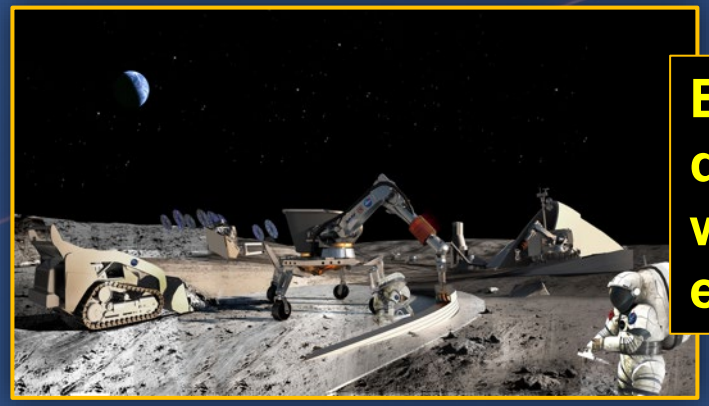
NASA's Space Technology Mission Directorate Overview And Moon-to-Mars Strategic Framework

Walt Engelund | Deputy Associate Administrator for Programs, Space Technology Mission Directorate

Ensuring American global leadership in Space Technology

STMD is building upon the Strategic Technology Framework creating an integrated strategy that shows our investments across technical thrust areas leading to achieving strategic outcomes

Advance US space technology innovation and competitiveness in a global context



Encourage technology driven economic growth with an emphasis on the expanding space economy

Inspire and develop a diverse and powerful US aerospace technology community

SPACE TECHNOLOGY PORTFOLIO

EARLY STAGE INNOVATION AND PARTNERSHIPS

- Early Stage Innovation
  - Space Tech Research Grants
  - Center Innovation Fund
  - Early Career Initiative
  - Prizes, Challenges & Crowdsourcing
  - NASA Innovation Advanced Concepts
- Technology Transfer

SBIR/STTR PROGRAMS

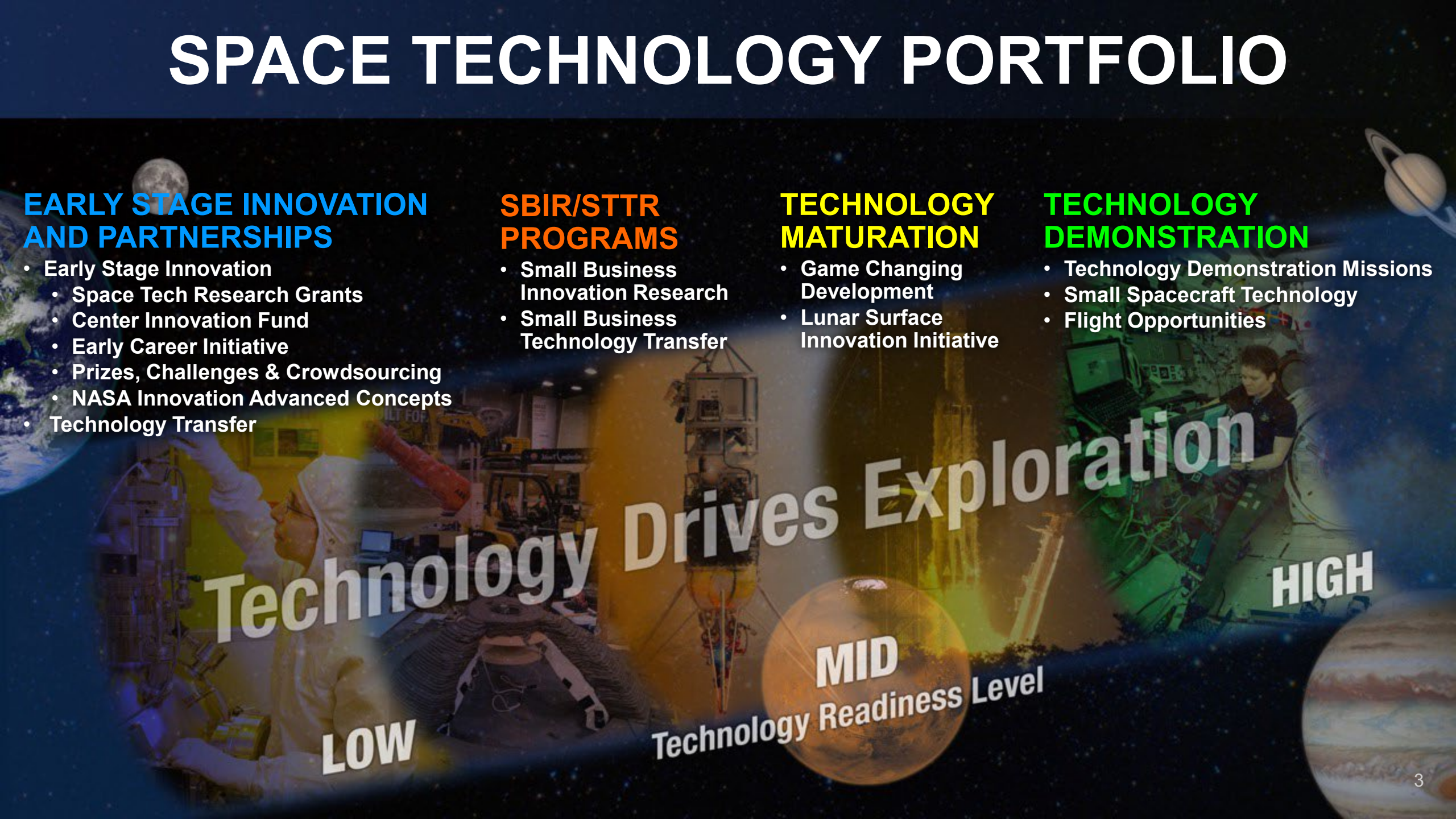
- Small Business Innovation Research
- Small Business Technology Transfer

