Sample Return & Lunar Exploration

Overarching Question:

How can risk/cost be reduced through cooperation and partnerships in technological developments and demonstrations?

What technologies exist and what technologies need to be developed in order to reduce risk/cost for (1) robotic sample return, (2) human sample return, and (3) robotic-human sample return?

What analysis can be done on the surface robotically and with crew vs. required sample return?

What are the limiting technologies for analysis on the lunar surface versus sample return?”

What are the roles of NASA, non-US space agencies, and the private sector in sampling the Moon?

exploration science resources commerce

Program

8:00 a.m. **Exploring the Moon with Samples. Scientific and Exploration Importance of Sample Return and Buying Down Risk and Cost of Sample Return Missions**
Charles Shearer, University of New Mexico

8:30 a.m. **The Lunar Collection: Status and the Future**
Gary Lofgren, NASA Johnson Space Center

9:30 a.m. **Future of Lunar Sample Return: Robotics, Humans, and Robotic-Human Partnerships**
Jeff Taylor, University of Hawai'i

10:00 a.m. **Management of Future Lunar Samples: Back to Basics**
Dean Eppler, NASA Johnson Space Center

10:30 a.m. **Automated Subsurface Sample Acquisition Technologies for Lunar Exploration**
Kiel Davis, Honeybee Robotics

11:00 a.m. **OSEWG/LEAG Workshop on Architecture Issues Associated with Sampling**
Kelly Snook, NASA SMD

11:30 a.m. **Panel Q&A Discussion**

12:00 noon LUNCH

Why go to the Moon?

We are going to work and learn how to live on another planet.

The Moon has unique significance for all space applications for a reason that to my amazement is hardly ever discussed in popular accounts of space policy. The Moon is the closest source of material that lies far up Earth's gravity well. Anything that can be made from Lunar material at costs comparable to Earth manufacture has an enormous overall cost advantage compared with objects lifted from Earth's surface. The greatest value of the Moon lies neither in science nor in exploration, but in its material.

John Marburger, 44th Robert H. Goddard Memorial Symposium, March 15, 2007, Keynote Address

However….

Science might not be the (or a) driver, but science will be one of the key legacies.

Sample return is important – Samples are a key legacy of exploration and they are a "gift that keeps on giving."

- **new science questions**
- **new analysis techniques**
- **exploration – enabling issues, safety**
- **ISRU – process development, resource assessment**
- **other uses, e.g., education, political, public outreach**

What technologies exist and what technologies need to be developed in order to reduce risk/cost of lunar sample return?

- Identify technology linkages/commonalities among different styles of missions (non-SR & SR) at system and subsystem levels.

- Apollo provides a starting point for sample return collection, handling, curation. How successful were these approaches?

  Special environmental sample containers, container seals.

- What level of sample culling and curation on lunar surface is needed?

  - Dictates technologies and infrastructure needed.

  - Will effect potential sources of sample contamination.

Sample Return: Technologies

- What technologies exist and what technologies need to be developed in order to reduce risk/cost for:
  - Robotic sample return
    - Sample collection tools (mobility, analysis, drilling, high-grading, context)
    - Robots for dangerous sampling activities and routine activities.
  - Human sample return
    - Astronaut in the loop always enhances exploration. Geologic context, decision making…
    - Mass issues
    - outpost sample analysis (lab in the hab) and sample “prep” – remains an issue.
    - Capabilities to make decisions about sample disposition.
    - Sample “caching” at the Outpost
  - Robotic-human sample return
    - Long-range roving with sample collection
    - Teleoperation

Sample Return: Technologies

- How to reduce risk & cost with technology development?
  - Precision landing
  - Sample containment/preservation
  - Coring & manipulation
    - Sampling subsurface
      - Don’t forget Apollo coring experience/knowledge
      - Coring/drilling polar regolith;
      - Controlled or deep regolith stratigraphy
  - Contamination mitigation
  - On-surface curation

Sample Return: Technologies

- What are the limiting technologies for analysis on the lunar surface versus sample return?
  - Precision of analysis – age dating and context analyses
  - Astronaut assist – instruments, suits (glove dexterity), data systems
  - Telerobotics
  - Lab-in-Hab issues and contamination
- What are the technological challenges for future automated lunar sample return?
  - Cryogenic samples
    - Collection
    - Collection without modification
    - Sample transfer
    - Environmental control
    - Containment – need work on vacuum seals, contamination prevention
    - Maintaining integrity through return to Earth
  - Oriented samples
  - Drilling rocks and regolith – volcanic & paleoregolith layers

Science Issues

- Different categories of samples to address science and exploration questions
  - Samples that are best returned to Earth (rocks, regolith, special samples)
    - Polar volatiles for science
  - Samples that are best analyzed in-situ
    - Polar regolith
    - Regolith to determine reactivity
- What are the key sample types needed to advance our understanding of the Moon?
  - Materials for dating lunar craters and terranes
  - Volatiles at the poles
  - Volcanic materials to sample the lunar interior
- What questions are better addressed with samples on the surface vs. returned to Earth?
  - Note: collection and return strategy dictated by the question to be addressed.
  - But… we do not always foresee good questions that will be asked

Exploration Issues

- Analysis of physical properties and for ISRU
  - In-situ vs. return
- Utilization of lunar resources
  - Are samples required or nice to have?
  - Assumes we know what we are looking for. Sometimes we get surprises. Better to have the samples.
- Need a contamination Czar
  - consider science <u>and</u> exploration issues
  - Alteration/contamination of ‘pristine’ nature of samples by exposure to atmosphere is a concern.
- xxxx

What are the roles of NASA, non-U.S. space agencies, and the commercial sector in sampling the Moon?

NASA:

- Expensive robotic and human sample return missions.
- Infrastructure to carry out these missions.
- Curation and allocation of samples for current and future science-engineering communities.

Non-U.S. space agencies:

- Sample return missions are ideal for multi-national collaboration.
- Development of sample return and handling technologies
- Sharing of samples

Commercial sector:

- Contribution to the development of SR subsystems
- Mini-SR missions with well focused goals.