NASA Objectives

National Aeronautics and Space Administration

Materials Science in Space Workshop
ISS R&D Conference
Atlanta, GA

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Human Exploration & Operations Mission Directorate

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Organizational Context

- **NASA**
  - Aeronautics Mission Directorate
  - Science Mission Directorate
  - Space Technology Mission Directorate
  - Human Exploration and Operations Mission Directorate
    - ISS Program
    - Human Spaceflight Capabilities
    - Commercial Spaceflight Development
    - Exploration Systems Development
    - Advanced Exploration Systems
    - Space Life and Physical Sciences Research and Applications
      - Human Research Program
      - Space Biology
      - **Physical Sciences**

- **Physical Sciences**
  - Biophysics
  - Combustion
  - Complex Fluids
  - Fluids
  - Fundamental Physics
  - **Materials Science**

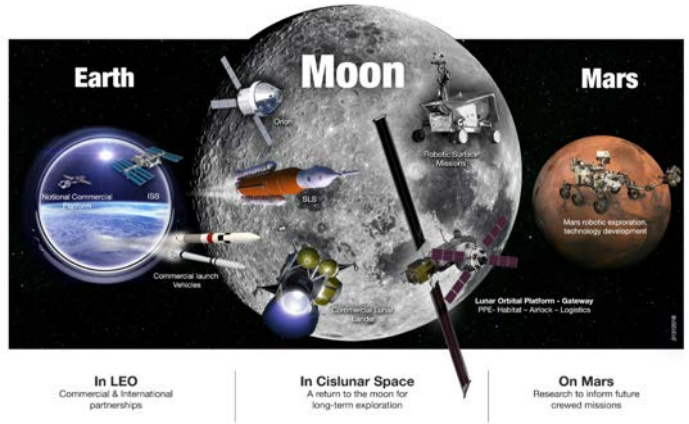
SLPSRA Strategic Framework

Vision

We lead the space life and physical sciences research community to enable space exploration and benefit life on Earth

