EXPLORE MOON to MARS

Moon to Mars Update

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Exploration Science Strategy and Integration Office

Implementation Strategy

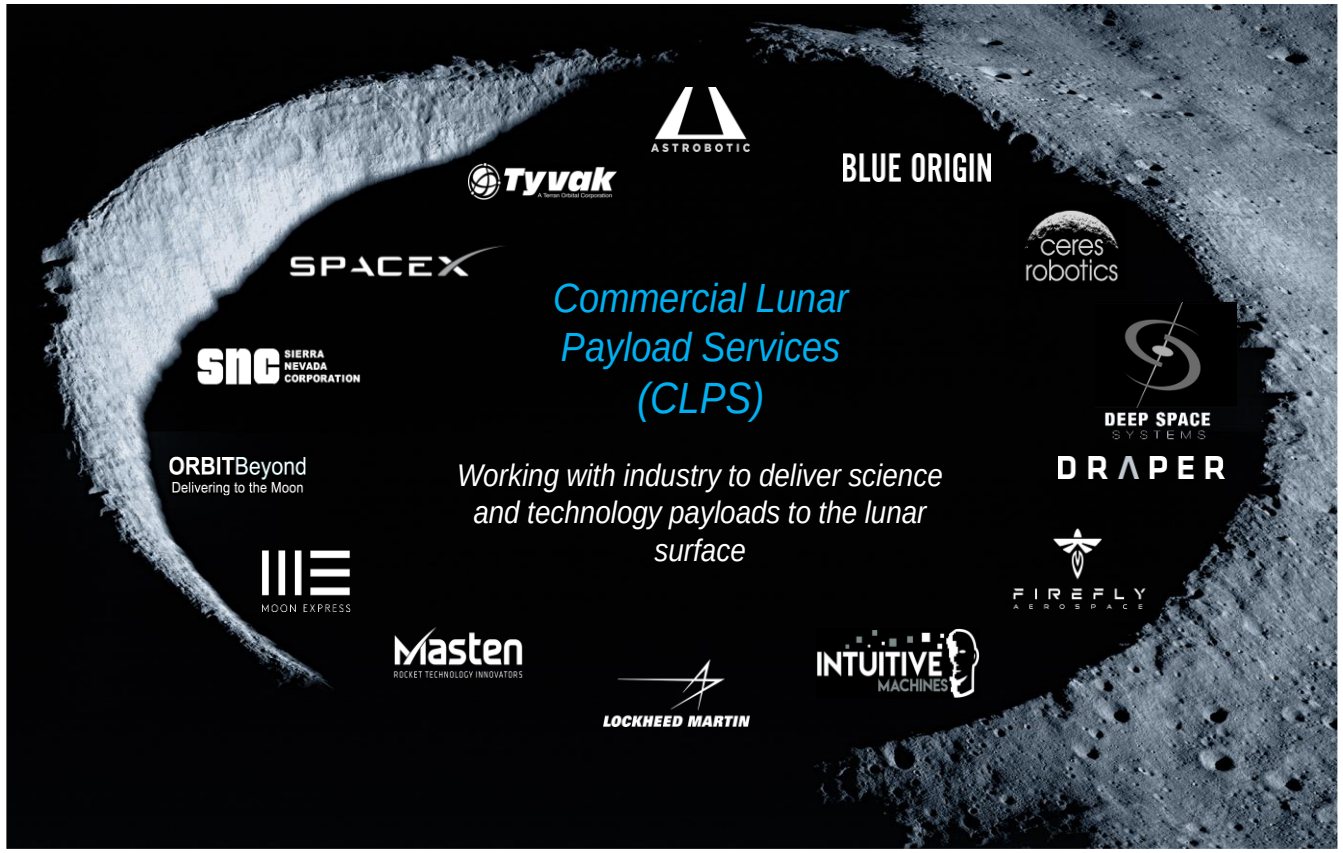
- Develop lunar surface science instruments
- Use commercial companies to deliver payloads to the Moon
- Develop mobility systems to expand and enhance science investigations on the surface
- Leverage international partnerships for additional opportunities (e.g., instruments, rovers)
- Obtain new scientific data from lunar orbit using smallsats
- Use new human exploration systems, such as Gateway and Human Landing System (HLS) to enable science
- Lead the science mission planning for humans on the lunar surface

