



National Aeronautics and  
Space Administration

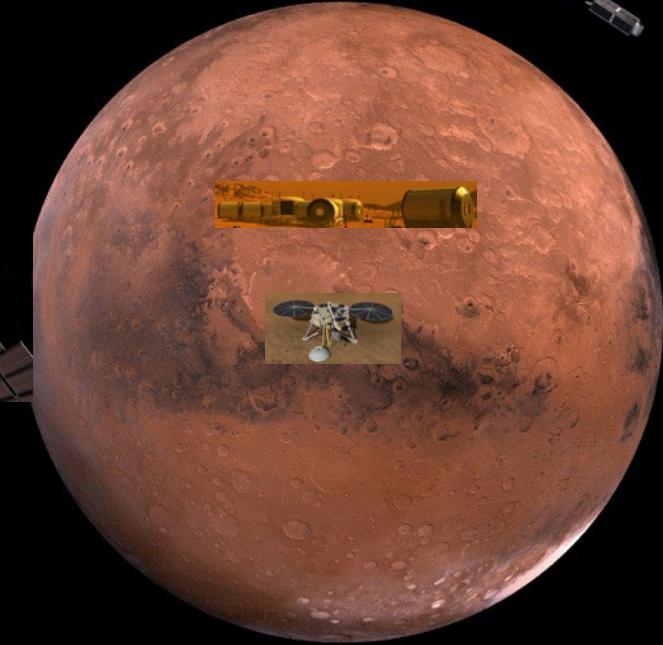
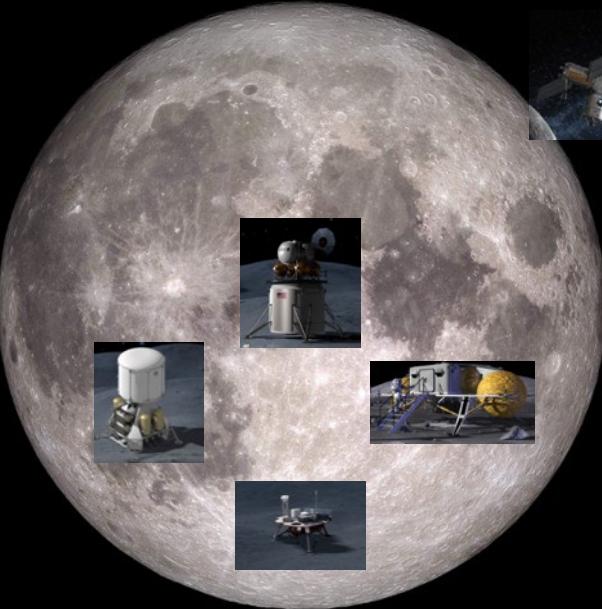
# NASA Moon to Mars Updates and Division Space Labs Goal

**Kevin Sato, Ph.D.**  
Program Scientist for Exploration  
Biological and Physical Sciences Division  
NASA Science Mission Directorate  
NASA Headquarters | Washington, DC

**BPS**  
Oct. 9, 2024 | Committee on Biological & Physical Sciences in Space  
Biological & Physical Sciences



# BIOLOGICAL AND PHYSICAL SCIENCES ADVANCING THE FRONTIERS OF SPACE EXPLORATION



Earth-based and LEO research and technology to advance lunar exploration and habitats development

Lunar research and technology to advance Mars exploration and habitat development

# Opportunities

## **Lunar Surface Science Solicitation:**

**Released by NASA SMD Exploration Science Strategy and Integration Office**

**All solicitations include funding for the science, instruments, and project management by the proposal team**

### **1) F.13 Lunar Terrain Vehicle Instruments**

- 1) \$44 million – at least 2 proposals will be selected
- 2) South Pole; delivered to the Moon before the launch of Artemis V
- 3) U.S-led and Foreign-led proposals eligible
- 4) Currently in Step-1 proposal phase – Due Oct. 23, 2024
- 5) Step-2 proposals due Dec. 23, 2024

### **2) F.12 Artemis IV Deployed Instruments Program**

- 1) \$25 Million – at least 1 proposal selected (or more if the total cost does not exceed the total maximum funding of the program)
- 2) Draft solicitation released for community comments – Due Oct. 15, 2024
- 3) South Pole – for lunar surface only
- 4) U.S.-led and Foreign-led proposals eligible
- 5) Selectin candidate payloads for Artemis IV payload manifest

### **3) PRISM Stand Alone Landing Site Agnostic Instruments Call (Commercial Lunar Payload Services) 2024**

# Opportunities

## Lunar Surface Science Solicitation:

### In planning:

- **PRISM 4 solicitation**
- **A4 Hand-Held Instruments RFP**
- **NASA Planetary Sciences Division Solar System Exploration Virtual Research Institute Cooperative Agreement 5**
  - Large science teams
  - Multi-year ground-only research investigations
  - Draft late fall 2024

## Lunar Exploration Analysis Group (LEAG) Executive Committee Search

- **LEAG announced call for Executive Committee positions for**
  - Community Liaison, Biological and Physical Sciences
  - Note: These liaisons are not representatives for the NASA SMD Divisions but are representative of the community itself
- **Closed September 30, 2024**

## National Academy of Sciences Special Study on Human Exploration of Mars

- Requested by the NASA Science Mission Directorate and Exploration Systems Development Mission Directorate

# New White Papers



**Lunar Surface Cargo**

**Introduction**

The exploration of the lunar surface, as described in NASA's Moon to Mars Architecture Definition Document (ADD), will require a wide variety of landed systems, including scientific instruments, habitats, mobility systems, infrastructure, and more. Given diverse cargo needs of varying size, mass, cadence, and operational needs, access to a range of cargo lander capabilities will be a strategic benefit.

While current cargo lander development activities will contribute to meeting some cargo delivery demands, a substantial gap in landed capability remains. This paper characterizes lunar surface cargo delivery needs, compares them with current cargo lander capabilities, and outlines strategic considerations for filling the remaining capability gap.

**Cargo Deliveries to Gateway** This paper describes the cargo delivery needs for the Moon to Mars Architecture Concept Review (2024). It highlights a well-organized delivery system that maximizes the length of cargo stays on Gateway. While use of the Gateway as a logistics cache for future exploration could be considered, this paper does not attempt to speculate on concepts of operation. Instead, it specifically addresses architectural gaps for cargo deliveries to the lunar surface. The specific functions furnished by GL-1 may be found in Table 3.6 of ADD Revision A/A.