TECHNOLOGY MATURATION

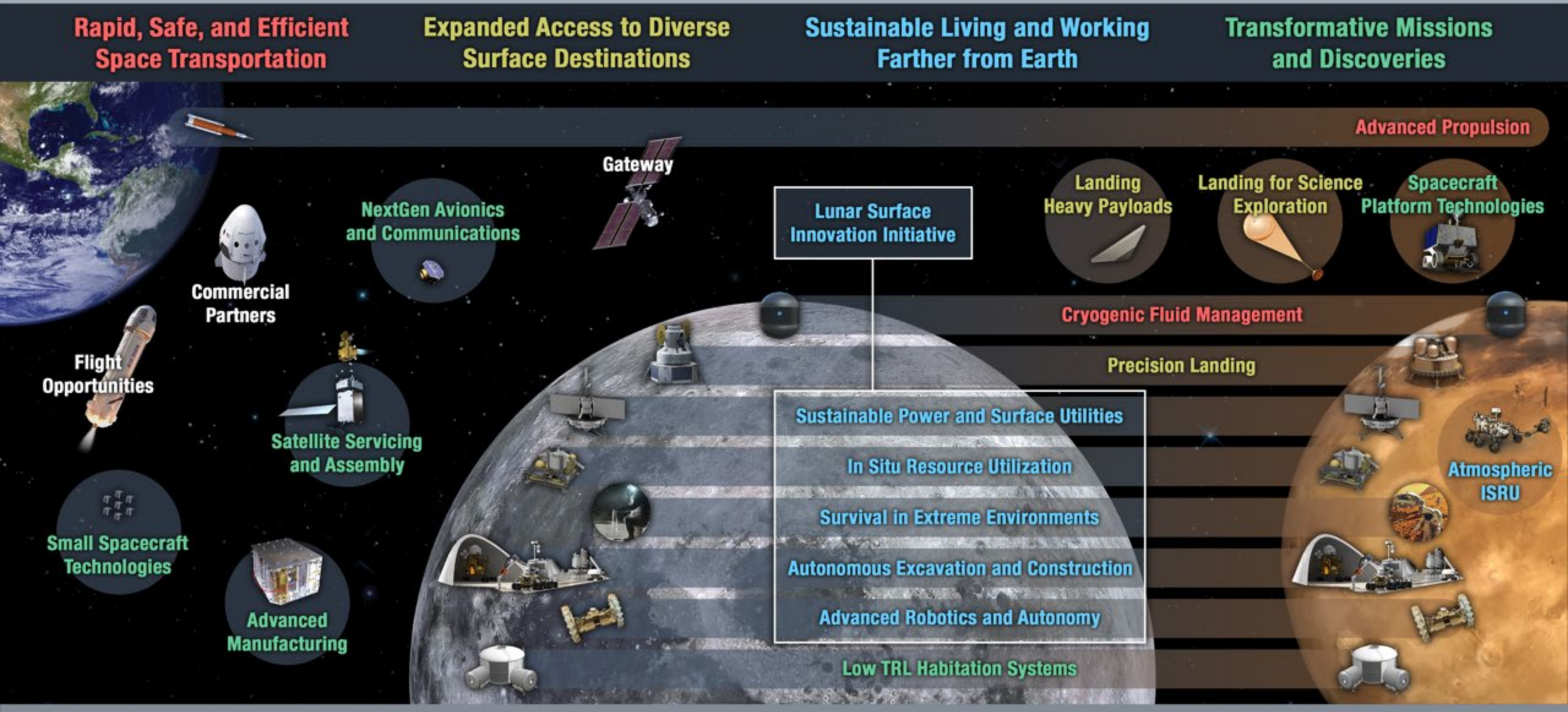
- Game Changing Development
- Lunar Surface Innovation Initiative

TECHNOLOGY DEMONSTRATION

- Technology Demonstration Missions
- Small Spacecraft Technology
- Flight Opportunities

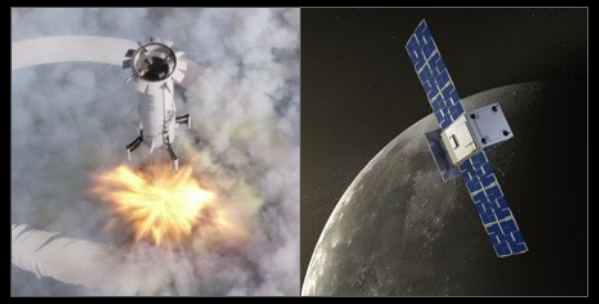


Ensuring American Global Leadership in Space Technology



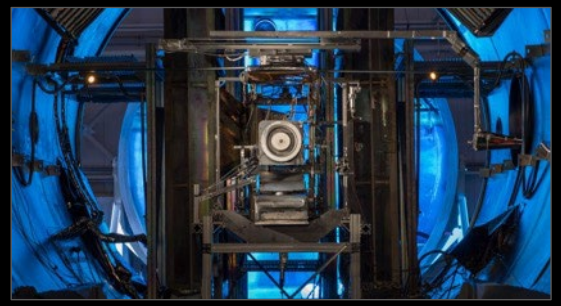
Technology Drives the Space Economy

STMD FY 2022-2023 Highlights



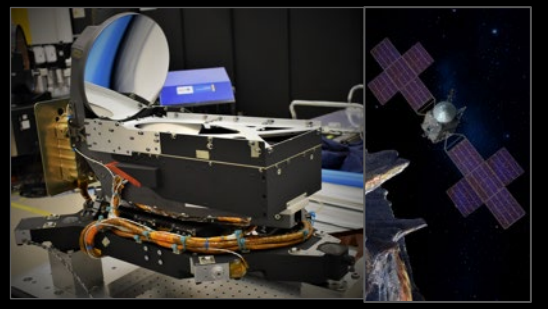
Flight Opportunities and Small Spacecraft Technology

- 35+ suborbital and small spacecraft flights planned ’22 - ‘23
- CAPSTONE lunar mission launch in May ‘22 in support of Artemis program



Solar Electric Propulsion
April 2023

Qualification thruster #1 assembly complete



Deep Space Optical Communications

- Delivered in June 2021
- Tech demo flying with Psyche mission to a metal asteroid (Oct 2023)

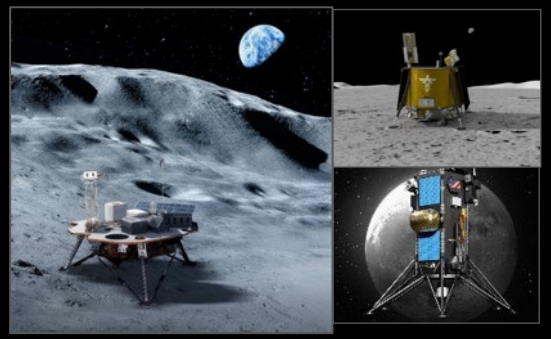
LOFTID Mission
November 2022

In partnership with ULA, tested an inflatable heat shield - the largest blunt body aeroshell ever demonstrated

DARPA/NASA Nuclear Thermal Propulsion Flight Demo
Demonstration Rocket for Agile Cislunar Operations (DRACO)

Cryogenic Fluid Management
FY 2023-2026

Four (4) flight technology demonstrations



CLPS Missions
2024-25

Space tech has over 25 payloads manifested on commercial robotic landers with more opportunity in the future (Intuitive Machines, Firefly etc.)

Navigation Doppler LiDAR (NDL)
LaRC NDL CLPS Demos on Astrobotic and Intuitive Machines and commercialization through Psionic

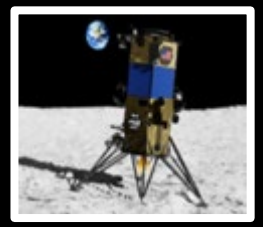
Near-term Lunar Technology Demos

Early lunar surface demonstrations, via the Commercial Lunar Payload Services (CLPS) Program, are key opportunities to mature the key capabilities required for NASA and industry.