Lunar Discovery & Exploration Program (LDEP)

Commercial Lunar Payload Services (CLPS)

Goal: Utilize commercial end-to-end delivery services to enable access to the lunar surface

- Deliveries initiated using a Task Order (TO)
  - Any of the 14 companies on the catalog can respond to a task order
  - Expected Task Order cadence of 2 per year
- Task Orders list what NASA wants delivered and any constraints
  - E.g., landing site, specific needs of instruments
- First 4 lunar surface delivery Task Orders awarded with deliveries commencing in 2021
  - 2021: Non-polar delivery (Astrobotic & Intuitive Machines) – TO 2A & 2B
  - 2022: Polar delivery (Masten) – TO 19C
  - 2022: PRIME-1 (Intuitive Machines)
  - 2023: Volatiles Investigating Polar Exploration Rover (VIPER) to Moon's south polar region (Astrobotic) – TO 20A



CLPS Deliveries 2021-2024

Delivery Site:
Oceanus Procellarum
Provider:
Intuitive Machines
Task Order (TO) 2 | 2021

Delivery Site:
Lacus Mortis
Provider:
Astrobotic
TO2 | 2021

Delivery Site:
Lunar Pole
Provider:
Astrobotic
VIPER | 2023

Delivery Site:
Reiner Gamma
Provider: TBD
PRISM-1a | 2023

Delivery Site:
Mare Crisium
Provider: TBD
TO19D | 2023

Delivery Site:
Schrödinger Basin
Provider: TBD
PRISM-1b | 2024

Delivery Site:
South Pole
Provider:
Intuitive Machines
TO PRIME-1 | 2022

Delivery Site:
South Pole
Provider:
Masten
TO19C | 2022

2021 CLPS Delivery Manifests

Payloads largely selected from NASA Provided Lunar Payloads (NPLP)

Astrobotic

- Surface Exosphere Alterations by Landers (SEAL)
- Photovoltac Investigation on Lunar Surface (PILS)
- Near-Infrared Volatile Spectrometer System (NIRVSS)
- Mass Spectrometer Observing Lunar Operations (Msolo)
- PROSPECT Ion-Trap Mass Spectrometer for Lunar Surface Volatiles (PITMS)
- Linear Energy Transfer Spectrometer (LETS)
- Neutron Spectrometer System (NSS)
- Neutron Measurements at the Lunar Surface (NMLS)
- Fluxgate Magnetometer (MAG)
- Navigation Doppler Lidar for Precise Velocity and Range Sensing (NDL)

Key

- Science
- Technology
- Exploration
- HEOMD/STMD

Intuitive Machines

- Lunar Node 1 Navigation Demonstrator (LN-1)
- Stereo Cameras for Lunar Plume-Surface Studies (SCALPSS)
- Low-frequency Radio Observations from the Near Side Lunar Surface (ROLSES)
- Navigation Doppler Lidar for Precise Velocity and Range Sensing (NDL)
- Radio Frequency Mass Gauge (RFMG)

2022 CLPS Delivery Manifests

Payloads largely selected from Lunar Surface Instrument and Technology Payloads (LSITP)

Polar

Masten Space Systems - South Pole

- Sample Acquisition, Morphology Filtering & Probing of Regolith (SAMPLR)
- Camera System for lunar science on commercial vehicles (Heimdall)
- Near-Infrared Volatile Spectrometer System (NIRVSS)
- Linear Energy Transfer Spectrometer (LETS)
- Lunar Compact Infrared Imaging System (L-CIRiS)
- Moon Rover with Exploration Autonomy (Moon Ranger)
- Laser Retroreflector
- Neutron Spectrometer System (NSS) – Deployed on Moon Ranger
- Mass Spectrometer Observing Lunar Operations (Msolo)