**Cargo Lander Architecture**

Lunar surface exploration will require the delivery of assets, equipment, and supplies to the lunar surface. While some limited supplies and equipment may be delivered alongside crew on NASA's Human Landing System (HLS), the breadth and scale of logistical needs for deep space exploration require additional surface cargo lander capabilities.

NASA has developed a conceptual reference mission for cargo lander delivery that will be added to the ADD Revision B. This mission will add cargo to the lunar surface.

- Provide delivery of necessary exploration cargo items in space transit through landing on the lunar surface until the cargo is either off-loaded from the lander or in an experimental state where these services from the lander are no longer needed, in accordance with cargo lander provider agreements.
- Ensure successful landing of cargo on designated landing locations on the lunar surface and off-load cargo.
- Establish safe conditions on the lunar surface for the crew to approach the lander.
- Verify health and function of lander off-loaded ready off-load cargo.
- Perform any lander and off-load operations—including potential relocation—ensuring that the cargo or other assets are not damaged or lost during the lander off-loading operations.

As noted above, cargo deliveries will need support services infrastructure to ensure safe delivery of cargo to the surface. Service interfaces may support the off-loading of cargo, compatibility to surface mobility system interactions, and/or providing resources to the cargo, such as power, communications, data, and navigation. These services will be required to support the delivery of the cargo to the lunar surface, including delivery after the cargo is off-loaded to the surface.

Landers and cargo may also need additional, cross-located lander interfaces such as interlander mobility (ILM) touch interfaces to support cross interactions. Lastly, given potential cross interactions for more than one lander, landers must have the ability to self-soft-land on landing surfaces that cross or protected while in lander's vicinity.

**2024 Moon to Mars Architecture Concept Review**

**white paper**

## Lunar Surface Cargo

This paper characterizes lunar surface cargo delivery needs, comparing them with current cargo lander capabilities, and outlining strategic considerations for filling capability gaps.

**Lunar Mobility Drivers and Needs**

**Introduction**

NASA's new campaign of lunar exploration will see astronauts visiting sites of scientific or strategic interest across the lunar surface, with a particular focus on the lunar South Pole region.<sup>1</sup> After landing, crew and cargo at these destinations, local mobility around landing sites will be key to movement of cargo, logistics, science payloads, and more to maximize exploration returns.

NASA's Moon to Mars Architecture Definition Document (ADD)<sup>2</sup> articulates the work needed to achieve the agency's human lunar exploration objectives by decomposing needs into use cases and functions. One key function is the delivery of cargo to the lunar surface. The delivery of cargo to the lunar surface requires a range of transportation and cargo support services. The movement of cargo from the point of delivery to points of use will be particularly important. Exploration systems will often need to support deployment of cargo in closer proximity to other surface infrastructure. This cargo movement will range from the cargo logistics and consumables described in the 2023 "Lunar Logistics Drivers and Needs" white paper,<sup>3</sup> to science and technology demonstrations, to large-scale infrastructure that requires precision relocation.

The current defined mobility elements—the Lunar Terrain Vehicle (LTV) and Personnel Rover (PR)—are primarily for crew transportation, with limited cargo mobility functions. Conversely, planned near-term cargo delivery systems, such as the Commercial Cargo System (CCS) and Commercial Cargo System (CCS) program—provide only small-scale mobility. This paper describes the integrated cargo mobility drivers for consideration in future architectures and system studies, with a focus on the human lunar exploration architecture. Scientific confinement, robotic missions, and non-crew additional mobility needs beyond off-planed exploration are discussed.

The reference, mass, and number of cargo lander deliveries will be used to support the definition of required NASA lunar surface mobility services including mobility, navigation, lighting, communications, and safety concerns. In many cases, cargo off-loading and mobility needs will need to be conducted before the crew arrives at each landing location (point of origin) and then again at local lunar exploration and habitation sites (point of use). These exploration and habitation sites will likely be located away from each landing location. This would require mobility capabilities to transport cargo of varying size and mass for fuel, habitation, and other needs.

Current capabilities planned for lunar surface operations are limited to transporting approximately 1,500 kg of cargo. However, fulfilling other key exploration objectives could require cargo of mass and masses beyond off-planed capabilities, creating the need for additional mobility capabilities.

**Mobility Needs**

One of the largest drivers of mobility needs on the lunar surface is moving cargo from its landing site to its point of use. Numerous factors drive cargo point of use, many of which necessitate separation from the lander (e.g., distance required by lander to mobile, point of use determined by mission, or limit speeds from lander plasma surface interactions). These relocation distances can include the following factors:

- Separation from lander shadowing (size of lander)
- Lander blind spots (constraints >1,000 m due to separation between the lander and landing site and the lander's size)
- Support for segregation of elements in ideal habitation zones from available regional landing sites (up to 500 m)

For more insight into lunar lighting considerations, see the 2022 Moon to Mars Architecture "Lunar Site Selection" white paper.<sup>4</sup>

**2024 Moon to Mars Architecture Concept Review**

**white paper**

**Lunar Mobility Drivers and Needs**

**Introduction**

NASA's new campaign of lunar exploration will see astronauts visiting sites of scientific or strategic interest across the lunar surface, with a particular focus on the lunar South Pole region.<sup>1</sup> After landing, crew and cargo at these destinations, local mobility around landing sites will be key to movement of cargo, logistics, science payloads, and more to maximize exploration returns.

NASA's Moon to Mars Architecture Definition Document (ADD)<sup>2</sup> articulates the work needed to achieve the agency's human lunar exploration objectives by decomposing needs into use cases and functions. One key function is the delivery of cargo to the lunar surface. The delivery of cargo to the lunar surface requires a range of transportation and cargo support services. The movement of cargo from the point of delivery to points of use will be particularly important. Exploration systems will often need to support deployment of cargo in closer proximity to other surface infrastructure. This cargo movement will range from the cargo logistics and consumables described in the 2023 "Lunar Logistics Drivers and Needs" white paper,<sup>3</sup> to science and technology demonstrations, to large-scale infrastructure that requires precision relocation.

The current defined mobility elements—the Lunar Terrain Vehicle (LTV) and Personnel Rover (PR)—are primarily for crew transportation, with limited cargo mobility functions. Conversely, planned near-term cargo delivery systems, such as the Commercial Cargo System (CCS) and Commercial Cargo System (CCS) program—provide only small-scale mobility. This paper describes the integrated cargo mobility drivers for consideration in future architectures and system studies, with a focus on the human lunar exploration architecture. Scientific confinement, robotic missions, and non-crew additional mobility needs beyond off-planed exploration are discussed.

