National Aeronautics and
Space Administration

NASA Advisory Council
Moon to Mars Architecture Updates

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Strategy and Architecture Office
Exploration Systems Development Mission Directorate

11/17/2023

STRATEGY AND ARCHITECTURE OFFICE
EXPLORATION SYSTEMS DEVELOPMENT MISSION DIRECTORATE

Agenda

- **Organizational Updates**
- **ACR23 Status**
- **Element Initiation**

National Aeronautics and
Space Administration

Exploration Systems Development Mission Directorate (ESDMD)

Office of the
Associate Administrator

Strategy and
Architecture Office*
HQ

Moon to Mars
Program Office
HQ

ESDMD
Business Office
HQ

Mars Campaign
Office
HQ

Safety and Mission
Assurance Office
HQ

Systems Engineering
and Integration Office*
HQ

Exploration
Operations
JSC

Program Planning
and Control Office
HQ

PROGRAMS

EVA and Human
Surface Mobility
JSC

Exploration
Ground Systems
KSC

Gateway
JSC

Human Landing
System
MSFC

Orion
JSC

Space Launch
System
MSFC

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

Exploration Systems Development Mission Directorate (ESDMD)

Strategy and Architecture Office*

- Defines architecture for crewed exploration of the Moon and Mars.
- Maintains the agency's baseline exploration architecture.
- Engages and integrates other stakeholder input into the architecture.
- Guides applicable programs and projects through the pre-formulation phase.

Moon to Mars Program Office

- Supervises development and operations of individual Moon to Mars elements.
- Manages and accepts risk for Moon to Mars crewed exploration efforts.
- Integrates the design, engineering, operations, and budget formulation for elements.
- Oversees Artemis mission preparation, training, operations, and execution.

ESDMD Business Office

- Takes responsibility for budget formulation and integration for the mission directorate.
- Reports budget, cost, and performance to stakeholders.
- Distributes funding for directorate efforts.
- Oversees planning, documentation, human resources, information technology, etc.

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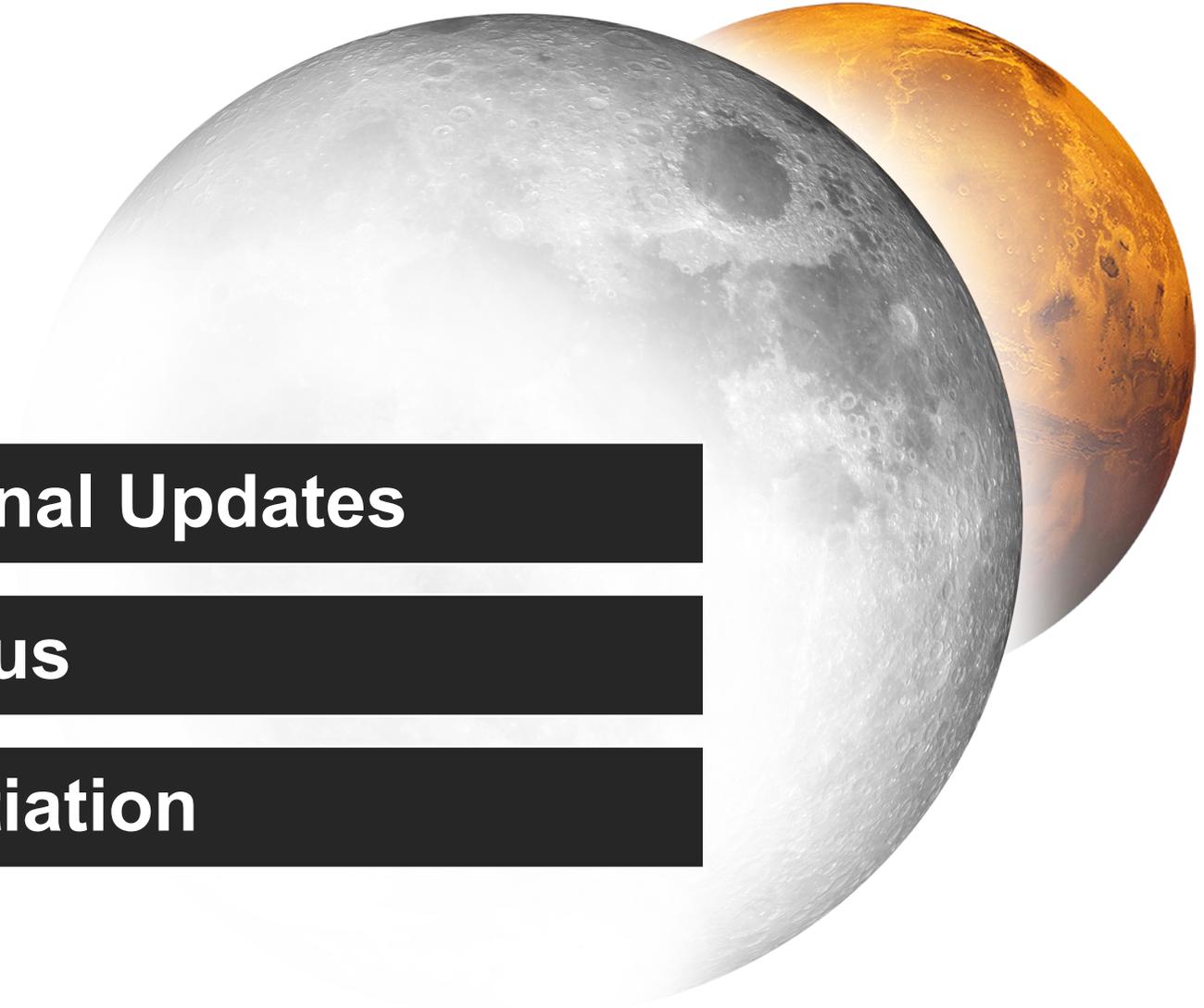
ACR23 Status