Intuitive Machines (IM)-2 Mission Late 2024

Polar Resources Ice-Mining Experiment (PRIME-1)

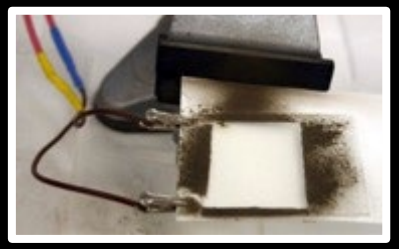
LTE Proximity Comms (Tipping Point w/Nokia)



Deployable Lunar Hopper (Tipping Point w/IM)

CLPS 19D Mission (Firefly) Late 2024

LaRC Stereo Camera for Lunar Plume Surface Studies (SCALPSS)



Electrodynamic Dust Shield (EDS)

CLPS CP11 Mission (IM) Early 2025

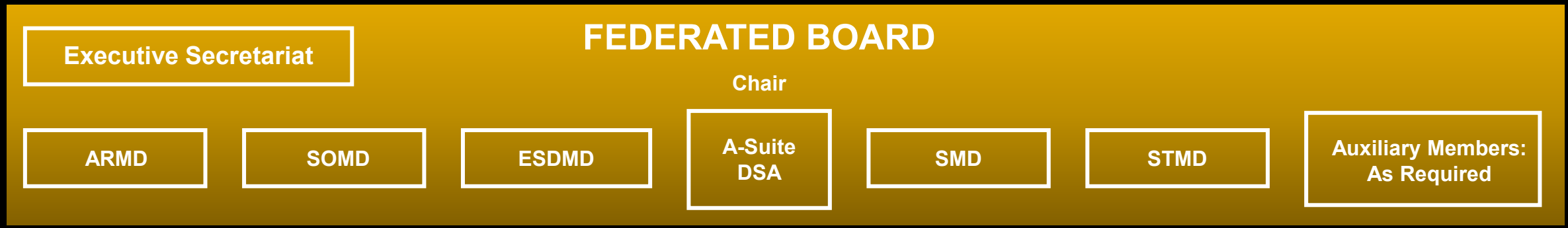
Cooperative Autonomous Distributed Robotic Explorers (CADRE)


National Aeronautics and
Space Administration
NASA
NASA'S
MOON TO MARS
STRATEGY AND
OBJECTIVES
DEVELOPMENT
A blueprint for sustained
human presence and
exploration throughout
the Solar System

Cross-Directorate Federated Board

The Federated Board (FB) seeks to drive consensus, promote efficient conflict resolution, help interpret strategic guidance and expectations from Agency leadership, and provide advice to Mission Directorate/Agency leadership, including governance councils. It is not a decision-making body.

**Revised scope emphasized structured vetting and advisory functions. Architecture ownership resides in the MD's.*



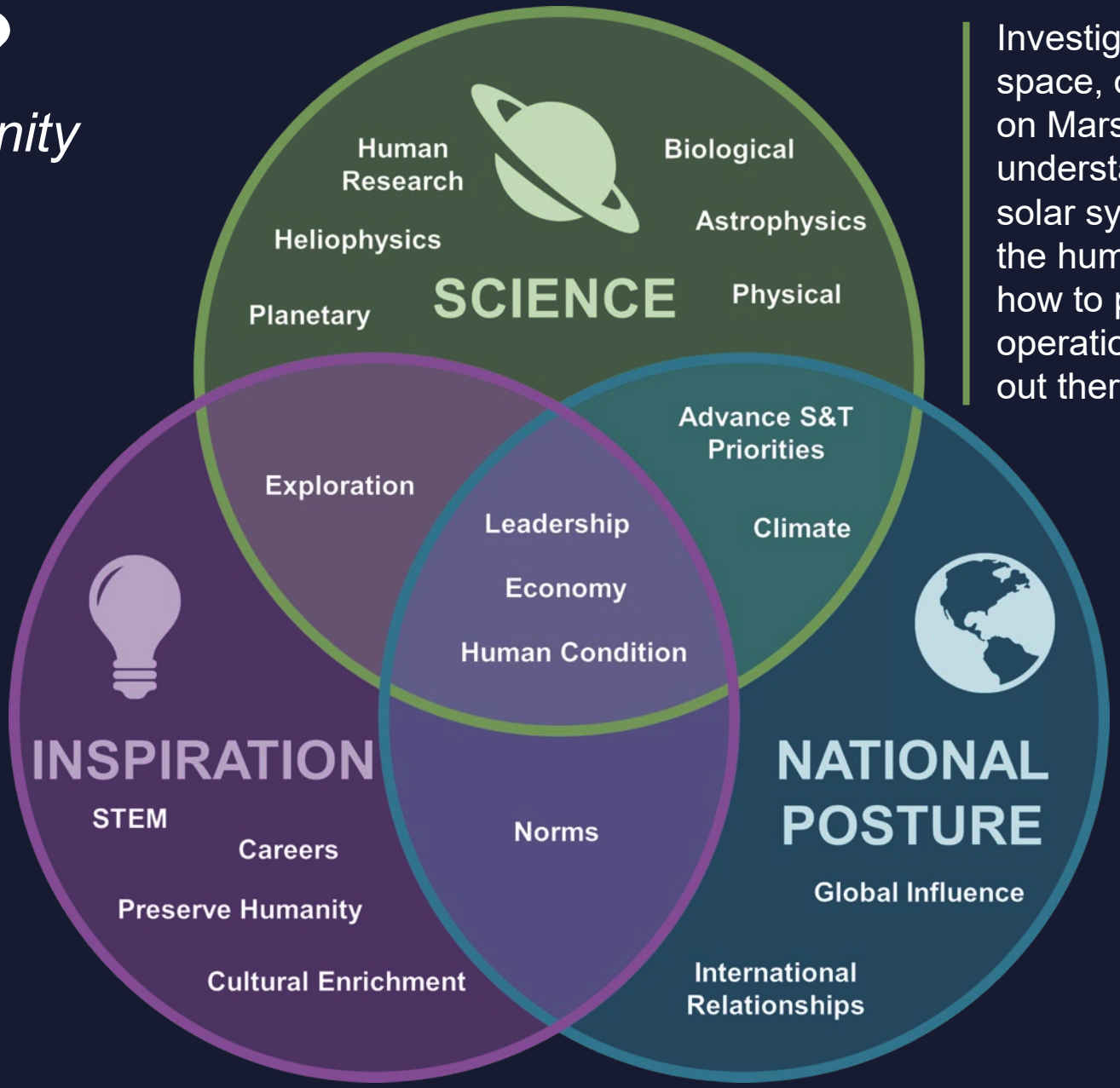
CORE FUNCTIONS

- Coordinate
- Review
- Advise
- Advocate

"Ensures Agency priorities and general architectural direction are tightly/efficiently integrated for Artemis/M2M and other activities that require coordination across the Mission Directorates (MDs)"

Why Go?