The reference, mass, and number of cargo lander deliveries will be used to support the definition of required NASA lunar surface mobility services including mobility, navigation, lighting, communications, and safety concerns. In many cases, cargo off-loading and mobility needs will need to be conducted before the crew arrives at each landing location (point of origin) and then again at local lunar exploration and habitation sites (point of use). These exploration and habitation sites will likely be located away from each landing location. This would require mobility capabilities to transport cargo of varying size and mass for fuel, habitation, and other needs.

Current capabilities planned for lunar surface operations are limited to transporting approximately 1,500 kg of cargo. However, fulfilling other key exploration objectives could require cargo of mass and masses beyond off-planed capabilities, creating the need for additional mobility capabilities.

**Mobility Needs**

One of the largest drivers of mobility needs on the lunar surface is moving cargo from its landing site to its point of use. Numerous factors drive cargo point of use, many of which necessitate separation from the lander (e.g., distance required by lander to mobile, point of use determined by mission, or limit speeds from lander plasma surface interactions). These relocation distances can include the following factors:

- Separation from lander shadowing (size of lander)
- Lander blind spots (constraints >1,000 m due to separation between the lander and landing site and the lander's size)
- Support for segregation of elements in ideal habitation zones from available regional landing sites (up to 500 m)

For more insight into lunar lighting considerations, see the 2022 Moon to Mars Architecture "Lunar Site Selection" white paper.<sup>4</sup>

**2024 Moon to Mars Architecture Concept Review**

**white paper**



**Read the White Papers Here:**  
<https://www.nasa.gov/moontomarsarchitecture-whitepapers/>

## Lunar Architecture

# Architecture Workshops

---



## 2024 Industry and Academia Workshop

National Academy of Sciences



## 2024 International Partner Workshop

National Academy of Sciences



## Yearly Architecture Workshops

2025 workshops tentatively scheduled  
for February 11 to 13 in Washington, D.C.

<https://socialforms.nasa.gov/Architecture-Updates>



Subscribe to  
Updates

## Lunar Discovery and Exploration Program (LDEP) Update

July 10, 2024 <sup>10</sup>

National Aeronautics and Space Administration

LUNAR MISSIONS  
2022–2027

## CLPS NASA PAYLOAD GOALS

## PEREGRINE-1

- Regolith volatiles composition
- Local radiation environment

## 1ST NOVA-C

- Plume/surface interactions, charged particles near surface
- Lander prop tank gauge test