2023 Architecture Concept Review

Key Dates

ACR23
November 14-16, 2023

Executive Council
January 18, 2024

Product Release
January 22, 2024

International Partner Workshop
February 20, 2024

Industry/Academia Workshop
February 22, 2024
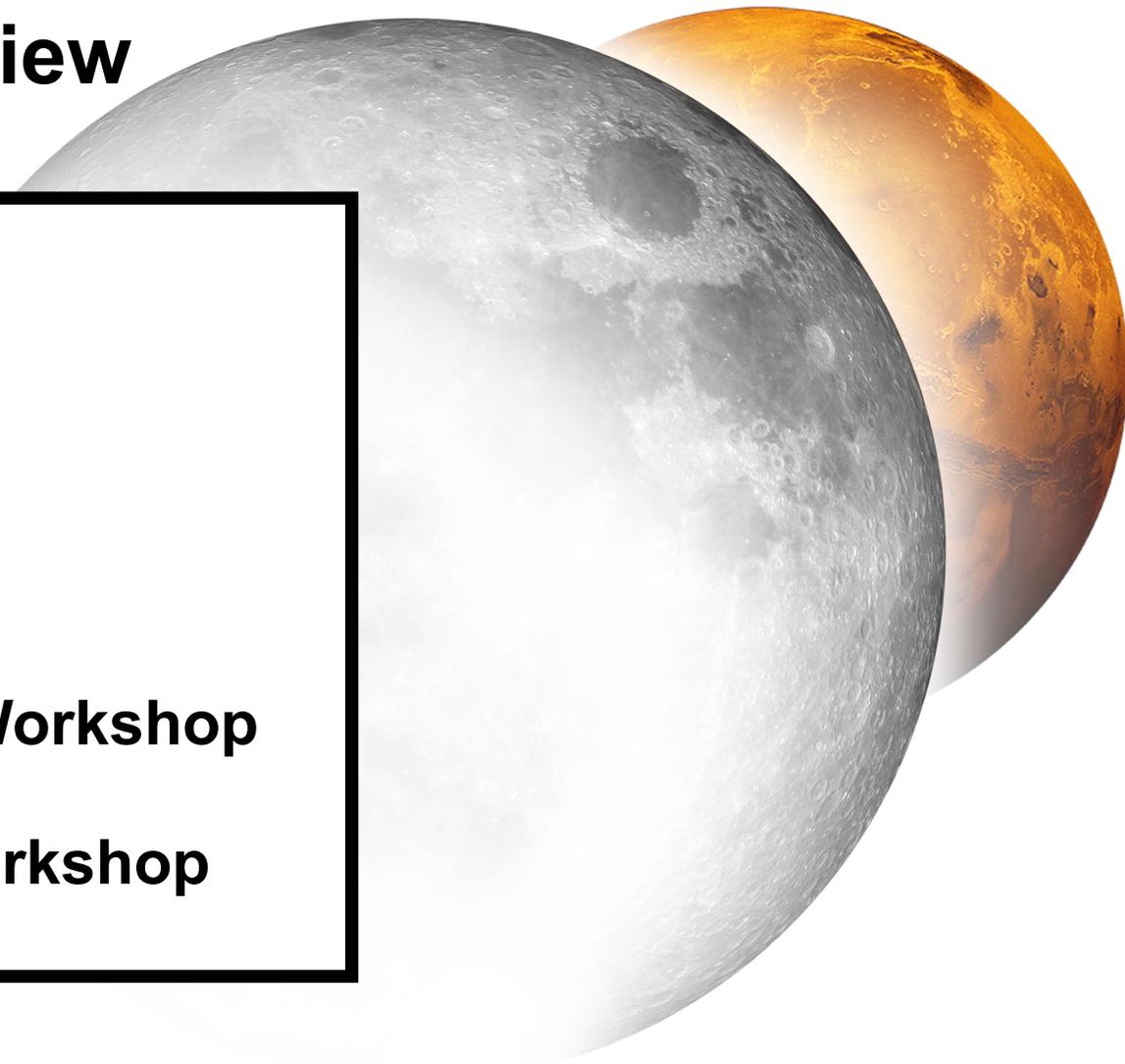
2023 Architecture Concept Review