Key

- Science
- Technology
- Exploration

Non-Polar

TBD - Crisium

- Lunar Environment Heliophysics X-Ray Imager (LEXI)
- Next Generation Lunar Retroreflectors (NGLR)
- Radiation Tolerant Computer System
- Sample Acquisition & Delivery System for Instruments & Sample Return (PlanetVac)
- Lunar Instrumentation for Subsurface Thermal Exploration with Rapidity (LISTER)
- Lunar Magnetotelluric Sounder (LMS)
- Regolith Adherence Characterization (RAC)

CLPS Deliveries & Future Payloads

While the payloads for the first CLPS deliveries from the NPLP (NASA internal) and LSITP (external) calls, were focused first and foremost on speed, we are now working towards a science-driven model through PRISM (Payloads and Research Investigations for the Surface of the Moon)

- We expect PRISM calls to occur on a regular cadence
  - PRISM instruments will feed the manifests for Task Orders for CLPS deliveries from late 2023 onwards
  - The first call requests science investigations utilizing multi-instrument suites to maximize the science for named locations
  - High-value 'location agnostic' instruments may be called for in PRISM-2
- The locations are high science-value targets, as discussed in numerous community documents and where significant progress can be made utilizing CLPS platforms, the locations for this call are:
    - ❖ Reiner Gamma magnetic anomaly (lunar swirl)
    - ❖ Schödinger far side basin impact melt
- The destinations for these two deliveries were announced in July, allowing PIs time to prepare to propose science optimized for those locations
  - Step 1 proposals were received in December 2020, and step 2 were due February 3, 2021

ESSIO & PSD
Top Level Organization

Dr. Thomas Zurbuchen
Associate Administrator
Science Mission Directorate

Dr. Joel Kearns
Deputy Associate Administrator
for Exploration (DAAX)

Dr. Lori Glaze
Division Director
Planetary Science Division (PSD)

ESSIO
Program Scientists:

ESSIO
Program Executives:
Angela Melito
Jay Jenkins
Dr. Zachary Pirtle

Dr. Ryan Watkins

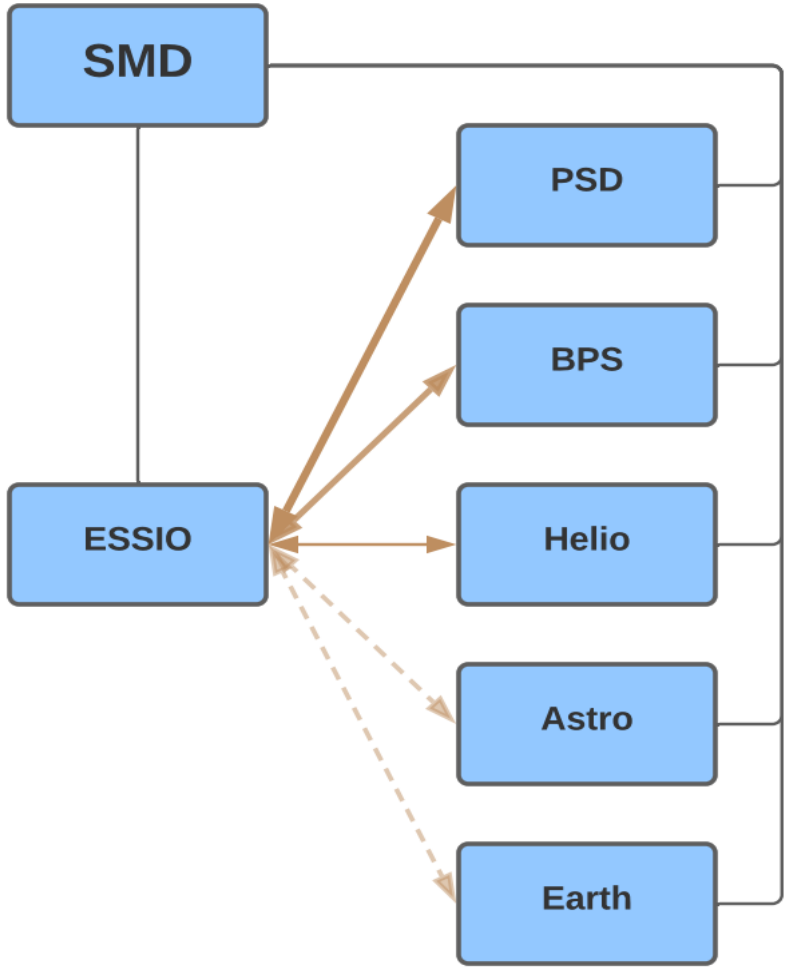
Dr. Debra Hurwitz Needham

Dr. Brad Bailey

Dr. Sarah Noble
-- ½ ESSIO | ½ PSD --

ESSIO's Artemis role within SMD is to provide the **integration** function

- Working closely with PSD as well as with BPS and Heliophysics (to a lesser extent Astrophysics and Earth Sciences) to maximize the science return from Artemis
- Making sure that science is in the room and has a seat at the table as decisions are being made that impact science
- Engaging with the science community
  - Lunar Surface Science Workshops



Coordinated activities with PSD

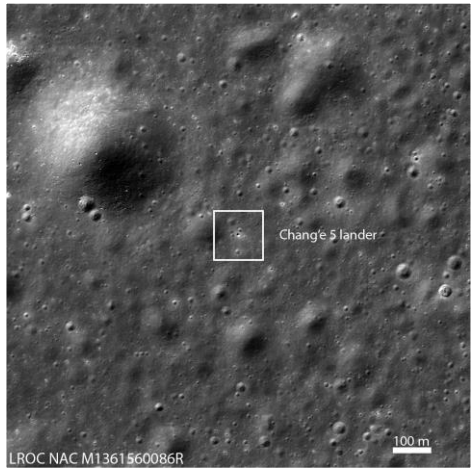
- VIPER
  - Rover managed by PSD
  - CLPS landing managed by ESSIO
- Lunar Trailblazer
  - Funded by ESSIO, managed by PSD
- ANGSA
  - Funded by ESSIO, managed by PSD
- DALI
  - Funded by ESSIO, managed by PSD
- LRO
  - Transferred to ESSIO

Lunar Reconnaissance Orbiter

The LRO spacecraft began it's 50,000th orbit of the Moon in August 2020

Still going strong after more than 11 years in orbit!

After starting its life as an Exploration asset under ESMD, then transitioning to a science workhorse that has revolutionized our global understanding of the Moon, LRO is once again being called upon to serve our exploration needs by providing input to landing site characterization for Artemis and CLPS landers.