Mission

1. Enable exploration (EE)
2. Pioneer scientific discovery (PSD)

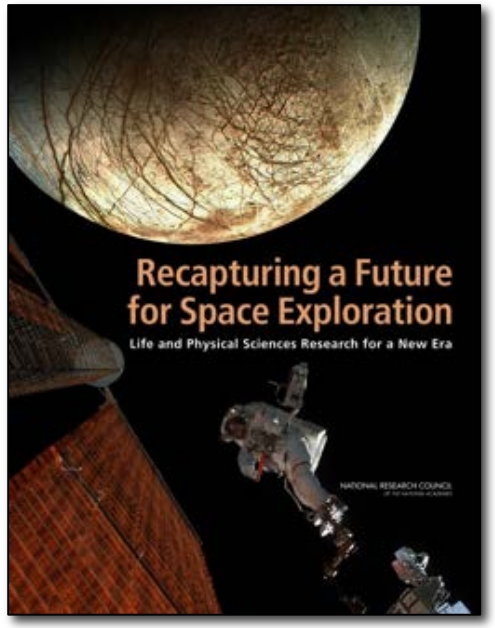


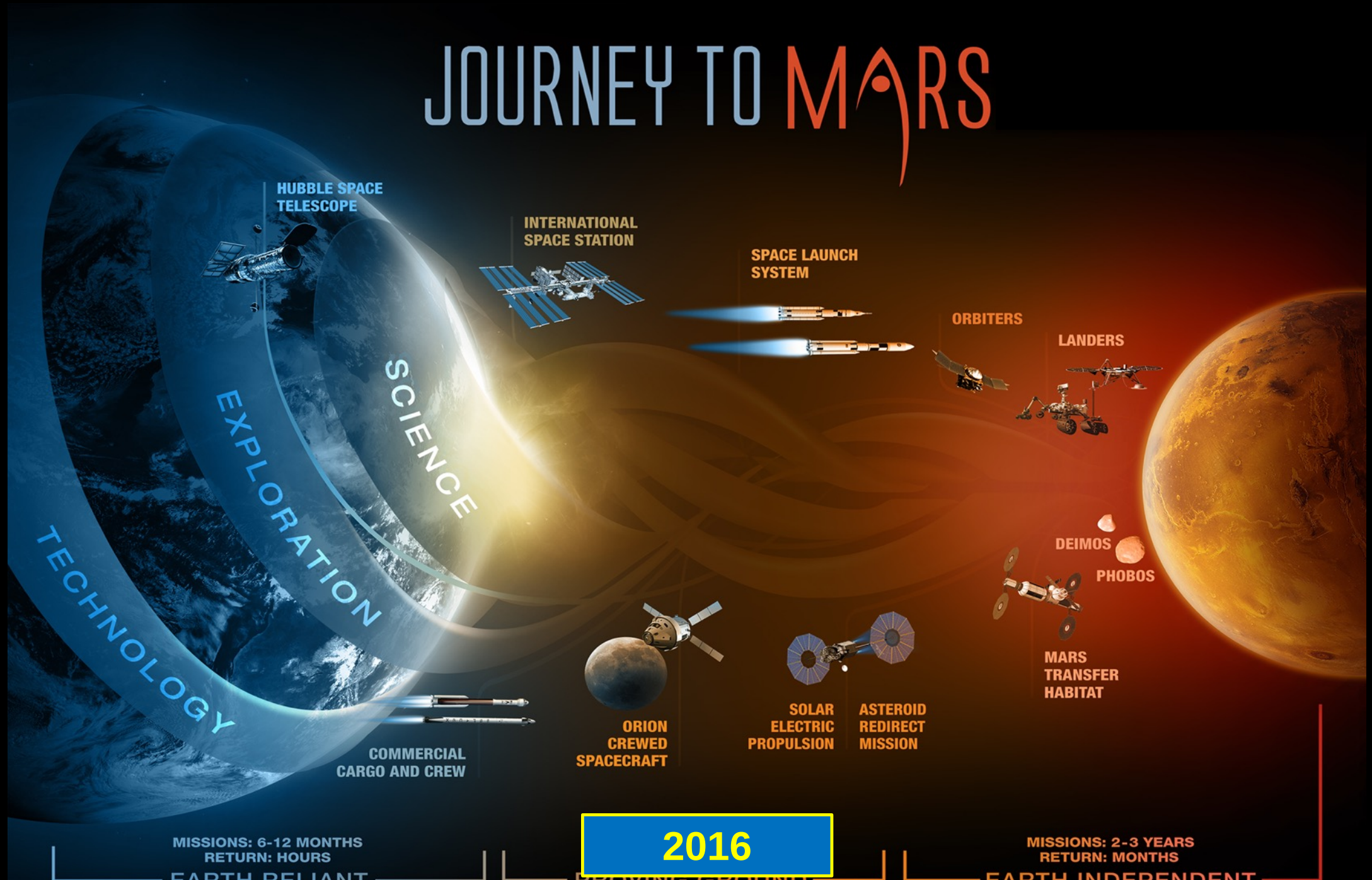
Goals

1. EE in response to pull
2. EE by providing push
3. PSD by refining use of all platforms
4. PSD by helping others utilize space
5. Inspire and train next generation
6. Maintain key capabilities

Implementation Principles

1. Ensure Scientific Integrity
2. Maximize Open Science
3. Cultivate Partnerships
4. Use Stepping Stones
5. Be an Early Adopter
6. Share Methods and Results




JOURNEY TO MARS
HUBBLE SPACE TELESCOPE
INTERNATIONAL SPACE STATION
SPACE LAUNCH SYSTEM
ORBITERS
LANDERS
SCIENCE
EXPLORATION
TECHNOLOGY
DEIMOS
PHOBOS
MARS TRANSFER HABITAT
COMMERCIAL CARGO AND CREW
ORION CREWED SPACECRAFT
SOLAR ELECTRIC PROPULSION
ASTEROID REDIRECT MISSION
2016
MISSIONS: 6-12 MONTHS
RETURN: HOURS
MISSIONS: 2-3 YEARS
RETURN: MONTHS