Benefits to Humanity



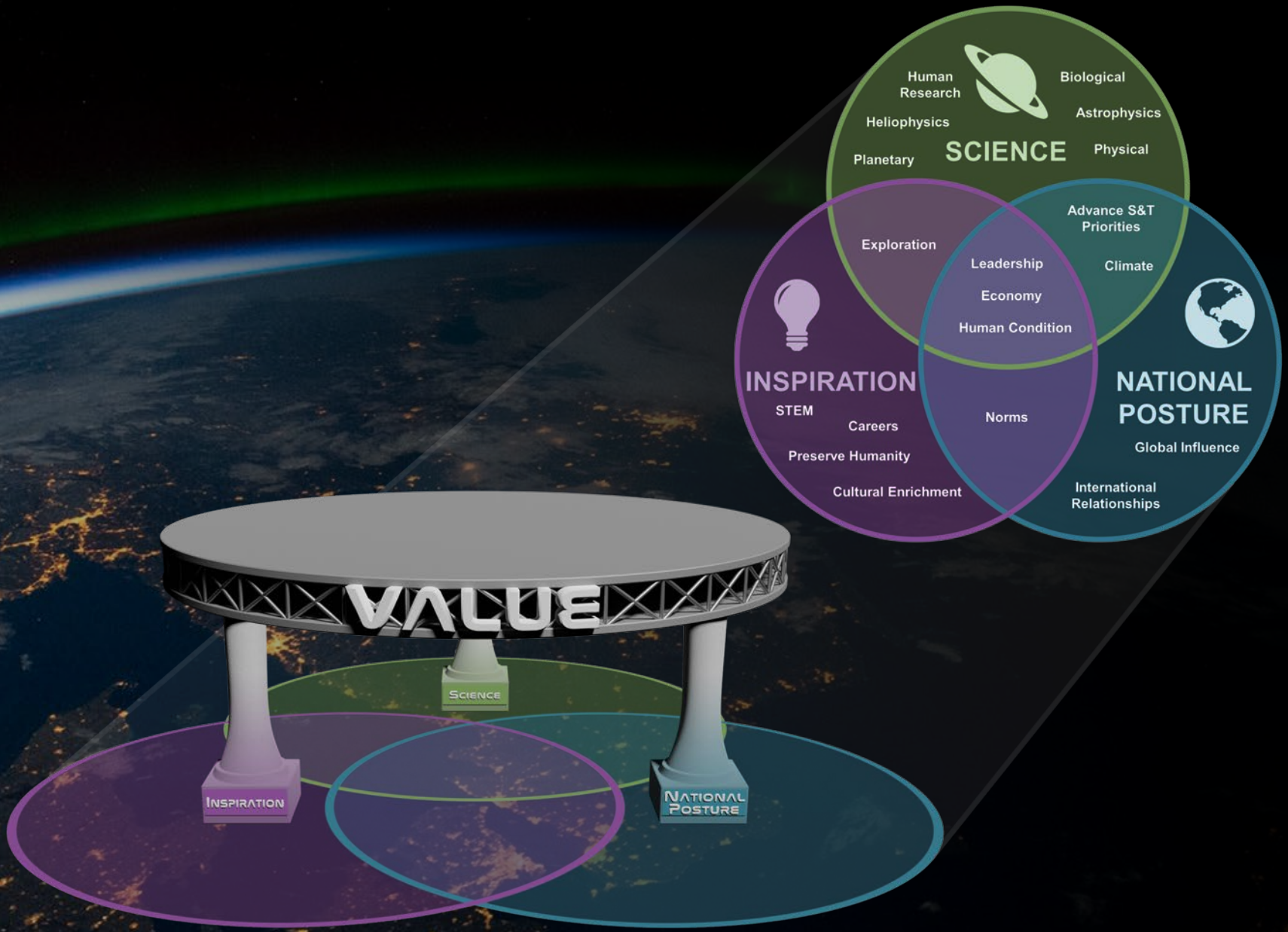
Investigations in deep space, on the Moon, and on Mars will enhance our understanding of the solar system, the Earth, the human body, and how to perform new operations while we are out there exploring.

Accepting audacious challenges and succeeding through perseverance and tenacity in the face of adversity motivates current and future generations to dare mighty things.

What we choose to do, how we do those things, and who we do them with greatly impacts our place in the world today, our quality of life, and our possibilities for the future.

Why Go?

Benefit to Citizens

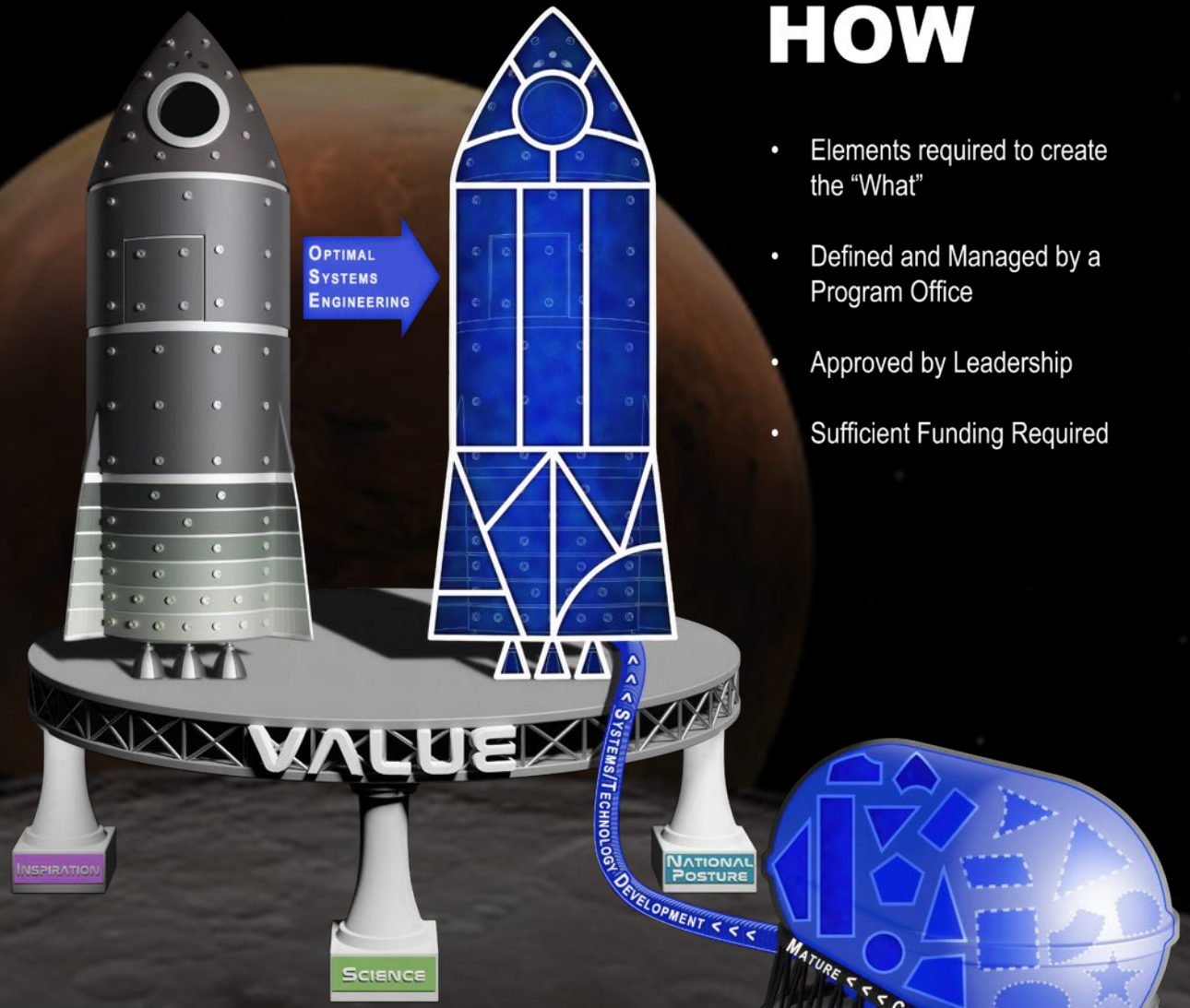


WHAT

- Rigorously Developed
- Detailed
- Consistent

HOW

- Elements required to create the “What”
- Defined and Managed by a Program Office
- Approved by Leadership
- Sufficient Funding Required