NASA's Kennedy Space Center
November 14-16, 2023

- The agency's annual Architecture Concept Review process enabled stakeholders across NASA and among its partners to provide feedback on our Moon to Mars exploration plans.

- Products that come out of the Architecture Concept Review include updates to the agency's Architecture Definition Document and White Papers highlighting key results from that year's Strategic Analysis Cycle.

- ACR23 focused on refining and adding subarchitectures, adding mature elements, and architectural strategies for the first crewed missions to Mars.

Architecture Definition Document (ADD)
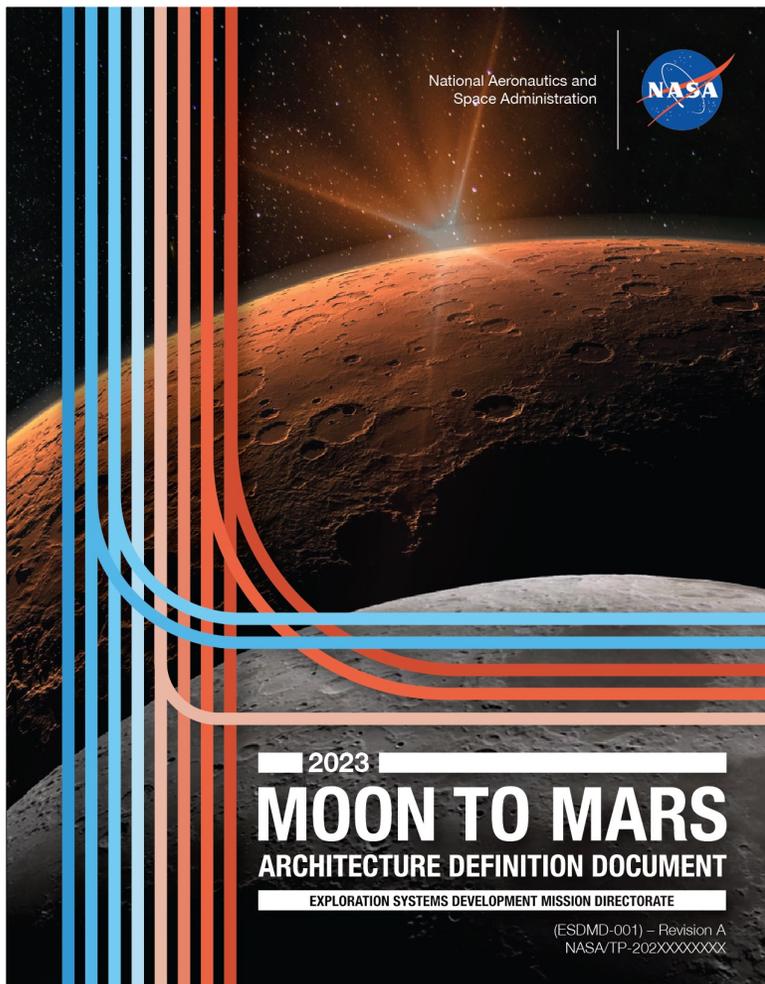
Draft Cover Art for the 2023 Revision of the ADD