EXPANDING HUMAN PRESENCE IN PARTNERSHIP

CREATING ECONOMIC OPPORTUNITIES, ADVANCING TECHNOLOGIES, AND ENABLING DISCOVERY

Now

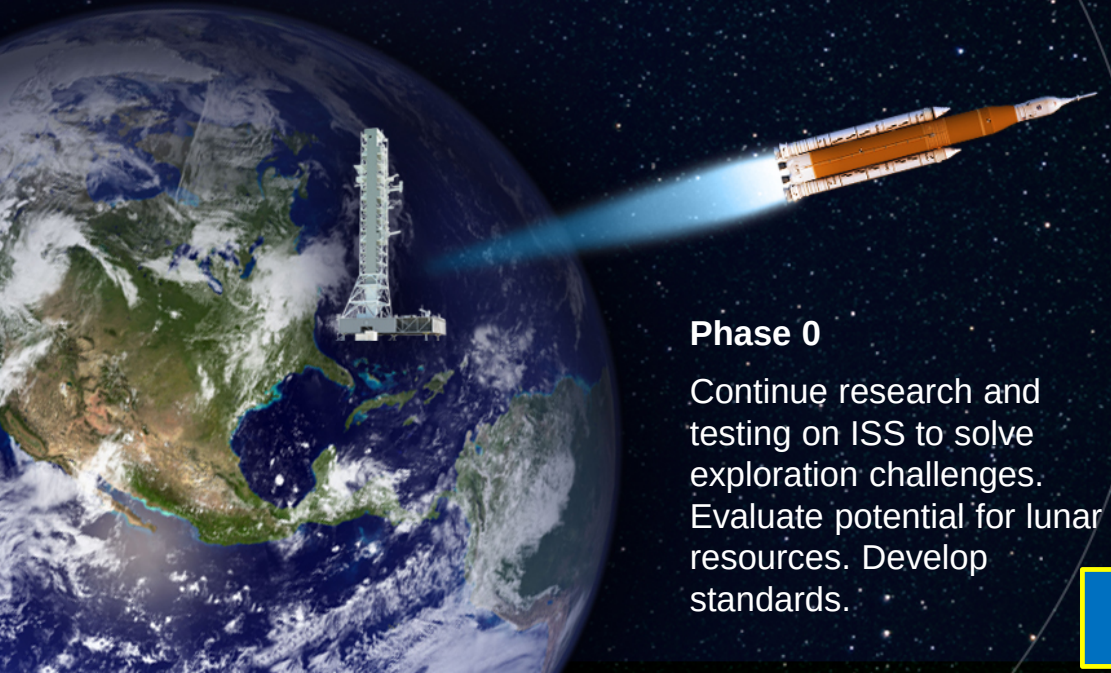
Using the International Space Station

2020s

Operating in the Lunar Vicinity (proving ground)

After 2030

Leaving the Earth-Moon System and Reaching Mars Orbit



Phase 0

Continue research and testing on ISS to solve exploration challenges. Evaluate potential for lunar resources. Develop standards.

Phase 1

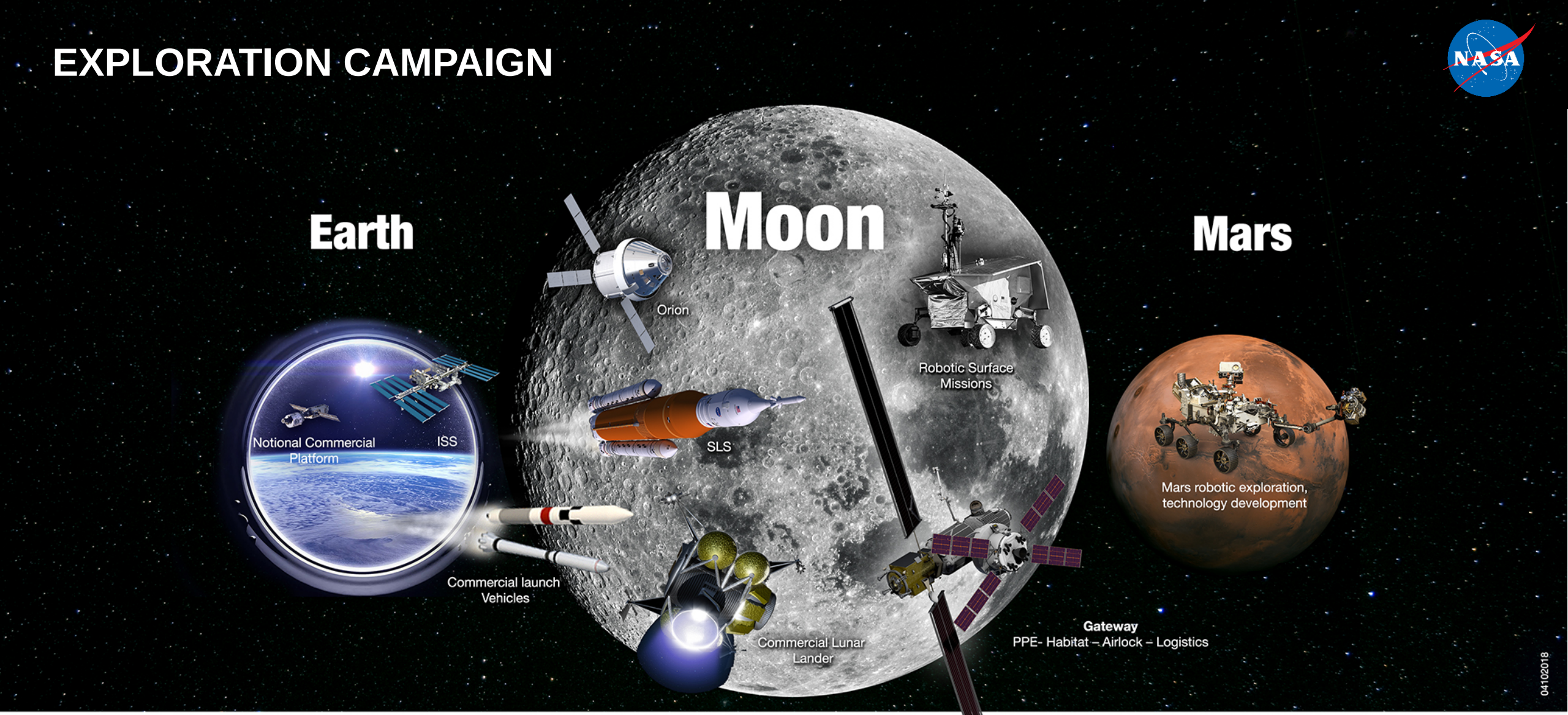
Begin missions in cislunar space. Initiate next key deep space capability.