## 2ND NOVA-C

- Drilling for volatiles

## 1ST BLUE GHOST

- Characterize Earth's magnetosphere and Moon's interior

## 3RD NOVA-C

- Lunar Magnetic Anomalies

## GRIFFIN-1 &amp; VIPER

- Search for volatiles, below surface & shadowed regions

## APEX 1.0

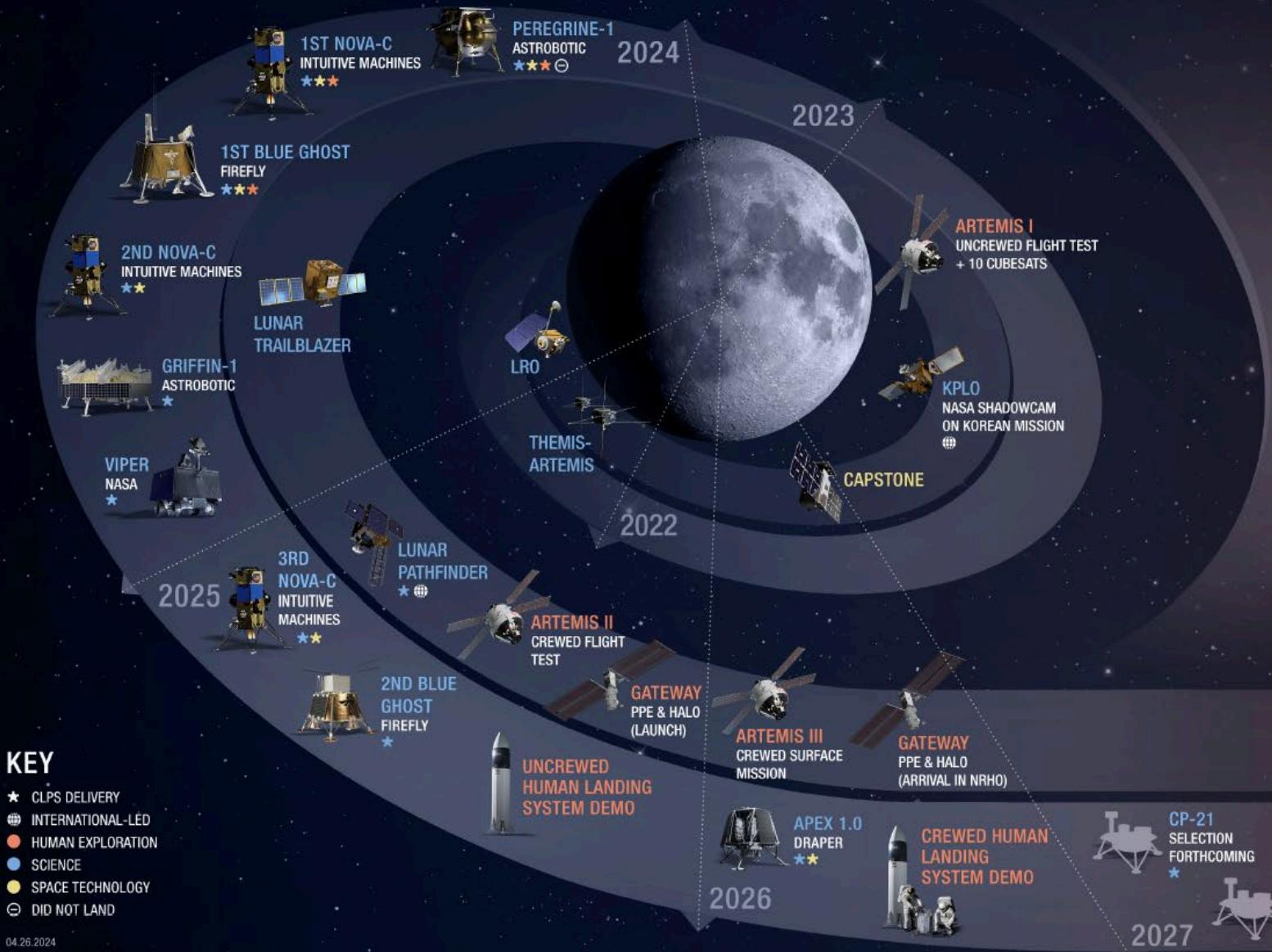
- Geophysics of the Schrödinger Basin

## 2ND BLUE GHOST

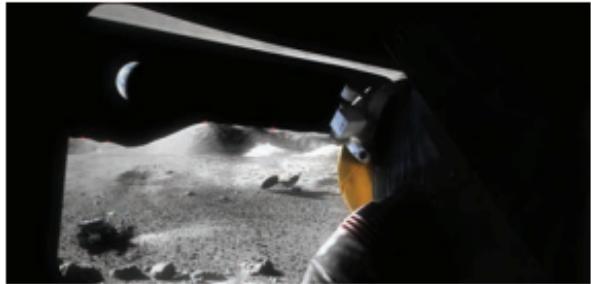
- Dark Ages observations from the lunar far side
- ESA lunar comm relay satellite deployment

## ORBITAL MISSIONS

## SURFACE MISSIONS



# ARCHITECTURE SEGMENTS



## HUMAN LUNAR RETURN

Initial capabilities, systems, and operations necessary to re-establish human presence and initial utilization (e.g., science) on and around the Moon.

Orion, SLS, EGS, Gateway, HLS, Deep Space Logistics, xEVAS, CPNT



## FOUNDATIONAL EXPLORATION

Expansion of lunar capabilities, systems, and operations supporting complex orbital and surface missions to conduct utilization (e.g., science) and Mars-forward precursor missions.

LTV, PR, MPH, Large Cargo



## SUSTAINED LUNAR EVOLUTION

Enabling capabilities, systems, and operations to support regional and global utilization (e.g., science), economic opportunity, and a steady cadence of human presence on and around the Moon.

Power, ISRU, Expanded mobility/habitation,



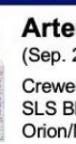
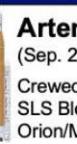
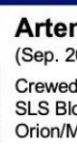
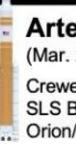
## HUMANS TO MARS

Initial capabilities, systems, and operations necessary to establish human presence and initial utilization (e.g., science) on Mars and continued exploration.

Transportation, EDL, Ascent, Science Ops, Return needs



# FY 2025 President's Budget Request Moon to Mars Manifest

FY	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Exploration Systems Development Mission Directorate			 <p><b>Artemis II</b> (Sep. 2025) Crewed Flight SLS Block 1/ Orion/ML1</p>	 <p><b>Artemis III</b> (Sep. 2026) Crewed Flight SLS Block 1/ Orion/ML1</p> <p>HLS Crewed Lunar Demo</p> <p>xEVA Surface Suits</p> <p>HLS Uncrewed Lunar Demo</p> <p>Gateway PPE/HALO Launch</p>		 <p><b>Artemis IV</b> (Sep. 2028) Crewed Flight SLS Block 1B/ Orion/ML2</p> <p>I-Hab to Gateway</p> <p>Gateway Logistics Services</p> <p>Sustaining HLS Crewed Lunar Demo</p> <p>xEVA Surface Suits</p> <p>Sustaining HLS Uncrewed Lunar Demo</p>		 <p><b>Artemis V</b> (Mar. 2030) Crewed Flight SLS Block 1B/ Orion/ML2</p> <p>ESPRIT to Gateway</p>	 <p><b>Artemis VI</b> (Mar. 2031) Crewed Flight SLS Block 1B/ Orion/ML2</p> <p>Airlock to Gateway</p> <p>Gateway Logistics Services</p> <p>Gateway External Robotics System</p> <p>TBD Sustaining HLS Services</p>	 <p><b>Artemis VII</b> (Mar. 2032) Crewed Flight SLS Block 1B/ Orion/ML2</p> <p>Gateway Operations</p> <p>TBD Sustaining HLS Services</p> <p>xEVA Surface Suits</p> <p>Pressurized Rover</p>
Space Operations Mission Directorate	 <p><b>Completed</b> DSN Upgrades (DLEU) Completed DSS-36 [Canberra]</p>	 <p><b>Completed</b> DSS-34 [Canberra]</p>	 <p>DSS-56 [Madrid]</p>			 <p>Lunar Exploration Ground Sites 1-3 DSS-54 [Madrid]</p>				
Science Mission Directorate	 <p>LRO</p>	 <p>ESCAPE</p>	 <p>TO 20A: VIPER</p>	 <p>Artemis III Surface Science Instruments</p>	 <p>LRO continued ops</p>	 <p>Artemis IV Surface Science Instruments</p>		 <p>Rosalind Franklin Mission (RFM) Launch, Landing</p>	 <p>Artemis V Surface Science Instruments</p>	 <p>Artemis VI Surface Science Instruments</p>
Space Technology Mission Directorate	 <p>CLPS Flights Outlined</p>	 <p>Mars 2020:</p>	 <p>Attempted Completed TO 2-AB TO 2-IM</p>	 <p>TO 19D</p>	 <p>TO CP-11</p>	 <p>TO CS-3&amp;4</p>	 <p>TO CP-12</p>	 <p>TO CS-06</p>	 <p>TO CP-21</p>	 <p>TO CP-22</p>
			 <p>TO PRIME-1: Drill; Nokia LTE/4G Comm; IM Deployable Hopper</p>	 <p>MMX (MEGANE/ P-Sampler)</p>	 <p>TO CS-6</p>	 <p>TO CP-31</p>	 <p>TO CP-41</p>	 <p>TO CP-42</p>	 <p>TO CP-51</p>	 <p>TO CP-52</p>
			 <p>TO PRIME-1: Drill; Nokia LTE/4G Comm; IM Deployable Hopper</p>	 <p>CFM Lockheed Martin TP Flight Demo</p>	 <p>DRACO Demonstration</p>	 <p>TO LIFT-1: Lunar Surface Power Demo (i.e., RFC, VSAT, Wireless Charging); Lunar Surface Scaled Construction Demo 1; ISRU Pilot Excavator; ISRU Subscale Demo</p>		 <p>SEP qual. complete</p>		 <p>TO LIFT-2: Lunar Surface Scaled Construction Demo 2; Autonomous Robotics Demo; Deployable Hopper 2; ISRU Subscale Demo 2</p>
			 <p>CFM SpaceX TP Flight Demo</p>	 <p>NEP Concept Design</p>						