📅 **Rev A Publication**
January 22, 2024

- The Architecture Definition Document is a NASA-published reference document that presents the current state of the human spaceflight architecture and exploration strategy.
  - The document decomposes Moon to Mars objectives into functions and use cases for allocation to implementable programs and projects.
  - It includes current partnerships presence in the architecture, identifies architectural gaps, and presents opportunities for further collaboration.
  - It is **NOT** a requirements document, a mission definition document, a planning manifest, or a procurement strategy.
  - The current version was published April 1, 2023.

- NASA plans to publish yearly updates to the Architecture Definition Document, incorporating the results of the prior year's Architecture Concept Review.

# What's New in Revision A?

Addition of Mature Elements:

Provided by the Canadian Space Agency (CSA) ◯

Provided by the European Space Agency (ESA) ◯

Lunar Terrain Vehicle (LTV)

Gateway Extra-Vehicular Robotic System (GERS)

Pressurized Rover (PR)
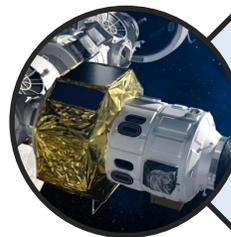
Gateway European System Providing Refueling, Infrastructure, and Telecommunications (ESPIRIT) Refueling Module (ERM)
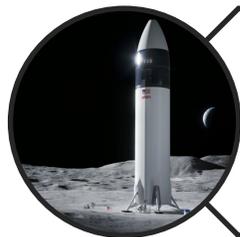
Human-class Delivery Lander (HDL)
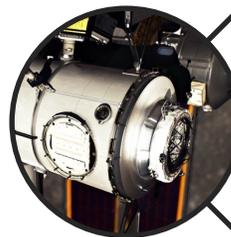
Gateway Airlock Module

*Elements will be documented once they pass internal NASA Mission Concept Review (MCR) Milestone and international agreements on project cooperation are concluded

Architecting from the Right

Strategy and Architecture Office (SAO)

Architecture

Organized by segments and sub-architectures in the Architecture Definition Document (ADD) to group similar features and express the progression of capabilities over time.

Moon to Mars Objectives

Agency Level

SEGMENTS
Use Cases

Operations executed to produce desired needs and/or characteristics.

(grouped to form reference missions)

Reference Missions

Characteristics & Needs

Features, activities, and capabilities necessary to satisfy the goals and objectives.

Objectives & Goals

Leadership defines blueprint vision for the Moon-to-Mars endeavor.

Program Level

Design Reference Missions / ConOps

SUB-ARCHITECTURES
Functions

Actions an architecture performs to complete a desired use case.

Elements / Requirements

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.

What's New in Revision A?

