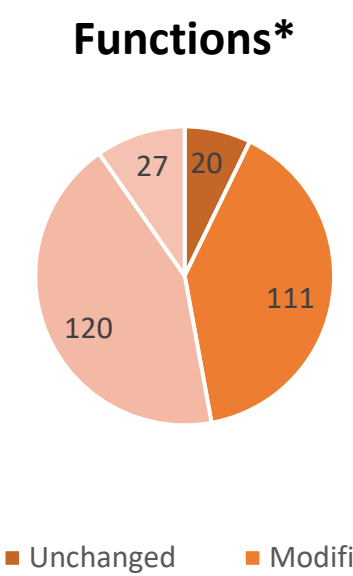
Refined Sub-Architectures and added 4 New Sub-Architectures

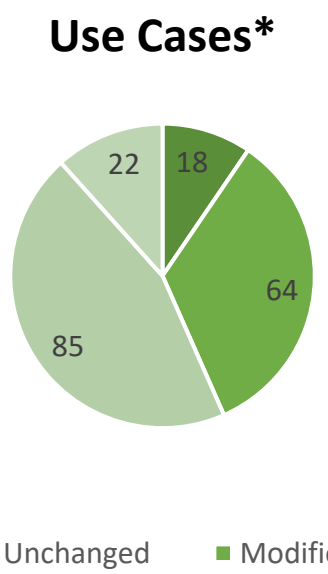
Communication, Positioning, Navigation, and Timing Systems	A group of services that enable the sending or receiving of information, ability to accurately and precisely determine location and orientation, capability to determine current and desired position, and ability to acquire and maintain accurate and precise time from a standard.
Data Systems and Management	The group of capabilities that works together to transfer, distribute, receive, validate, secure, decode, format, compile, and/or process data and commands for use throughout the architecture. This includes future capabilities such as internet of things (ioT), cloud computing, servers, etc.
Habitation Systems	A group of capabilities that provide controlled environments to ensure crew health and performance.
Human Systems	The overall capabilities of the crew, ground personnel, and the supporting systems required to develop and execute safe and successful crewed and uncrewed missions.
Infrastructure Support	The group of support capabilities including facilities (e.g., structures, site improvements), systems (e.g., environmental monitoring, contamination control, food/crop management), operations planning and control, equipment (e.g., access, construction, heavy equipment & common tools), and services (e.g., commodity storage & handling; inspection, maintenance, and repair) needed across all domains (i.e., Earth, in space, and surfaces).
In-Situ Resource Utilization Systems (ISRU)	The group of capabilities dealing with estimating resource reserves and harvesting these resources to generate products (e.g., consumables, feedstocks for manufacturing and construction) on other planetary bodies (the Moon, Mars, etc.) or environments to further the goals of a project or mission while reducing the reliance on Earth-based resources and make space missions more sustainable and cost-effective.

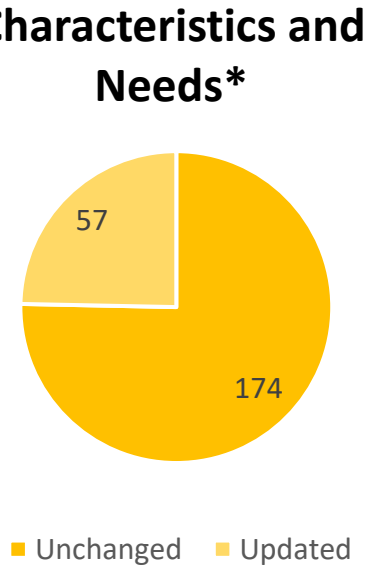
Logistics Systems	Systems and capabilities needed for packaging, handling, staging, storage, tracking, and transfer of logistics items and cargo, including equipment, spares required for anticipated repairs, materials, supplies, and consumables including capability for disposal.
Mobility Systems	A group of capabilities and functions that enable mobility of crew and/or cargo on and around the surface of the destination, including extravehicular activity systems.
Power Systems	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.
Autonomous Systems and Robotics	A group of capabilities which are accomplished with the use of software and hardware devices that can assist the crew and operate during uncrewed periods with remote operator control (tele-robotics) and/or perform work autonomously.
Transportation Systems	Capabilities that provide the transportation functions for all phases of the Moon and Mars missions for both crew and cargo, including in-space, Entry, Descent, and Landing (EDL), and ascent for all Earth, Moon, and Mars phases.
Utilization Systems	A group of capabilities whose primary function is to accomplish utilization which enables science and technology demonstrations.

What's New for ADD Revision A Cont.

- **Refined/Expanded M2M Objective Decomposition into Characteristics and Needs & Use Cases and Functions**







- **Added Synopsis of Architecture Decision Process and Roadmap**
  - Describes at a high-level the process for determining a logical flow of architectural decisions

*Final numbers are subject to change

What's New for ADD Revision A Cont.

- **Refined Human Lunar Return Segment**
  - Includes updated and M2M Objective decomposition into use cases and functions with element mapping
- **Expanded Foundational Exploration Segment**
  - Established M2M Objective decomposition into use cases and functions with element mapping for FE Segment
- **Refined Initial Human to Mars**
  - Content updated based on assessments and analysis from this year's Strategic Analysis Cycle (SAC23) for ACR23
  - Includes discussion of drivers related to the Mars architectural efforts
- **Expanded Assessments to the Recurring Tenets**
  - Added discussion of all the Recurring Tenets (RT) and their application throughout the Moon-to-Mars architecture including updates to RT-1 International Partnerships

White Papers for ACR23

Topic	Suggested from Workshops	Topic	Suggested from Workshops
Round-Trip Mars Mission Mass Challenges	☑	Lunar Communications and Navigation Architecture: Human Lunar Return	
Mars Mission Abort Considerations		Human Health Countermeasures: Keeping Astronauts Safe & Productive on a Mission to Mars	☑
Safe and Precise Landing at Lunar Sites	☑	Exploration Lessons from the ISS	☑
Mars Communication Disruption and Delay		Lunar Logistics Drivers and Needs	
Mars Surface Power Generation Challenges and Considerations		Analytical Capabilities In-situ Versus Mass of Returned Lunar Samples	☑
Lunar Surface EVA Architectural Drivers		Lunar Site Selection	

*Titles are subject to change