Icons are representative only, and may not reflect final configurations, not to scale | Icons represent the fiscal year in which an event occurs | Based on FY 2025 President's budget request

# Flammability of Materials on the Moon (FM<sup>2</sup>)

- Lunar surface ground truth of materials flammability data from drop tower-based partial gravity studies that also used the exploration atmospheric environment conditions
- Obtain new flammability data on different materials

SpaceX Starship Uncrewed Demonstration



# Artemis III Science

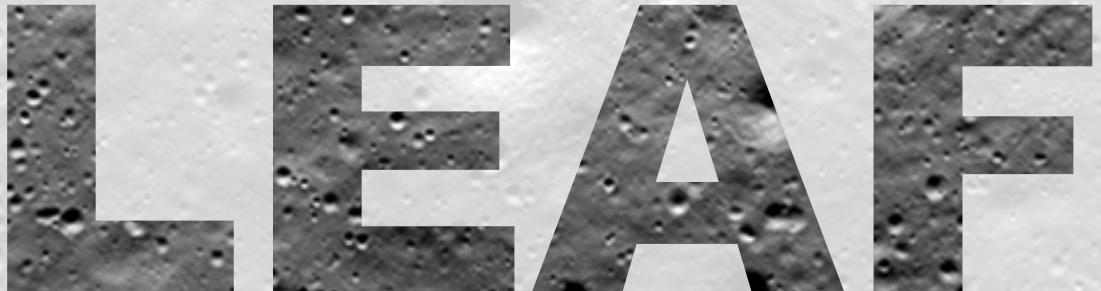


- NASA has chosen the first science instruments designed for astronauts to deploy on the surface of the Moon
- Once installed near the lunar South Pole, the three instruments will collect valuable scientific data about the lunar environment, the lunar interior, and how to sustain a long-duration human presence on the Moon
- Lessons learned from these experiments will help prepare NASA to send astronauts to Mars

**LEMS  
LEAF  
LDA**

**Lunar Environment Monitoring Station**  
**Lunar Effects on Agricultural Flora**  
**Lunar Dielectric Analyzer**





## Lunar Effects on Agricultural Flora

Summary: LEAF will apply system biology and engineering to investigate the effects of the lunar surface environment on the short-term organism-wide physiological responses of model space crops.

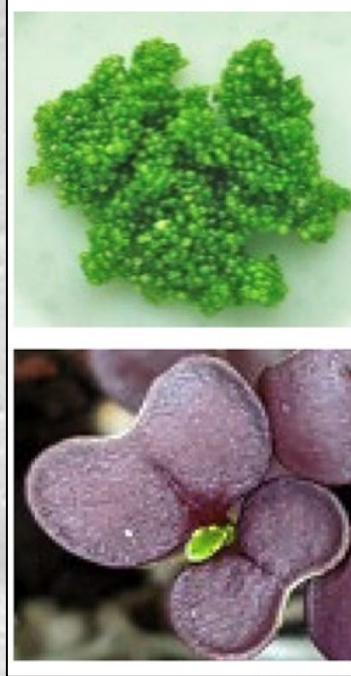


### Science Goals:

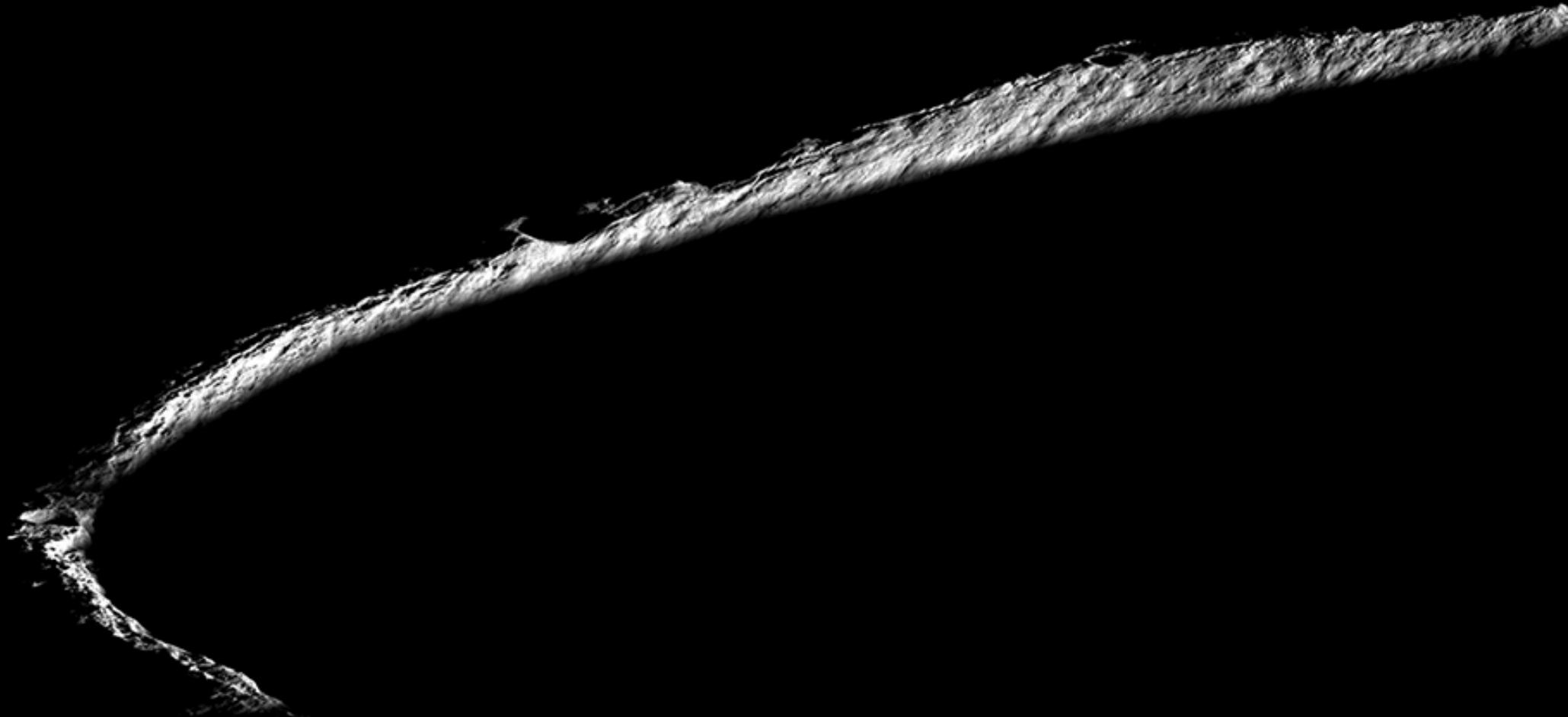
- Grow resilient model space-crops in lunar & Earth environments
- Compare crop phenotypes in lunar and Earth environments:
  1. Seed germination & clonal reproduction rates
  2. Crop morphology (size, orientation, and color) and growth
  3. CO<sub>2</sub> consumption and O<sub>2</sub> production
- Identify genome-wide biomolecular deviations in lunar grown crops
- Define future science hypotheses regarding crop potential for life support via photosynthetic gas exchange & nutrient production