Phase 2

Complete next deep space capability and checkout.

2017

EXPLORATION CAMPAIGN



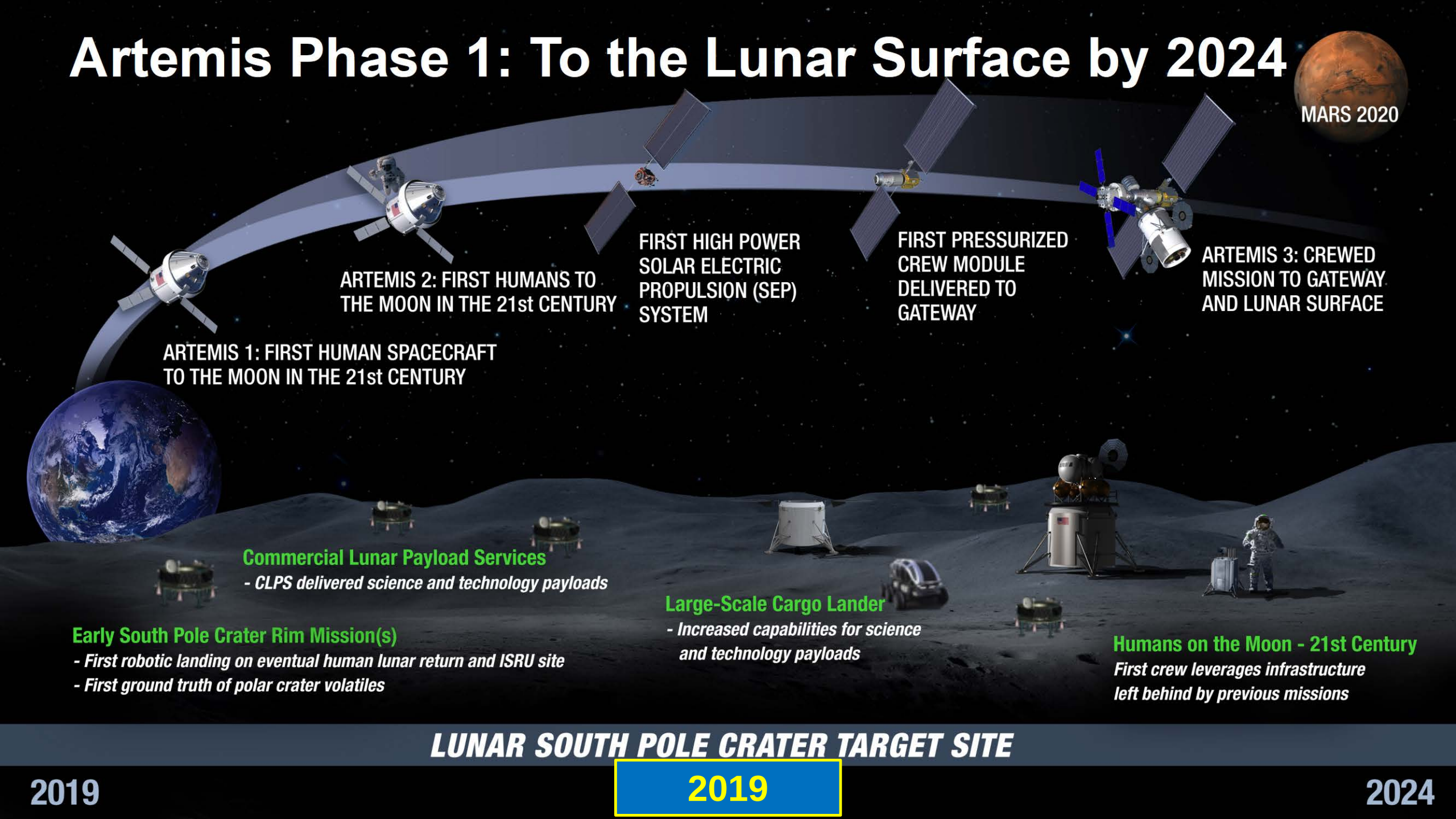
In LEO
Commercial & International partnerships