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

Functions*

135
22
251
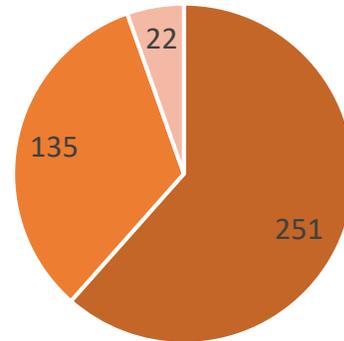
■ Unchanged ■ Updated ■ New

Use Cases*

2
52
115
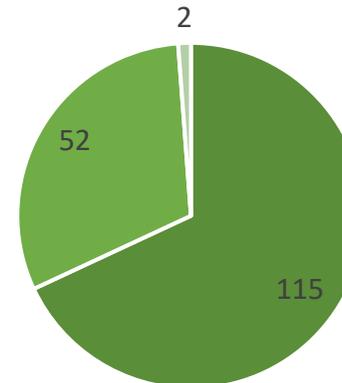
■ Unchanged ■ Updated ■ New

Characteristics and Needs*

57
174
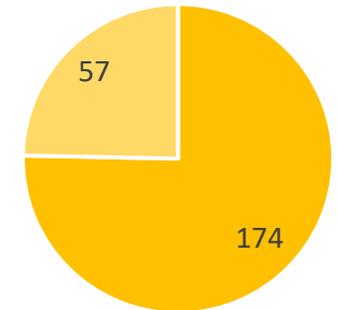
■ Unchanged ■ Updated

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

What's New in Revision A?

Refined Human Lunar Return Segment

- Includes updated objective decomposition into use cases and functions with element mapping.

Expanded Foundational Exploration Segment

- Establishes objective decomposition into use cases and functions with element mapping for the foundational exploration segment.

Refined Initial Human to Mars

- Updates content based on the results of this year's Strategic Analysis Cycle (SAC23) for the Architecture Concept Review (ACR23).
- Includes discussion of drivers related to the Mars architectural efforts.

Expanded Assessments to the Recurring Tenants

- Added discussion of Recurring Tenets (RT) throughout the architecture including updates to RT-1, International Partnerships.

White Papers (×12)

Publishing 12 White Papers alongside Architecture Definition Document Revision A

Mars Communication
Disruption and Delay

Safe and Precise
Landing at Lunar Sites

Mars Mission
Abort Considerations

Exploration Lessons Learned
from the Space Station

Surface EVA
Architectural Drivers

Human Health and Performance
for Mars Missions

Lunar Communications
and Navigation Architecture

Lunar
Site Selection

Mars Surface
Power Generation

Analytical Capabilities
In-situ vs. Returned

Lunar Logistics
Drivers and Needs

Round Trip Mars Mission
Mass Challenges

Suggestion from 2023 Architecture Workshops

Architecture Workshops
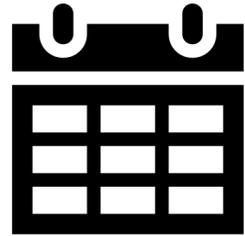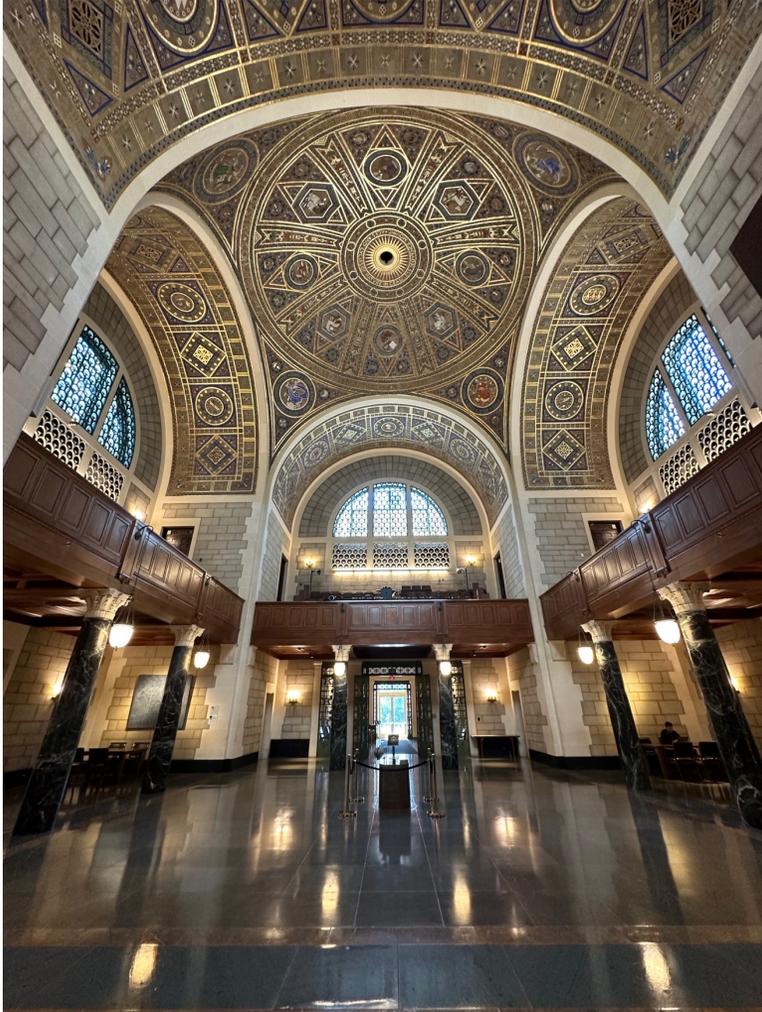
📅 **Save the Dates Sent**
October 23, 2023
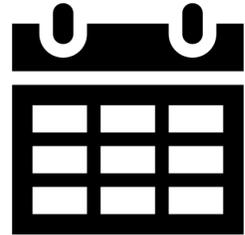
📅 **For International Partners**
February 20, 2024
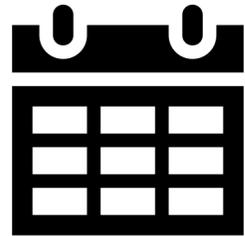
📅 **For Industry and Academia**
February 22, 2024