PI: Christine Escobar, Space Lab Technologies LLC

**Co-Sponsorship between ESSIO and Division**



# Where are we going?









National Aeronautics and  
Space Administration

# NASA Division Space Labs Goals Update

**Kevin Sato, Ph.D.**  
Program Scientist for Exploration  
Biological and Physical Sciences Division

**Ursula Koniges, Ph.D.**  
Deputy Program Scientist, Translational Research  
Biological and Physical Sciences Division

**Matthew Lera**  
Project Scientist for Exploration  
Biological and Physical Sciences Division

Oct. 2024 | Committee on Biological & Physical Sciences in Space  
Biological & Physical Sciences



# Space Labs Overview

# Space Labs Goal Overview

- **Goal Focus:** Spaceflight strategy and tactical implementation, and flight opportunities for Biological and Physical Sciences () Program Science
- Based on and incorporates all Goal roadmap capabilities & needs as well as Science Program objectives & priorities
  - **Goals:** Space Crops, Precision Health, Quantum Leaps, Foundations
  - **Programs:** Space Biology, Physical Sciences, Fundamental Physics, and Commercially Enabled Rapid Space Science (CERISSL)
- Incorporates the National Academies 2023-2032 Decadal Survey Report for biological and physical sciences research recommendations and findings

# Thriving in Space

Revolutionary research in extraordinary places.

## Precision Health

*Leveraging space to unlock the secrets of aging and disease*

## Space Crops

*Boldly growing where no one has grown before*

## Quantum Leaps

*Unraveling mysteries of the universe*

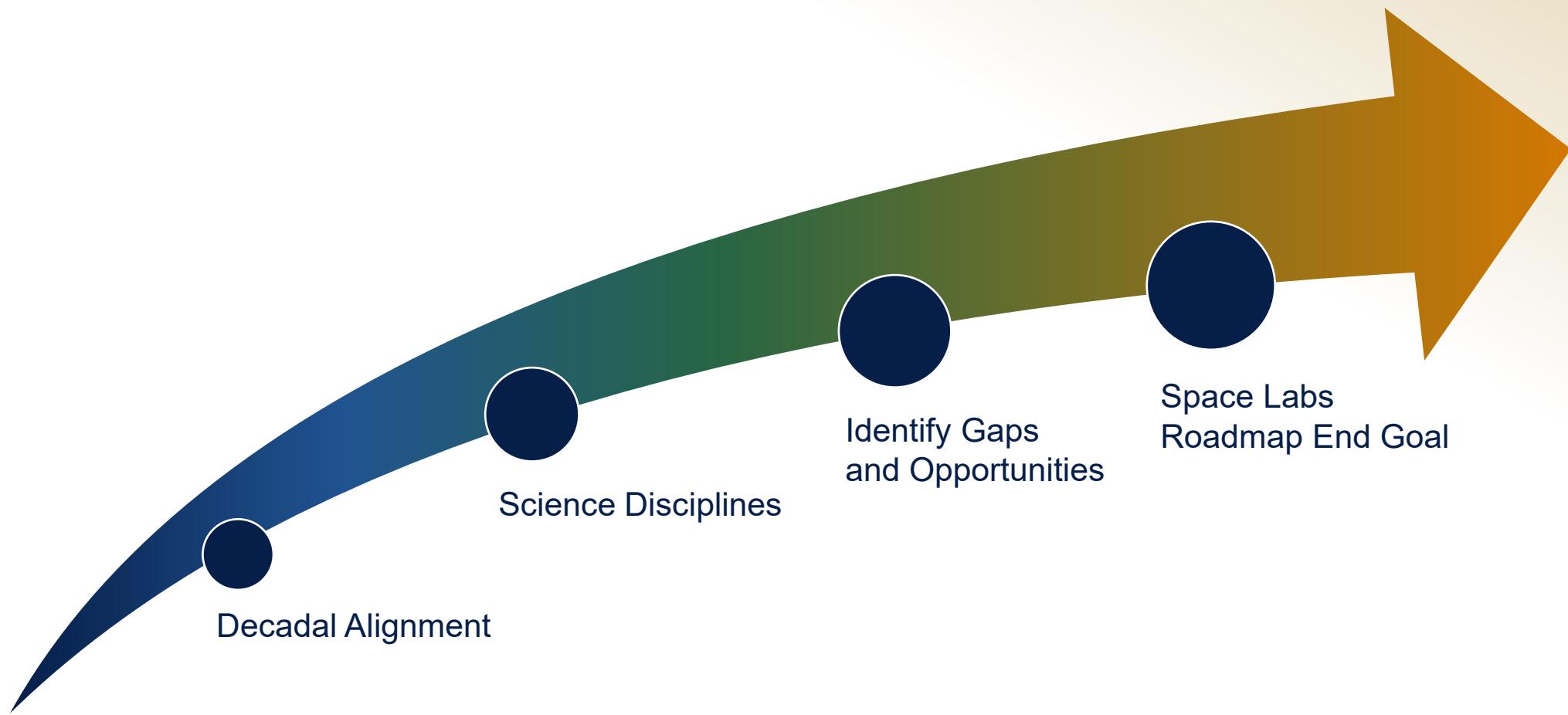
## Foundations

*Revealing the novel behaviors of fluids, fire, and materials in space*

## Space Labs

*Accelerating the pace and productivity of research*

# Goal Overview: Space Labs



# Decadal Alignment: Space Labs

Traceable to and aligns with the Decadal Survey Report recommendations, findings, and Key Science Questions (KSQ)

