Overview of Lunar Science Objectives.
Opportunities and guidelines for future missions.

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A rich scientific target

- Science for the origin and evolution of the Earth-Moon system.
- A witness plate for understanding fundamental solar system processes.
- A platform for human and robotic activities within and beyond the Earth-Moon system.
- Targets fit within variety of mission classes (e.g. small to flagship).
- Many partners (e.g. variety of space agencies, private sector).
SMD guide to lunar missions

Fundamental science questions that guide NASA’s solar system exploration:

• What is the inventory of solar system objects and what processes are active in and among them?
• How did the Sun’s family of planets, satellites, and minor bodies originate and evolve?
• What are the characteristics of the solar system that lead to habitable environments?
• How and where could life begin and evolve in the solar system?
• What are characteristics of small bodies and planetary environments that pose hazards and/or provide resources?
Mission Classes

- Small-Class Missions.
  - Discovery Program.
  - Extended missions for ongoing projects.
  - Missions of opportunity.
- Medium-Class Missions.
  - New Frontiers Program.
- Large-Class Missions.
  - Flagship.
New Frontiers Missions

2013-2022:
- Missions address broad and important questions in planetary science that have been judged to have high science merit when considered in light of the community-derived science priorities.
- Competed PI-led missions.
- Two missions to be selected.
- $1B budget excluding launch vehicle costs.

Previously selected missions:
- NF1. New Horizons mission to Pluto.
- NF2. Juno
- NF3. OSIRIS-REX
- NF4.
- NF5.
Recommended New Frontiers Missions 2013-2022

- Lunar South Pole-Aitken Basin Sample Return
- Lunar Geophysical Network
- Comet Surface Sample Return
- Saturn Probe
- Trojan Tour and Rendezvous
- Venus In Situ Explorer
- Io Observer

Not too early for the community to start preparing for mid-PSDS and PSDS 2023-2032!
Small-class Missions

Discovery class.

Extended mission or SMD ⇔ HEOMD partnerships

Stand Alone Mission of OpportuNity
**Discovery Mission Program**

- Competed PI-led missions.
- The low cost and short development times of Discovery missions provide flexibility to address new scientific discoveries on a timescale of significantly less than 10 years.
- The Discovery program is therefore outside the bounds of a decadal strategic plan, and the PSDS makes no recommendations for specific Discovery flight missions.
- However, it is important to link missions to important science goals and objectives that are outlined in SMD science plan, PSDS, SCEM, and LEAG Roadmap.
Discovery Mission Program

Previous mission selections:

- Stardust (1994)
- Genesis (1994)
- CONTOUR (1996)
- MESSENGER (1998)
- Dawn (2000)
- Kepler (2000)
- InSight (2010) (*no lunar missions were down selected to the final round*)
“The proximity of the Moon makes it an ideal target for future Discovery missions using both orbital and landed platforms, building on the rich scientific findings of recent lunar missions such as LRO, LCROSS, GRAIL and LADEE.”

PSDS p263
Discovery Mission
Science drivers from PSDS

How are volatile elements and compounds distributed, transported, and sequestered in near-surface environments on the surfaces of the Moon and Mercury?

What are the distribution and timescale of volcanism on the inner planets?
Discovery Missions
Science drivers from SCEM

- Determine the size, composition, and state (solid/liquid) of the core of the Moon.
- Characterize the chemical/physical stratification in the mantle, particularly the nature of the putative 500-km discontinuity and the composition of the lower mantle.
- How do we build on the Apollo Program and GRAIL?
GOAL Sci-A: Understand the formation, evolution, and current state of the Moon:


- Investigation-A: Inventory, relationships, and ages of nonmare rocks
- Investigation-C: Determine the composition, structure, and variability of the crust
Extended Missions

- Mission extensions with original scope.
  - Cassini
  - Mars Exploration Rover
  - LRO

- Missions with changes in scope because of unpredictable events or opportunities.
  - Stardust → NExT
  - Deep Impact → EPOXI
  - Lunar Communication Satellite ↔ Science Mission
Stand Alone Mission of Opportunity

- Investigations involving participation in non-NASA space missions through provision of a critical component of the mission, such as a science instrument, technology demonstrations, hardware components, microgravity research experiments, or expertise in critical areas of the mission (M³ and Mini-SAR Chandrayaan-1).
- Missions with a participating U.S. co-investigator (non-hardware) selected for a science or technology experiment to be built and flown by an agency other than NASA.
- Investigations that propose a new scientific use of existing NASA spacecraft.
- Small complete missions that enable realization of science or technology investigations within the specified cost cap.
- Focused investigations that address a specific, NASA-identified flight opportunity (2016 Mars Trace Gas Orbiter).
PSDS Lunar Flagship missions

2013-2022
- Enceladus Orbiter.
- Jupiter Europa Orbiter.
- Mars Astrobiology Explorer-Cacher.
- Uranus Orbiter and Probe.
- Venus Climate Mission.

2023-2032
- Are there competitive flagship-scale lunar science missions?
- Not too early to start discussions and planning.
Summary

- The Moon is a fertile scientific target that fit within variety of mission classes (e.g. small to flagship).
- The findings of previous and ongoing missions have provided both fundamental scientific framework to base future missions and fundamental observation to reduce risk to these future missions ($).
- Still need to develop a Moon-based infrastructure (e.g. com-sat) to enable new missions.
- Not too early for the community to start preparing for PSDS 2023-2032!
- LPSC 2014 propose a special session for new scientific discoveries and scientific summations from recent and current missions. Speakers will be requested to comment on next steps beyond their mission.