2024 Strategic Analysis Cycle

- The 2024 Fiscal Year will be first full, annual cadence for the new Architecture Concept Review.

- The architecture team endeavors to ensure repeatability and identify lessons learned for subsequent cycles.

- The volume of needed analysis, integration, and workload will be matched to available agency resources.

- Our priority is producing quality assessments that can be supported programmatically in implementation while ensuring communication with and feedback from the NASA community and government, industry, academic, and international stakeholders.

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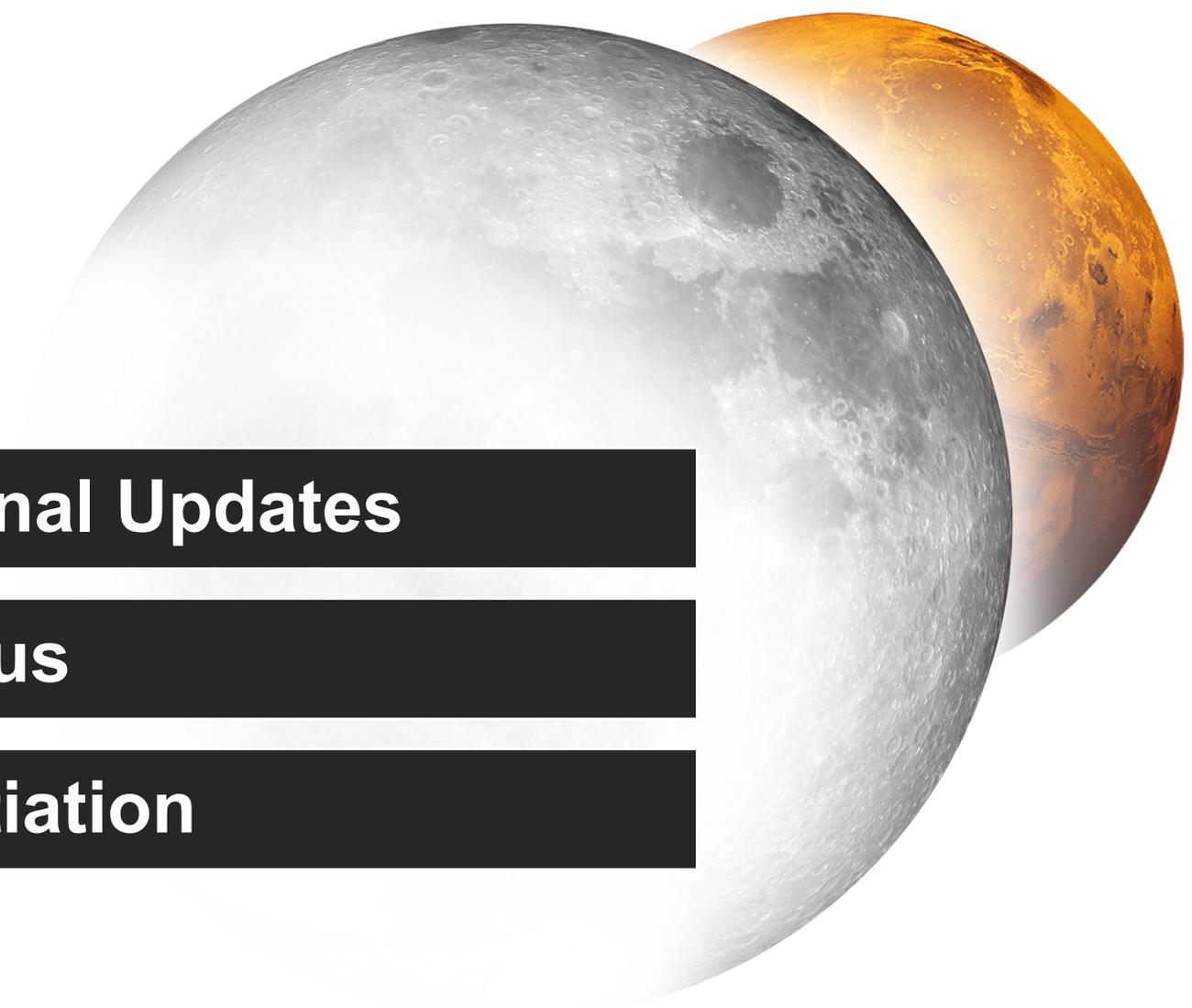
Current Process Limits

Historically, human spaceflight formulation have often been transient teams for single efforts. As a result, repeatable processes were not been established in many cases.

- **NASA Policy Directive 1000.5**
Acquisition strategy placement occurs _after_ mission concept review.

- **NASA Procedural Requirement 7120.5**
Program project process _begins_ at formulation milestone.

- **NASA Systems Engineering Handbook**
Describes formulation functions but _does not_ articulate ownership or process preceding a program.