## Adapting to Space

- Transition to/from space
- Genetic diversity & life history
- Interactions between organisms

## Living and Traveling in Space

- Multigenerational effects
- Integration of biological & abiotic systems
- *In situ* utilization
- Behavior of fluids in space

## Probing Phenomena Hidden by Gravity or Terrestrial Limitations

- Mechanisms for sensing & responding
- Structure & functionality of materials
- Systems far from equilibrium
- New physics

## Research Campaigns:

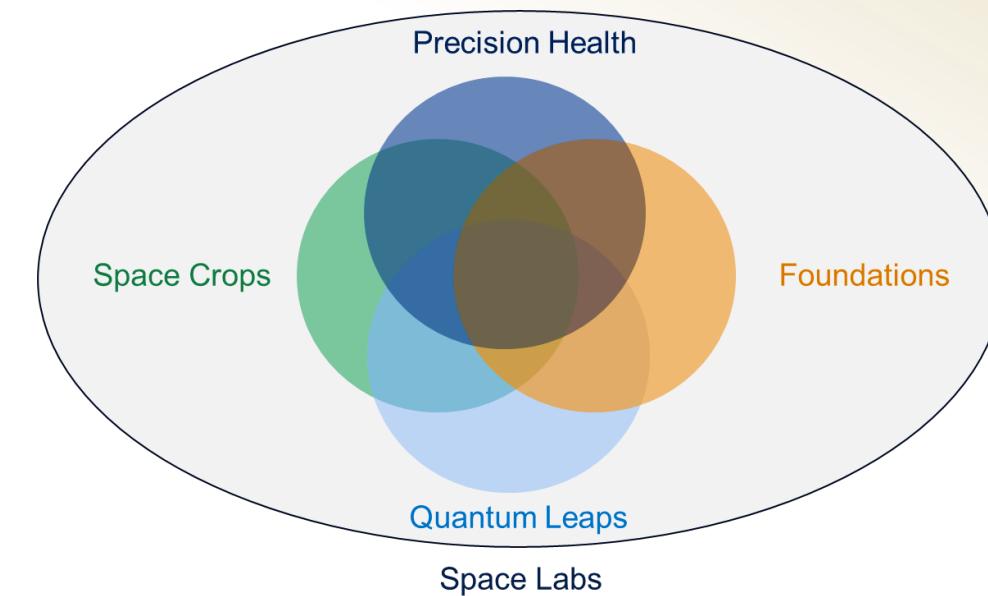
- BLiSS (Bioregenerative Life Support Systems)
- MATRICES (Manufacturing mATeRials & proCEsses for Sustainability in Space)
- PFaST (Probing the Fabric of Space Time)

**Note:** For beyond low Earth Orbit studies, aligns to the Moon to Mars Strategy and Objectives document and Architecture Definition Document, as well as other community-based objectives and roadmap documents (e.g. Lunar Exploration Analysis Working Group Roadmap and Artemis III Science Definition Team Report)

# Science Disciplines: Space Labs

- Incorporates and executes all of the Goals' roadmaps, capabilities/needs, objectives and priorities:

- **Goals:**
  - Precision Health
  - Space Crops
  - Quantum Leaps
  - Foundations



# Identifying Gaps & Opportunities: Space Labs

- What are all known, future, and desired spaceflight platforms and extra-terrestrial surface facilities?
- What and where are the destinations to conduct and address science research?
- What enabling capabilities and needs are necessary to conduct the scientific investigations in space for each Goal? How do we conduct experiments as we've done on ISS and in Earth research labs?
  - Science technology considerations: examples- miniaturization, multiple-use, *in situ* analysis, sample processing, capabilities for crew ops and science experiment continuity, sample and hardware return, cross-platform standardization, experiment iterations in same and multiple platform locations, etc.
  - Lunar surface and Gateway facilities
  - Low Earth orbit facilities (ISS, CLD, free-flyers, suborbital)
  - Deep space facilities
  - CERIIS initiative capabilities
- How do each of the Goal roadmaps for spaceflight research map or align to NASA timelines and roadmaps for spaceflight and exploration?
- What partnerships can we leverage?

# BPS Landscape Highlights: Suborbital, LEO

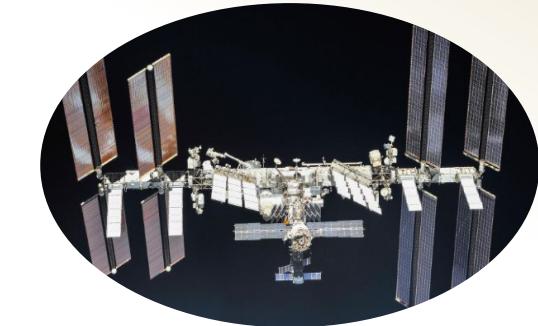
- **Suborbital**

- Blue Origin flight with scientist payload specialist



- **International Space Station**

- Past and present research investigations
- Science delivery on all commercial resupply missions
- Commercial access to ISS



- **Commercial Low-Earth-Orbit Destinations (CLDs)**

- science capability needs submitted to CLD leads

# BPS Landscape Highlights: M2M, Beyond

- **Moon to Mars (M2M)**

- M2M Architecture Definition Document
- BioExperiment-01 on Artemis I
- Regular solicitations for research on the Moon through Artemis and Commercial Lunar Payload Services (CLPS)
- Science payloads for Artemis II, SpaceX uncrewed demo
- Artemis III deployed instruments payload
- CLPS CP-22 LEIA (Lunar Explorer Instrument for space bio Applications)



- **Free-flyers:**

- BioSentinel
- X-37B for radiation studies

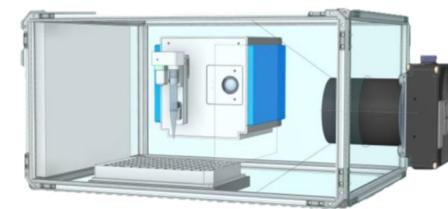


# BPS Landscape Highlights: CERISSL

## Commercially Enabled Rapid Space Science (CERISSL)

- **CERISSL developments and enabling capabilities**

- Lab capabilities under development  
(e.g. COTS-modified hardware, commercial hardware for CERISSL activity)
- CERISSL RFI Input received from community 2023
- 2023 TechFlights Award (SMD/STMD partnership)
- International space agencies and NASA investigating and developing *in situ* analysis capabilities
- Capabilities development within other Goals (e.g. Space Crops: spectrophotometer; Precision Health: *in situ* analysis studies, tissue chip longevity ground research enabling long duration studies)



# Exploration Space Labs



## Low Earth Orbit\* and Suborbital

### Low Earth Orbit

- International Space Station
- Commercial LEO Destinations
- Free-Flyers
  - Small Satellites
  - Large Multi-Payload Satellites

### Suborbital

- Balloon Flights
- Sounding Rockets
- Suborbital Flights

\*Standard LEO equatorial, polar orbit, high altitude / Van Allen Belts, etc.