WHY

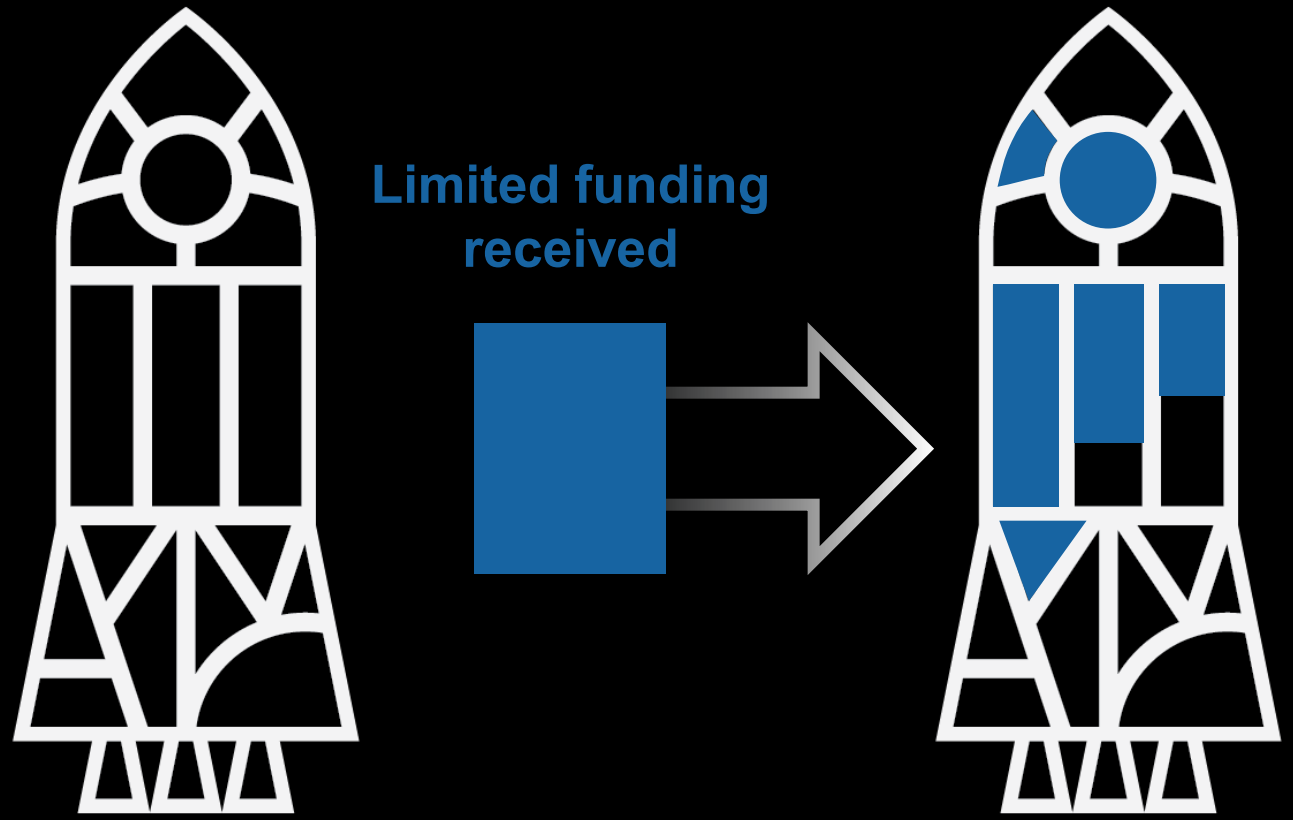
Historical Context

30+ year roller-coaster ride for Moon to Mars (M2M) development

Widespread stress/anxiety in the wake of Constellation cancellation

Capability-based approach does not fully support a long-term strategy to Mars.

The M2M Plan



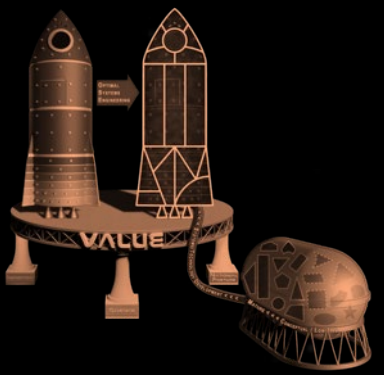
Attempts to "stick with the plan" behind the scenes…

- Initially, prioritized and prepared for more fruitful days
- Led to decentralized efforts
- Over time lose clarity on overall plan

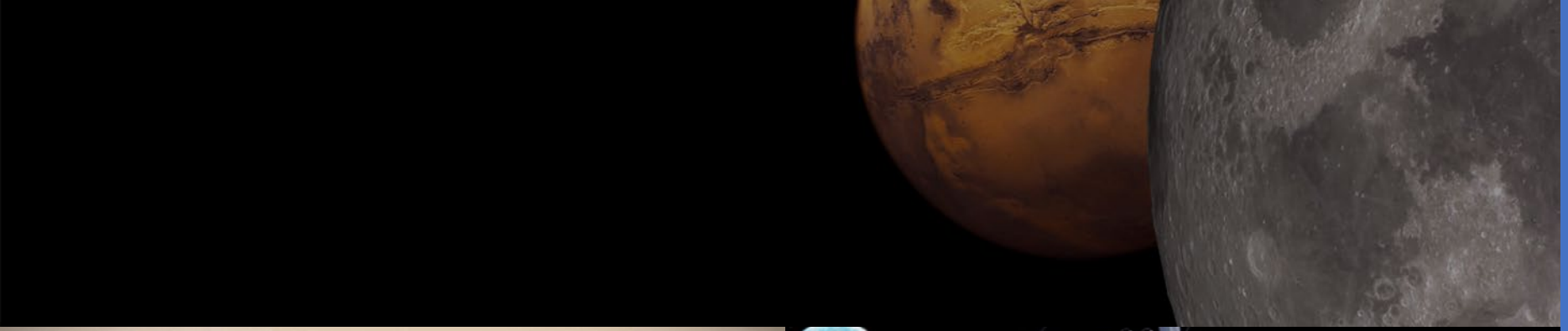
Need objective-based approach

Must think strategically…
with resilience/flexibility in mind…
to better achieve unity of purpose

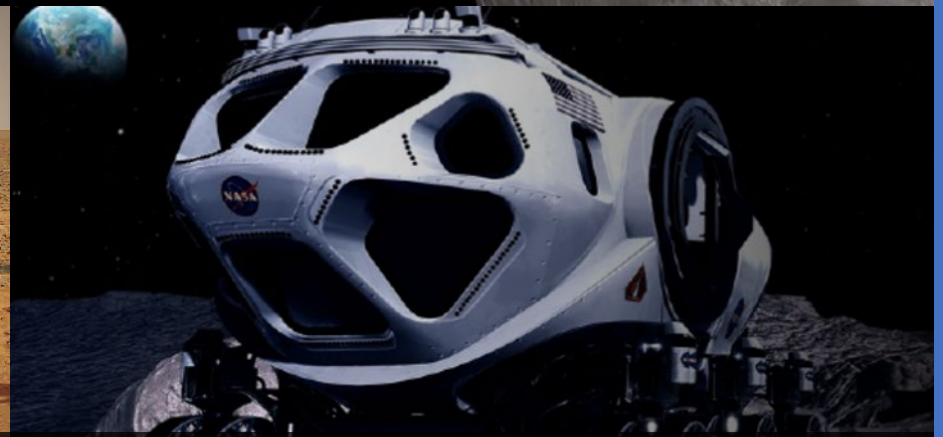
Hindrances to Effective Systems Engineering