Moon to Mars efforts are multi-decadal, necessitating consistent and repeatable processes.

Element Initiation

A New Pre-formulation Process

Meeting a Need

- Historically, exploration programs and projects have been developed through a variety of teams, processed, and functions.

- Inconsistency in technical maturity and mission expectations at formulation has led to issues for implementing programs including cost, schedule, and risk.

- Clarity and consistency in formulation and definition is necessary for NASA to execute the Moon to Mars exploration effort.

Element Initiation Purpose

- An overt integration point initiated by the Strategy and Architecture Office where the mission directorate commits to formulate element based on an identified architecture gap.

- The element initiation afirms a proposed element aligns to an architectural need and implies intent to apply necessary resources to formulate that element.
  - Includes initial use case and functions within the architecture, as well as a preliminary concept.
  - Highlights potential scope of international contributions to further bilateral study commitments.
 - Identifies a team to develop products needed for a successful mission concept review.
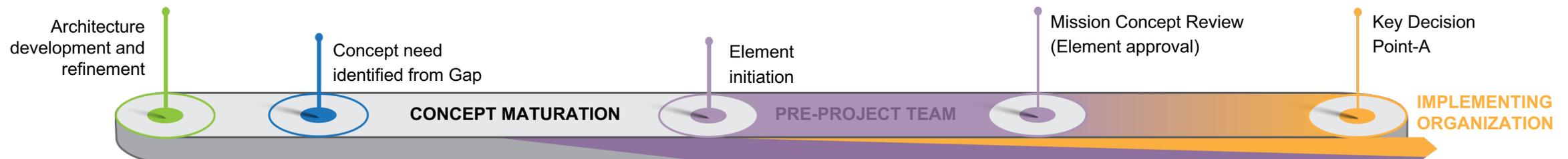
Architecture development and refinement