## Moon

### Flight (Lunar Orbit & Surface)

- Orion
- Human Landing System
- Gateway Logistics Module
- Gateway
- Space Launch System
- ESPA Ring Payloads
- Free-Flyers (robotic)
  - Small Satellites
  - Large Multi-Payload Satellites

### Lunar Surface

- Human Landing System
- Lunar Terrain Vehicle
- Pressurized Rover
- Multi-Purpose Habitat Lab
- Surface Habitat Lab
- Robotic Rover
- CLPS Landers
- Small Satellite Landers

## Mars

### Flight (Mars Orbit & Surface)

- Transit Vehicles
- Free-Flyers
  - Small Satellites
  - Large Multi-Payload Satellites
  - Rideshare Payloads

### Mars Surface

- Surface Habitat Lab
- Mobile Vehicle
- Robotic Rovers
- Large Robotic Landers
- Rideshare Payloads

## Deep Space and Other Destinations\*

- Free-Flyers
  - Small Satellites
  - Large Multi-Payload Satellites
  - Rideshare Payloads
- Robotic Vehicles

\*Deep space, other worlds, other planetary moons, Lagrange points, heliocentric, etc.

# Space Labs

## Science Strategy

### Division Science Goals

- Precision Health
- Space Crops
- Quantum Leap
- Foundations

Defines the Science Strategy to address Decadal recommendations and other science drivers for their Goal, including CERIIS applications

• **Input Drivers:**  
What, Where, When?

## Science Implementation Strategy

Space Labs defines space facilities, capabilities, and timeline strategies for implementing the BPS research investigations

- Map to the current Moon to Mars exploration phases and timeline for the vehicles and facilities
- Map to the vehicle flight cadences
- Map to and define uncrewed vehicles
- Define and map critical vehicle and facility capabilities to timeline
- Identify vehicles that may not exist yet

# Space Labs Input Drivers: What, Where, When?

- What is needed to do the science (**major GFE, facility capabilities, and resources to operate scientific research studies**)?
- Where to do the science (**location: facility, platform, geological/space**)?
- When to do the science (**timeline prioritization**)?

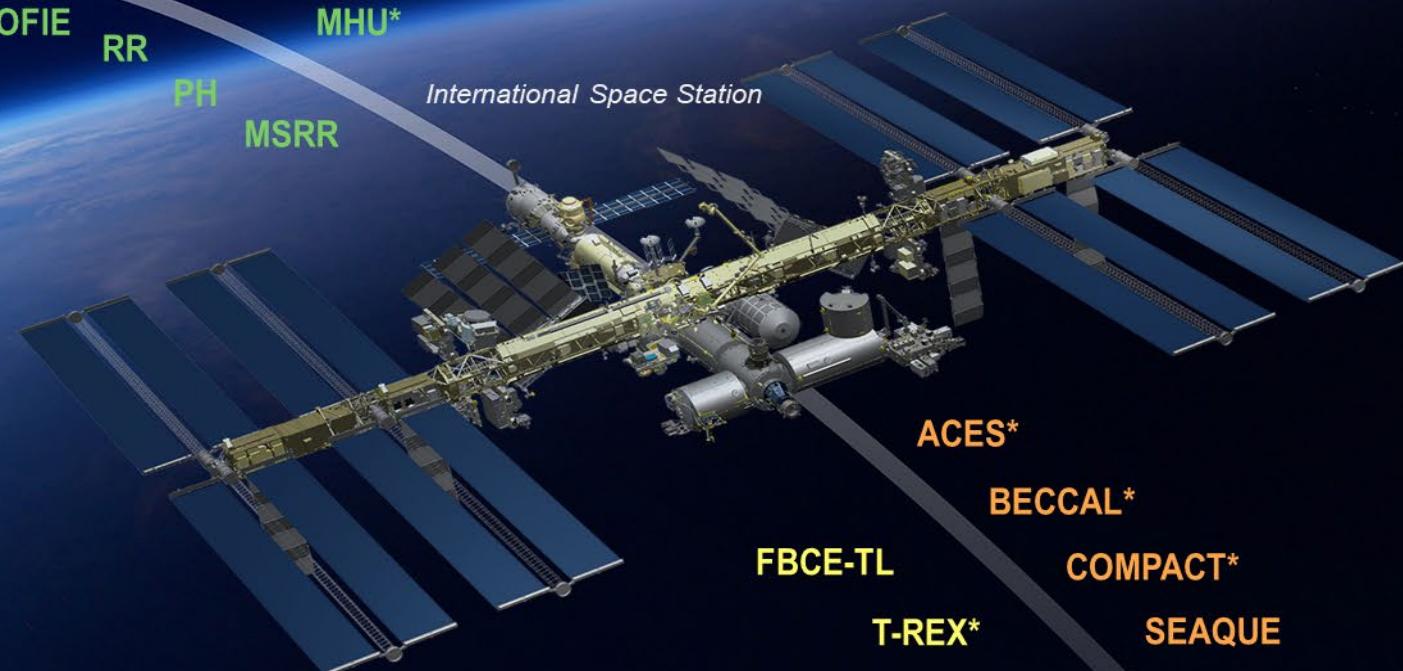
Mars

Moon



ARTEMIS II

ELF\* EML\* FBCE FLARE\*  
CAL SPECTRUM SOFIE RR MICRO  
BRIC-LED VEGGIE PH MHU\*  
BRIC MSRR  
APH XROOTS



# BIOLOGICAL & PHYSICAL SCIENCES FLEET

- FORMULATION
- IMPLEMENTATION
- OPERATIONAL

\*Partner-led

# Architecting from the Right, Executing from the Left

## Architecting from the Right, Executing from the Left

### INVESTIGATIONS

### THEMES\*

### GOALS



\*Draft – subject to change