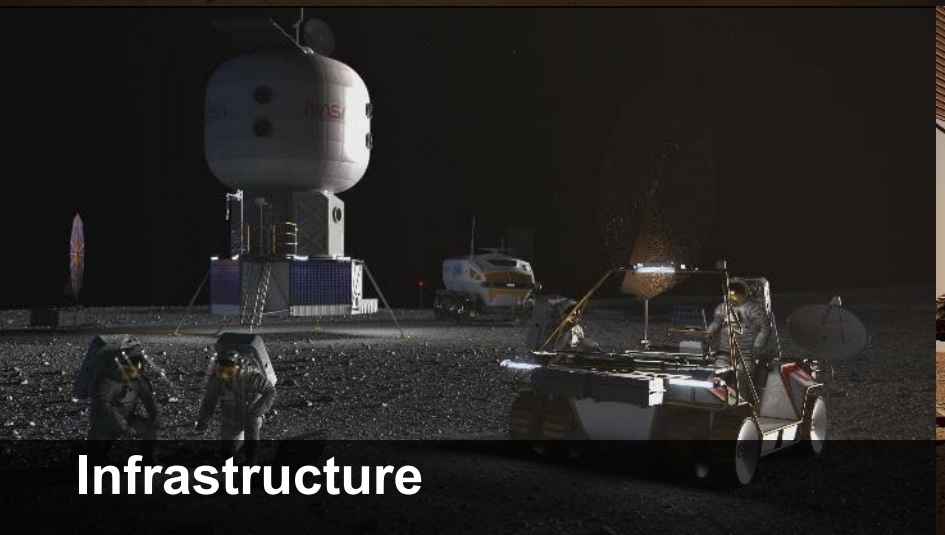
- Changing and/or broad goals
- Stovepipes
- External Pressures
- Fears of being cut
- Poor/Restricted Communication
- Insufficient Funding
- Distributed Motivations



Science



Transportation & Habitation



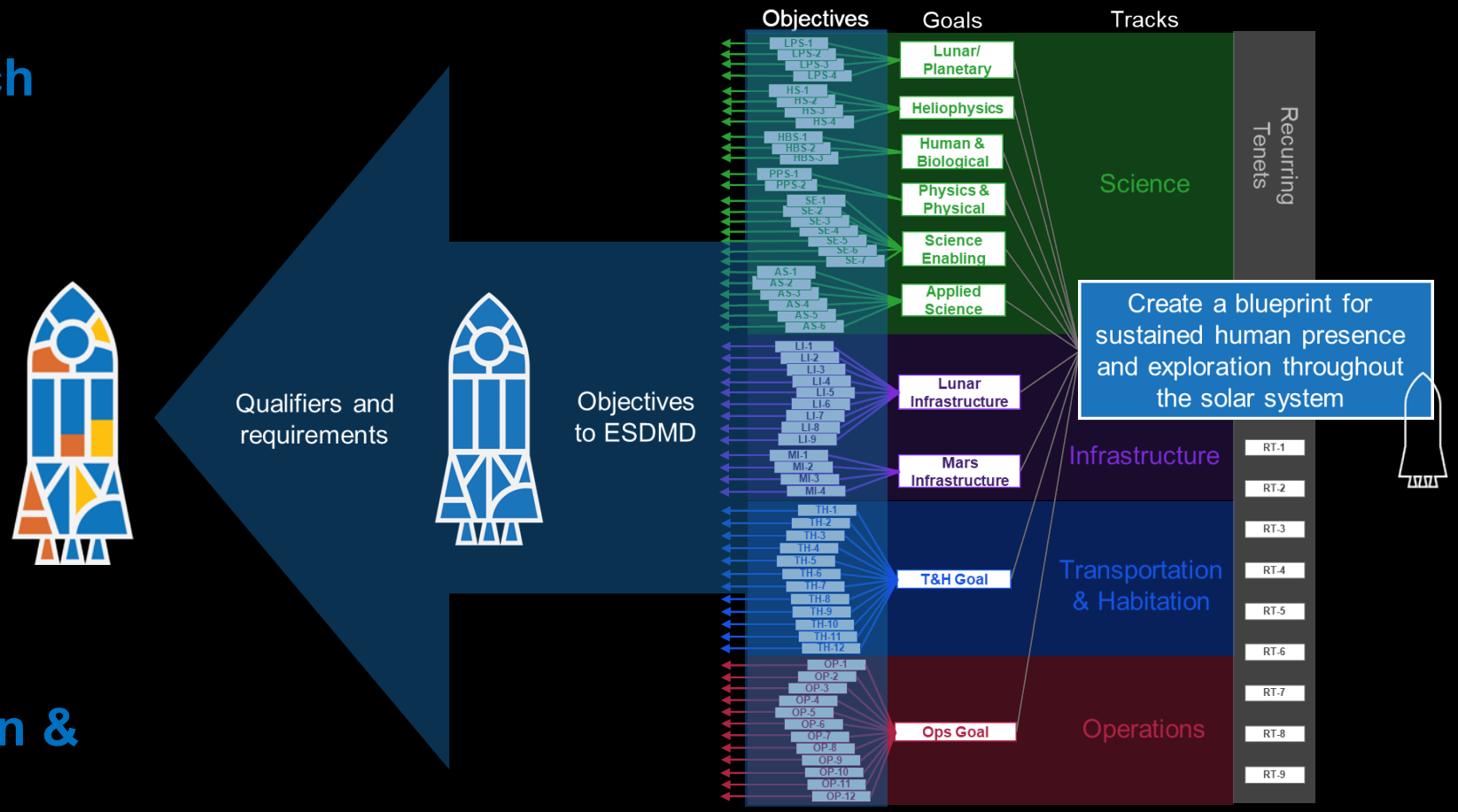
Infrastructure

Operations

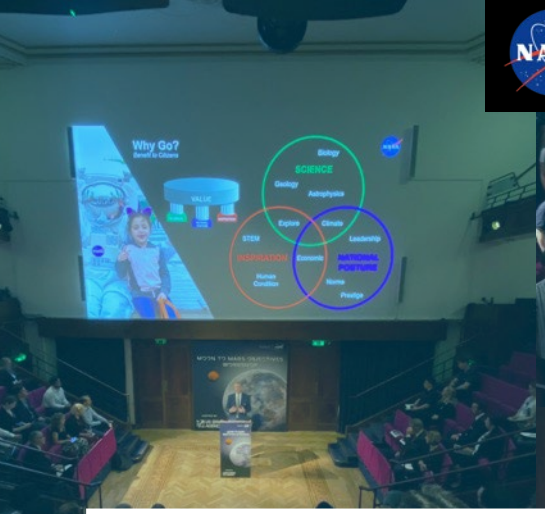
Create a blueprint for sustained human presence and exploration throughout the solar system

Methodology Principles of the M2M Strategy

- Objective-Based Approach
- Architect from the Right
- Constancy of Purpose
- Unity of Purpose
- Enhanced Communication & Engagement