In Cislunar Space
A return to the moon for long-term exploration

On Mars
Research to inform future crewed missions

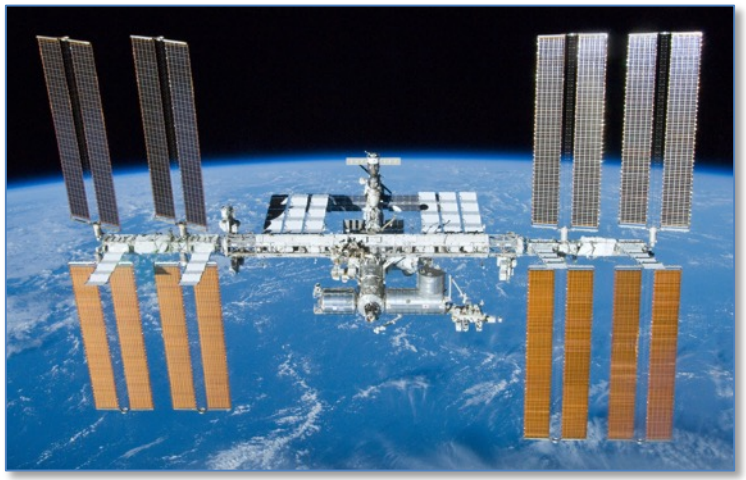
2018

Artemis Phase 1: To the Lunar Surface by 2024

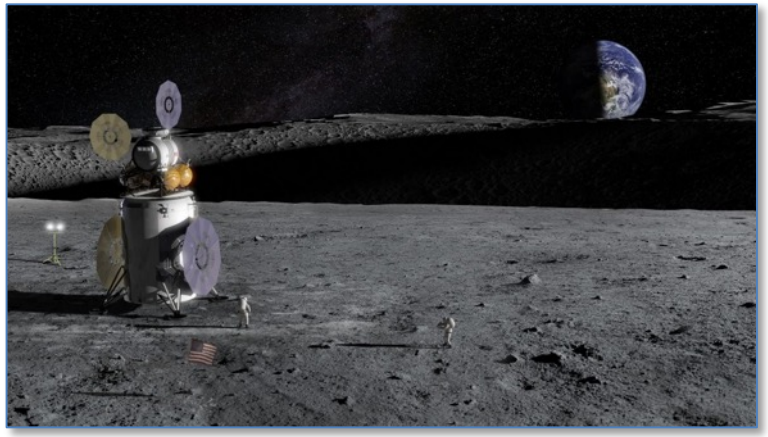


Stressors in Spaceflight

- **Acceleration (buoyancy-driven convection, sedimentation, hydrostatic pressure)**
  - Launch and landing loads (3-9 *g*)
  - Surfaces (Moon 1/6-*g*; Mars 3/8-*g*)
  - Transit (0 *g*)
- **Deep space radiation**
  - Solar Particle Events, Galactic Cosmic Rays
- **Altered internal atmosphere**
  - Elevated carbon dioxide
  - Trace contaminants (e.g., VOCs)
- **Altered light spectrum**



- **Celestial body (Moon, Mars, asteroid) "dust"**
- **Thermal cycling**
  - Moon (-250° C to +120° C)
  - Mars (-120° C to +30° C)
- **Altered external atmosphere**
  - Atomic oxygen (low Earth orbit)
  - High vacuum (transit and Moon)
  - 6 mbar, 96% CO_2 (Mars)
- **Ultraviolet radiation**