Concept need identified from Gap

Element initiation

Mission Concept Review (Element approval)

Key Decision Point-A

CONCEPT MATURATION

PRE-PROJECT TEAM

IMPLEMENTING ORGANIZATION
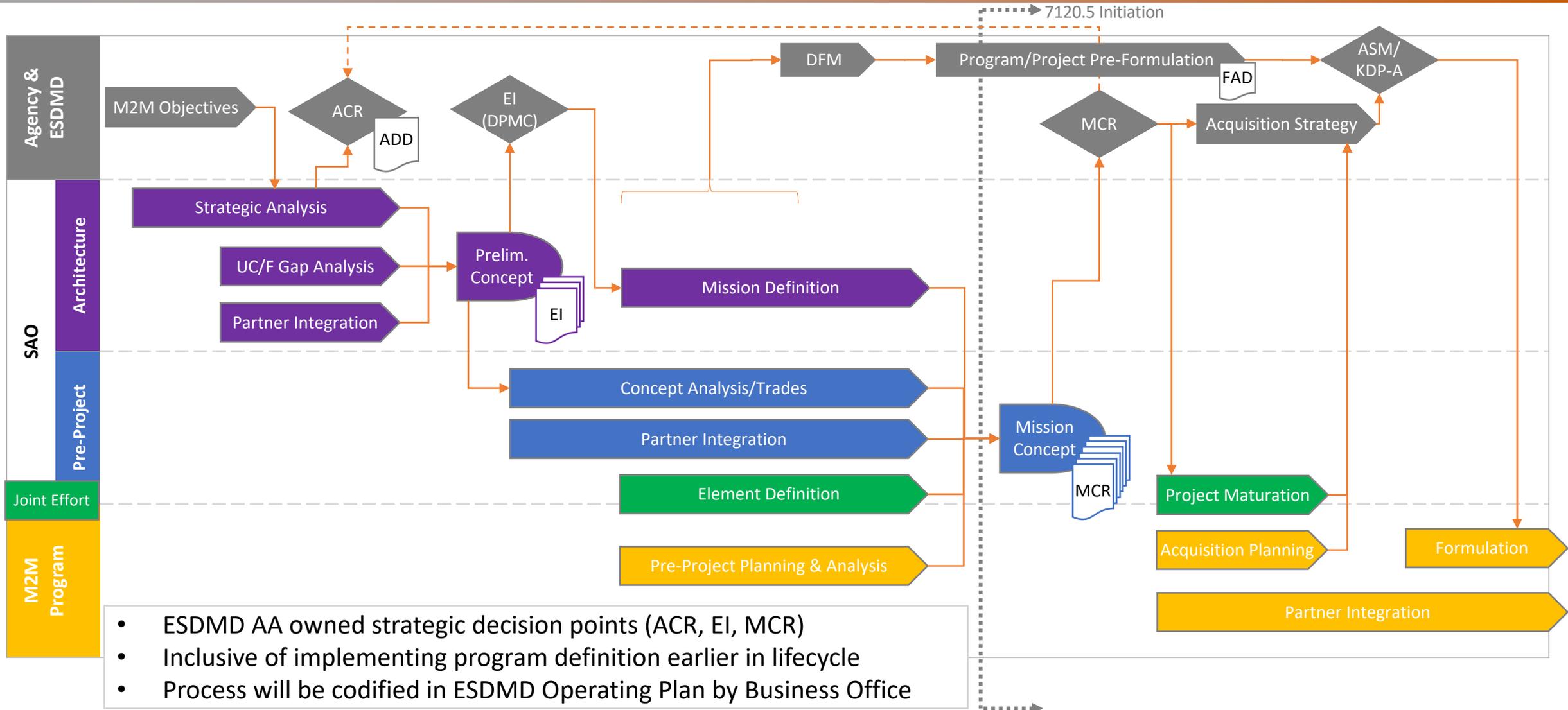
nasa.gov/architecture

Moon to Mars Architecture, Objectives, White Papers and More