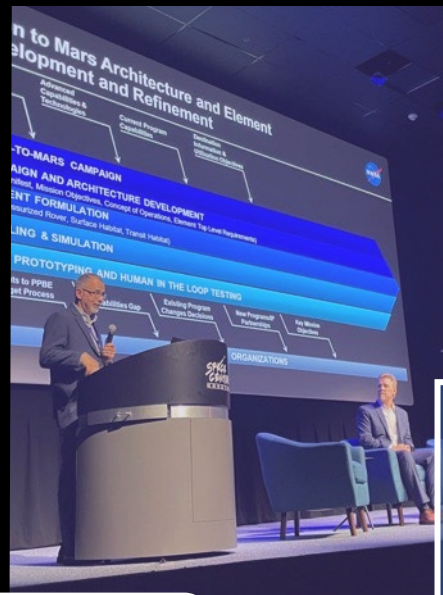


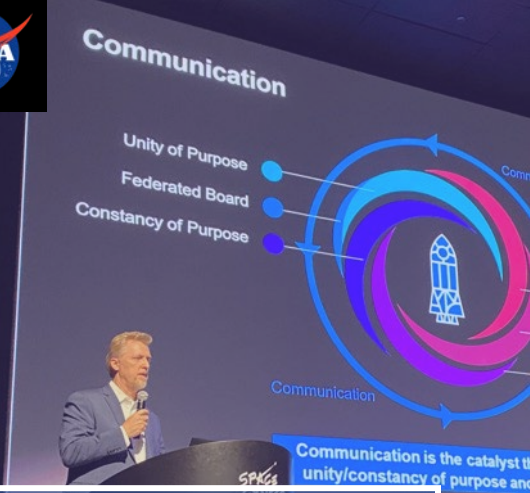
Stakeholder Outreach



International Workshops

- London, U.K.
- July 2022, 2023
- Feb 2024, Washington DC
- 22 Space Agencies

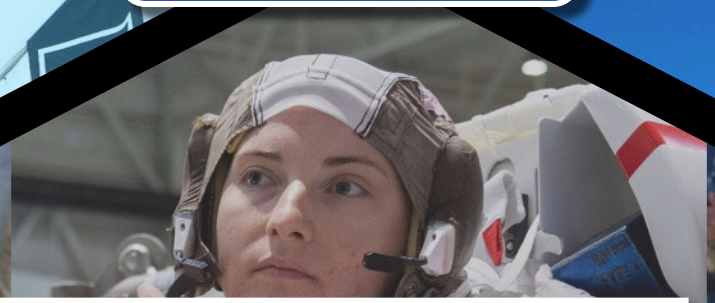




US Workshops

- June 2022, Houston, TX
- July 2023, National Harbor, MD
- Feb 2024, Washington, DC
- 900 responses
- 32 organizations

Over 5,000 inputs

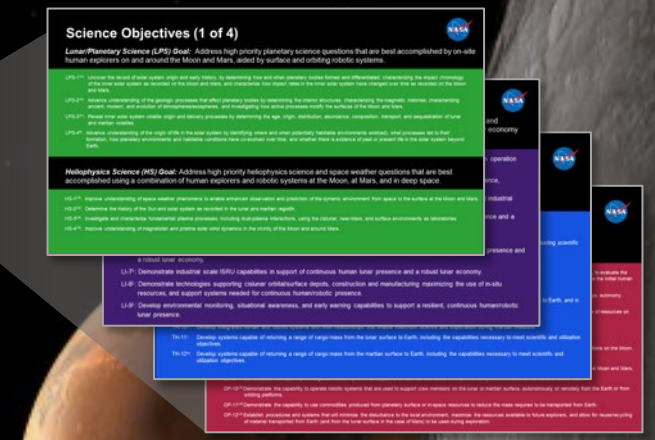


NASA@Work

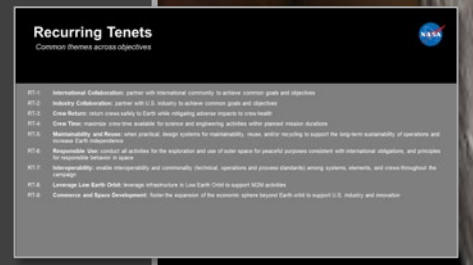
- Virtual campaign
- May 16th – June 3rd , 2022
- 156 inputs, 391 votes

Revised M2M Objectives Roll-up

- **63 Top-Level Objectives across 10 Top-Level Goals**
  - 26 Science
  - 13 Infrastructure
  - 12 Transportation & Habitation
  - 12 Operations
- **9 Recurring Tenets (RT)**
  - Common themes across objectives
- **Updated Glossary**



RT-1: **International Collaboration**
RT-2: **Industry Collaboration**
RT-3: **Crew Return**
RT-4: **Crew Time**
RT-5: **Maintainability and Reuse**
RT-6: **Responsible Use**
RT-7: **Interoperability**
RT-8: **Leverage Low Earth Orbit**
RT-9: **Commerce and Space Development**



Infrastructure Objectives (1 of 2)

Lunar Infrastructure (LI) Goal: Create an interoperable global lunar utilization infrastructure where U.S. industry and international partners can maintain continuous robotic and human presence on the lunar surface for a robust lunar economy without NASA as the sole user, while accomplishing science objectives and testing for Mars.

LI-1^{L}: Develop an incremental lunar power generation and distribution system that is evolvable to support continuous robotic/human operation and is capable of scaling to global power utilization and industrial power levels.

LI-2^{L}: Develop a lunar surface, orbital, and Moon-to-Earth communications architecture capable of scaling to support long term science, exploration, and industrial needs.

LI-3^{L}: Develop a lunar position, navigation and timing architecture capable of scaling to support long term science, exploration, and industrial needs.

LI-4^{L}: Demonstrate advanced manufacturing and autonomous construction capabilities in support of continuous human lunar presence and a robust lunar economy.

LI-5^{L}: Demonstrate precision landing capabilities in support of continuous human lunar presence and a robust lunar economy.

LI-6^{L}: Demonstrate local, regional, and global surface transportation and mobility capabilities in support of continuous human lunar presence and a robust lunar economy.

LI-7^{L}: Demonstrate industrial scale ISRU capabilities in support of continuous human lunar presence and a robust lunar economy.

LI-8^{L}: Demonstrate technologies supporting cislunar orbital/surface depots, construction and manufacturing maximizing the use of in-situ resources, and support systems needed for continuous human/robotic presence.

LI-9^{L}: Develop environmental monitoring, situational awareness, and early warning capabilities to support a resilient, continuous human/robotic lunar presence.

Superscripts indicate applicability to Lunar (L), Martian (M), or both (LM)

Infrastructure Objectives (2 of 2)

Mars Infrastructure (MI) Goal: Create essential infrastructure to support initial human Mars exploration campaign.

- MI-1^{M}: Develop Mars surface power sufficient for an initial human Mars exploration campaign.
- MI-2^{M}: Develop Mars surface, orbital, and Mars-to-Earth communications to support an initial human Mars exploration campaign.
- MI-3^{M}: Develop Mars position, navigation and timing capabilities to support an initial human Mars exploration campaign.
- MI-4^{M}: Demonstrate Mars ISRU capabilities to support an initial human Mars exploration campaign.

Superscripts indicate applicability to Lunar (L), Martian (M), or both (LM)

STMD Investment Areas Supporting Lunar Infrastructure Objectives

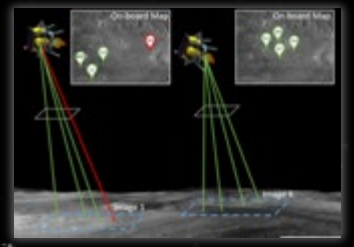
Creating an interoperable global lunar utilization infrastructure and essential infrastructure to support initial human Mars exploration campaign

LI-1^{L}: Develop an incremental **lunar power** MI-1^{M} generation and distribution system that is evolvable to support continuous robotic/human operation and is capable of scaling to global power utilization and industrial power levels.