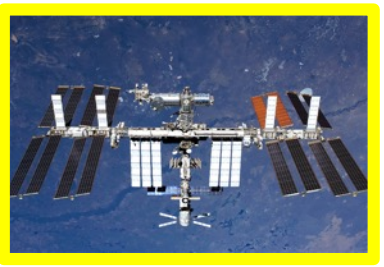
Stepping Stones to Exploration Spaceflight

Gravity Vector Averaging

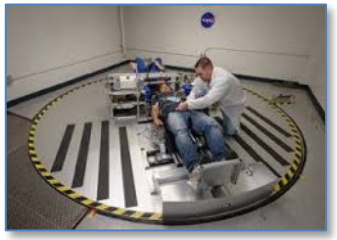

Drop Tower

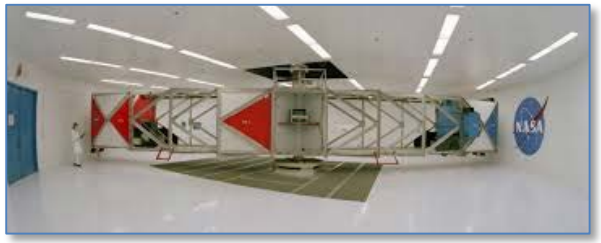

Low G Parabolic Flight


Sounding Rocket


Space Station


Animal Centrifuge


Short Arm Human Centrifuge



Long Arm Human Centrifuge


NASA Isolation Chamber

NSF Polar Station

Russian Isolation Chamber


Electrostatic Levitator


Balloon Flight


NASA Space Radiation Lab


Neutral Buoyancy Facility

PSI Physical Sciences Informatics System

GeneLab

Materials Workshop Mapping to Decadal Survey

Decadal Survey - From the Highest Priority Recommendations – Table 13.1

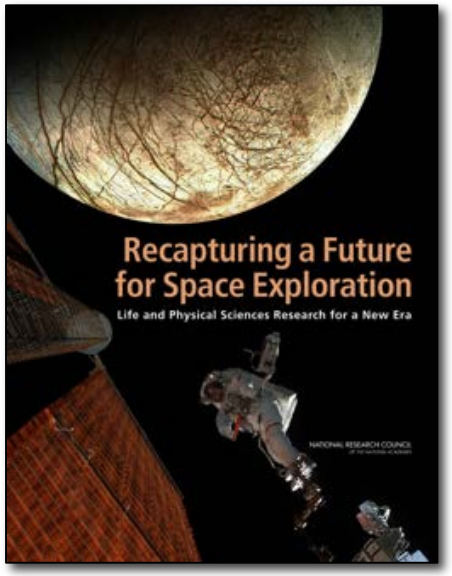
AP9 - Reduced-gravity research on materials synthesis and processing and control of microstructure and properties, to improve the properties of existing and new materials on the ground.

AP10 – Development of new and advanced materials that enable operations in harsh space environments and reduce the cost of human space exploration.

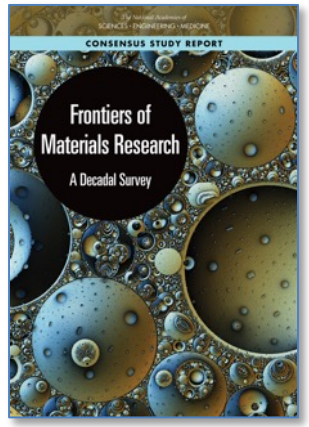
AP11 – Fundamental and applied research to develop technologies that facilitate extraction, synthesis, and processing of minerals, metals, and other materials available on extraterrestrial surfaces.

TSES15 – Research is needed to identify and adapt excavation, extraction, preparation, handling, and processing techniques for lunar water/oxygen extraction system.

TSES16 – NASA should establish plans for surface operations, particularly ISRU capability development and surface habitats. Research is needed to characterize resources available at lunar and martian surface destinations and to define surface habitability systems design requirements.



2011
(2021)



2019

Workshop breakout sessions and Decadal identifier

- Functional Materials - AP9, AP10, AP11
- Materials Characterization, Microstructure and Process Modeling – AP9, AP10, AP11
- Lunar Infrastructure and Surface Operations – AP9, AP10, AP11, TSES15, TSES16

Thank you