Implementation of Key Science into Lunar Exploration

Theme 1: Important Scientific Sites on the Moon

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The Context for Important Scientific Sites on the Moon

1. **What are the questions? Charge to Speakers:**
   - Summarize important scientific problems.
   - Define requirements to fulfill scientific objectives.
   - How does the implementation of scientific objectives fit in with the exploration architecture?

2. **Guidance from the past.**

3. **The present environment.**

4. **The future.**
Guidance from the Past: The Apollo Program

• Why did we go?

• What did we do to prepare to go?
  – Landing site mapping, analysis and selection studies.
  – Close coordination: Science and engineering synergism.

• What did we do when we got there?
  – Accomplished the national goal: Apollo 11.
  – Undertook an historic scientific exploration program (A11-17).
  – Optimized Human/Robotic Exploration (ALSEP, LSE, CSM SIM, DMLRV).
  – Sent a professional geoscientist to the Moon (A17 LMP Harrison Schmitt).

• What was the legacy?
  – Prestige, pride, and perspective.
  – Revolutionized human understanding of Earth and planetary origin and history! The Moon is a keystone in our knowledge.
Apollo and Luna
Lunokhod, Apollo and MER Traverses to Scale

Apollo 11 surface activities and Pathfinder Sojourner traverse are not visible at this scale

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Lunar maria and dark mantle deposits
Mechanisms of Lithospheric Heat Transfer

- Lithospheric conduction
- Mercury, Moon, Mars
- Venus
- Earth
- Plate recycling
- Volcanic heat pipes

S. C. Solomon
Lunar Atmosphere and Volatile Traps
The Lunar Samples

- Low TiO\textsubscript{2} Basalt
  - 12002

- Polymict Breccia
  - 72275

- High TiO\textsubscript{2} Basalt
  - 70017

- Anorthosite
  - 60025
Important Scientific Sites
Charge to Speakers

• Summarize important scientific problems.
  – A host of fundamental scientific problems related to lunar and planetary formation, internal structure, chronology, processes and evolution.

• Define requirements to fulfill scientific objectives.
  – Need global access (farside, nearside, polar) for robotic and human sortie missions.

• How does the implementation of scientific objectives fit in with the current architecture?
The Present Environment

• The Good News!
  – We have a Visionary Presidential Mandate.
  – NASA human exploration is on the move.
  – Humans are destined to explore the Solar System.
  – The Moon is the clear first stepping stone.
  – We have a dedicated Administrator, ESMD-SMD Staff.
  – Charge: Science, Resources, Commerce.

• The Chinese Fortune Cookie Conundrum.
The Present Environment

• Seven Steps to the Seventh Human Landing on the Moon:
  – Return to flight.
  – Complete the ISS (Space Station).
  – Retire the STS (Shuttle).
  – Build new launch capability.
  – Build new transportation capability.
  – Build new landing/infrastructure capability.
  – Undertake lunar surface landings and operations.

• Budget Reality: Iraq, Katrina, Continuing resolutions.

• NASA Organization and Funding: ESMD and SMD.
The Present Environment: ESMD

• What does all this say about important scientific sites on the Moon?
  – Currently no Vision/ESMD requirements or plans for post-LRO robotic missions.
  – Initial human landings are likely to go to the same place to build up infrastructure for the outpost.
  – The current notional outpost site is centered on South Pole-Shackleton Crater rim.
  – Equatorial to mid-latitude outpost locations require surviving lunar night.
  – Current cost envelope and schedule do not permit this option.
  – Capabilities for science sorties at/from notional South Pole outpost (LRV-S/C) are not in current plan or budget envelope.
  – Sorties from Earth to non-outpost destinations possible, but require extra $2-4B/flight.
  – None of this should be surprising.
The Future: Where Do we Go from Here?

- Maintain the Vision for Space Exploration.
- Help sustain the Vision for Space Exploration. The down years!
- Learn from Apollo: The science didn’t happen overnight.
- Support the ESMD staff:
  - Help develop Science and Engineering Synergism.
  - Help design outpost science exploration strategy and tools for humans.
  - Fight hard to keep exploration options open (global access, human/robotic).
  - Always ask: What is the legacy of today’s decisions?
The Future: Where Do we Go from Here?

• Support the SMD Staff:
  – Help define what science can and can’t be done at a human outpost.
  – Help develop complementary post-LRO robotic lunar program (global access).
  – Craft a Lunar Scout Program?
  – Help SMD/ESMD synergism: Coleen Hartman.
  – Maintain a balanced and vibrant SMD program.

• What is our responsibility as scientists? Be proactive:
  – Help mobilize Congress to provide additional funding for lunar science and the Vision.
  – Cultivate and pursue international scientific partners.
  – Maintain exciting cutting edge research to frame exploration activities and sustain the Vision.
  – Be critical but constructive: Fight hard to keep exploration options open.
  – Help to define the legacy for the Vision for Space Exploration.
    • Science, Resources, Commerce.