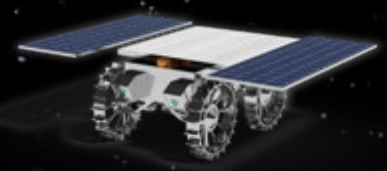
LI-2^{L}: Develop a lunar surface, orbital, and Moon-to-Earth **communications** architecture capable MI-2^{M} of scaling to support long term science, exploration, and industrial needs.

LI-3^{L}: Develop a lunar **position, navigation and timing** architecture capable of scaling to MI-3^{M} support long term science, exploration, and industrial needs.

LI-4^{L}: Demonstrate **advanced manufacturing and autonomous construction** capabilities in support of continuous human lunar presence and a robust lunar economy.

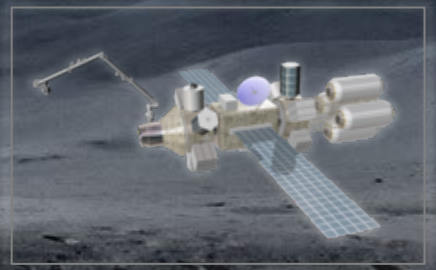


LI-5^{L}: Demonstrate **precision landing** capabilities in support of continuous human lunar presence and a robust lunar economy.

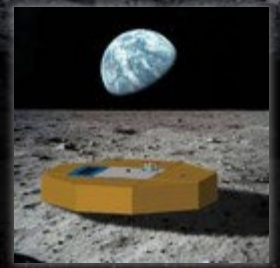


LI-6^{L}: Demonstrate local, regional, and global **surface transportation** and **mobility** capabilities in support of continuous human lunar presence and a robust lunar economy.

LI-7^{L}: Demonstrate industrial scale **ISRU** capabilities MI-4^{M} in support of continuous human lunar presence and a robust lunar economy.



LI-8^{L}: Demonstrate technologies supporting cislunar orbital/surface depots, **construction and manufacturing** maximizing the use of in-situ resources, and support systems needed for continuous human/robotic presence.

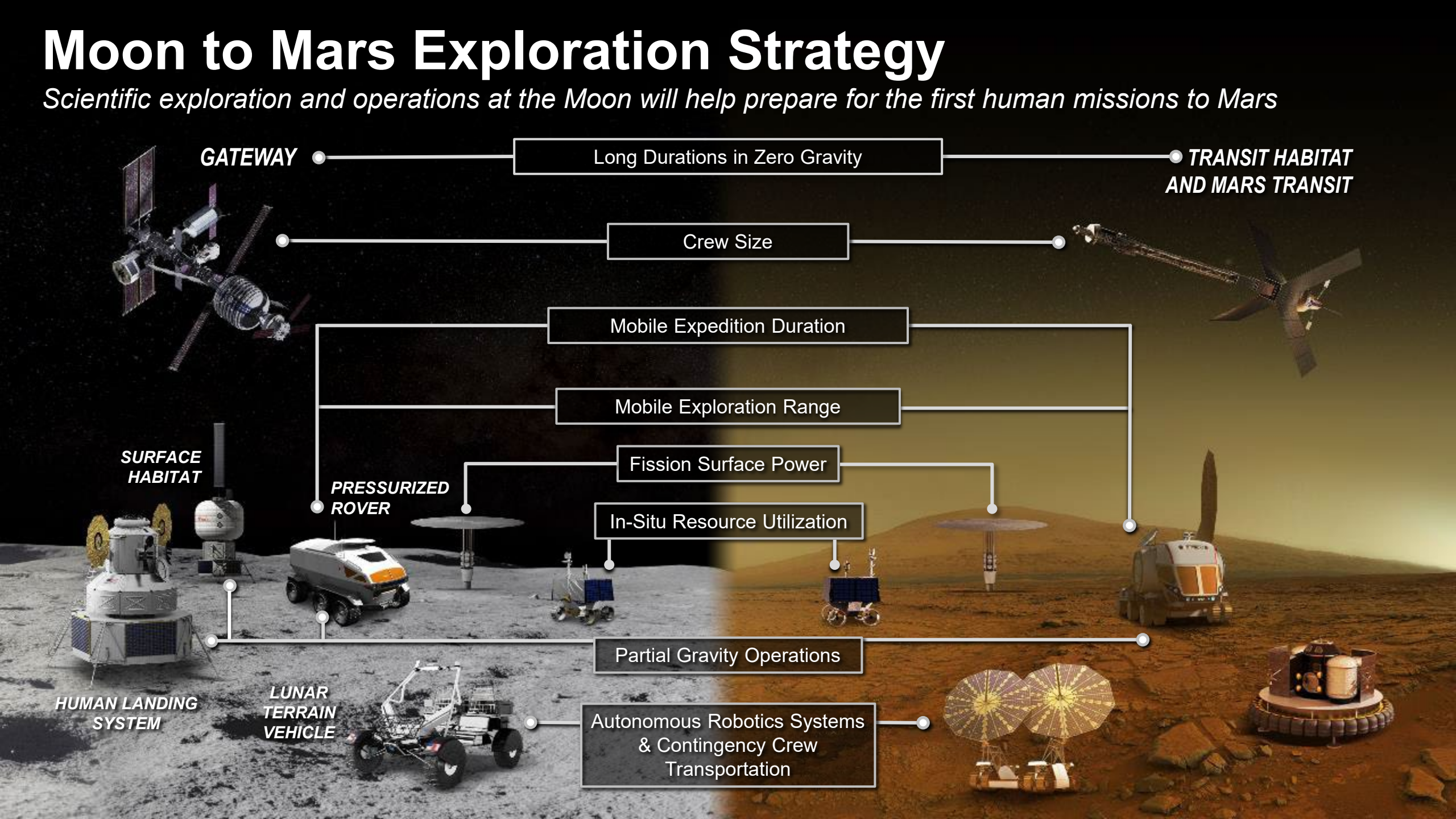


LI-9^{L}: Develop **environmental monitoring, situational awareness,** and early warning capabilities to support a resilient, continuous human/robotic lunar presence.

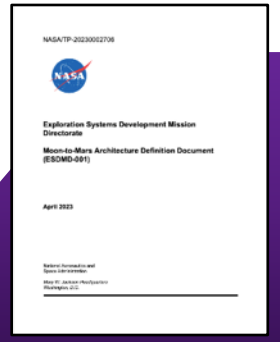
Current STMD Investment Areas

Moon to Mars Exploration Strategy

Scientific exploration and operations at the Moon will help prepare for the first human missions to Mars

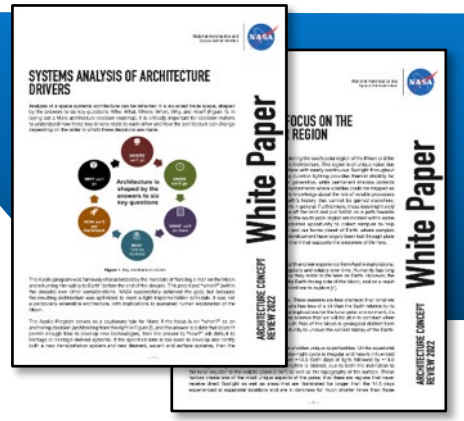


Downloadable Products



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

We came in peace.

We return for all humanity.

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