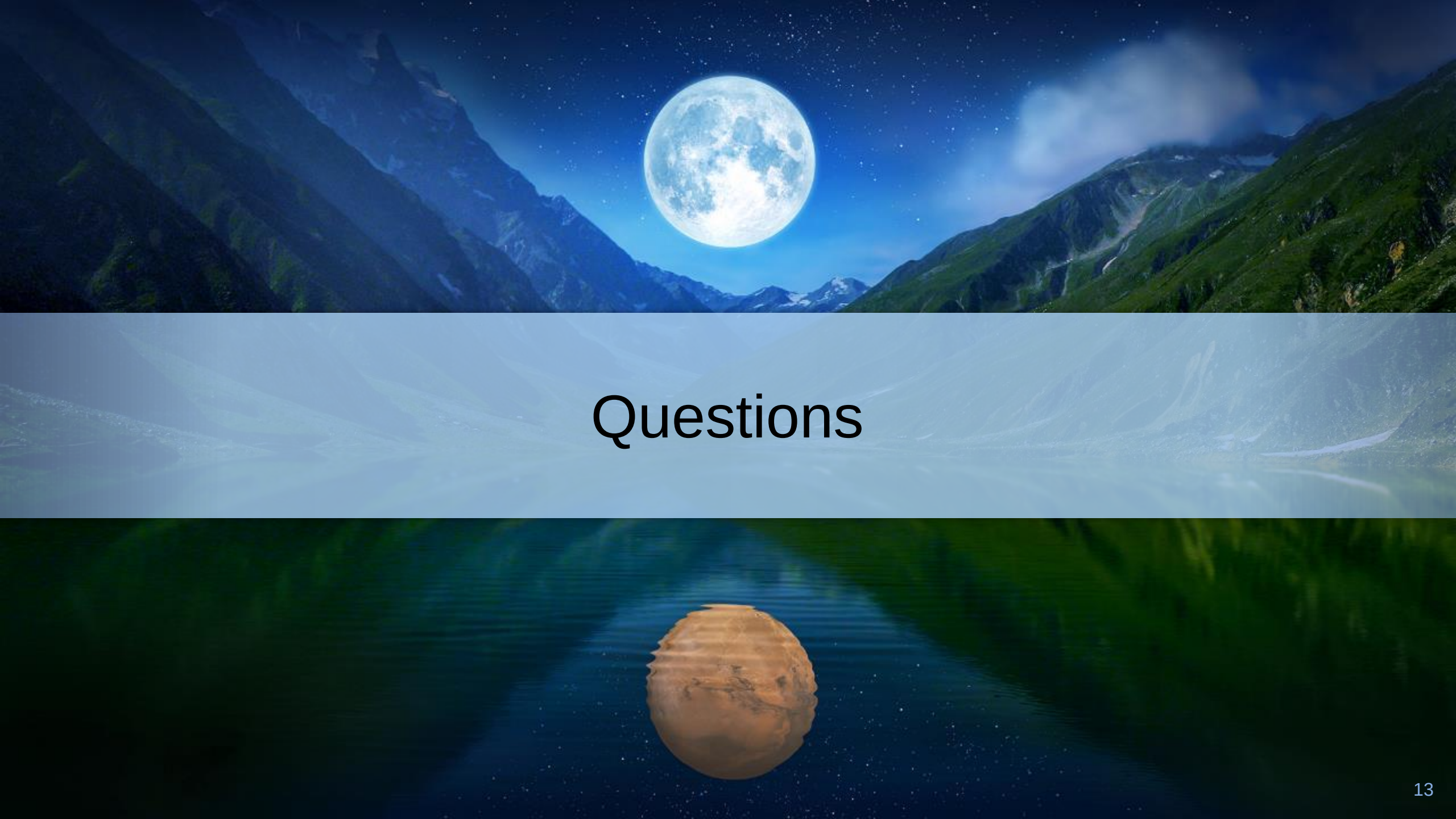


FY 2021 Budget (President's Budget Request)

PSD Budget Authority (in $ millions)	Op Plan FY 2020	Enacted FY 2021*	FY 2022	FY 2023	FY 2024	FY 2025
1. Discovery						
2. Planetary Science Research						
3. Planetary Defense						
4. **Lunar Discovery and Exploration (LDEP)**						
5. Mars Exploration						
6. New Frontiers						
7. Outer Planets and Ocean Worlds						
8. Radioisotope Power						
Total	**2,712.6**	**2,700.0**	**2,800.9**	**2,714.9**	**2,904.8**	**2,830.7**

LDEP Budget Authority (in $ millions)	Op Plan FY 2020	Enacted FY 2021*	FY 2022	FY 2023	FY 2024	FY 2025
Lunar Future	4.2	70.0	107.4	111.9	111.0	111.0
Lunar Reconnaissance Orbiter	22.0	22.0	22.0	22.0	22.0	22.0
Lunar Instruments	34.2	37.5	70.8	75.8	70.8	70.8
Commercial Lunar Payload Services	184.6	254.0	254.0	254.0	254.0	254.0
Lunar International Mission Collaboration	0.1	0.5	0.5	0.5	0.5	0.5
Volatiles Investigating Polar Exploration Rover	54.9	67.5	62.6	27.0	0.0	0.0
Total	**300.0**	**451.5**	**517.3**	**491.3**	**458.3**	**458.3**

**NASA is currently working an Initial Operating Plan proposal to Congress which may change FY 2021 totals*



Questions