Robotic Missions Summary

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Questions

- What can we learn from robotic missions before the next human landing?
- What do we need to learn from robotic missions before lunar settlement and commercial development?
- What role could be played by small, robotic lunar missions?
- What role could state governments play in lunar exploration?
- Can the CEV SIM Bay be used for deployment of robotic exploration missions?

Important Themes

- There is a long list of measurements to make and tests to do before and after human missions
- These will enhance lunar exploration
- There are innovative ways of implementing missions that could lead to lower cost

Why do robotic precursor missions?

- **Strategic knowledge**
  - Important information on lunar environment and materials obtained before people return
  - Scientific and operational reconnaissance
- **Programmatic milestones**
  - Decade between LRO and first human landings
  - Sustain program with cadence of visible milestones
- **Emplacement of assets**
  - Pre-landed machines can prepare site, emplace equipment for later human use
- **Site Precedence**
  - Assets in orbit and landed payloads are statement of intent to use lunar resources

Why do robotic scientific missions?

- Characterize processes and environments likely to be changed as a result of human presence (e.g., lunar atmosphere)
- Obtain information on unknown or poorly understood processes and history (e.g., polar deposits)
- Reconnoiter areas and sites to make subsequent human exploration more productive
- Explore to characterize, map, learn and understand (all sites)

Important Measurements to Enhance Exploration

- **Useful Lunar Information**
  - **Dust characterization & mitigation**
  - **Landing site reconnaissance**
  - **Lunar model validation (tie to ground truth)**
  - **Local radiation measurement**
  - **Spacecraft charging evaluation**
  - **Regolith handling/site preparation**
  - **ISRU characterization and demonstration**
  - **Lighting perspective (permanent low incidence at poles)**

Important Measurements to Enhance Exploration

- **Useful Lunar Information: Polar Volatiles**
- Inventory of trapped ice
- Composition of ice
- Variability in ice composition
- State of volatiles (ices, amorphous compounds, separate phases, clathrates)
- Spatial distribution of ice
- How ice binds soil grains
- Whether ice reacts with soil grains
- Geotechnical properties of ice-bearing regolith in cold traps
- Physical environment of polar regions

Technology Demonstrations

- Communications (surface mobile comm)
- Mechanisms (1/6G performance, dust impact on lifetime)
- Materials (dust compatibility)
- Thermal (surface influence, radiator dust exposure)
- Navigation and guidance (Precision Landing)
- Propulsion (system performance, plume interaction)
- Mobility (traction, dust impact)
- Power (Re-charging mobile robotic assets, fuel cell tech)
- Avionics (Open architecture, Rad hard)
- Cryo handling & storage (test demo)
- ECLSS (water loop performance in 1/6g, dust filters)

Innovative Robotic Approaches: Multiple hard landers for polar studies

- Cover diversity of polar lighting conditions
  - Ideal dispersion is at least one in light, one in dark
- Assure sensor release (no null results due to inverted orientation)
  - Will need to clear H-bearing material on spacecraft for accurate measurement of regolith
- Mission Redundancy
  - Assure at least one probe works and gives ground truth

Innovative Robotic Approaches: Small Spacecraft

- **Key Features**
  - Low Mission Costs ($50-100M), Short Schedule <24Months
  - Low Mass < 300kg, Low Cost Launch Vehicles
- **Benefits**
  - Lower Cost Enables Increased Number Of Missions
  - Faster Learning Cycle, Leads to Lower Costs
  - Demonstrate New Technology Sooner, Lowers Cost of Large Missions
  - Lower Overall Program Risk by Providing Several Flight Opportunities
  - Smaller Teams, Fewer Interfaces, Improved Collaboration
- **Drawbacks**
  - Size, Mass Eliminate Some Missions for Small Spacecraft
  - Higher Individual Risk Of Missions compared with $1B Spacecraft
  - Use of “Yet To Be Proven” Launch Vehicles, or Fly as a Secondary Payload

Lunar Science Robotic Campaign

- Establish an aggressive lunar science campaign to the lunar surface
- Enabled by commercial leveraging with NASA
  - Could follow approach to develop commercial orbital transportation system (COTS)
- Could lead to a near-term technology demonstration on the surface
- Campaign (series of missions) would provide information needed for exploration and science
- LEAG through NAC could define the campaign

Role of the States

- **Why should states get involved?**
  - **Affordability demands State participation**
  - **Sustainability demands State participatio**
  - **The public benefits more when States participate.**
  - **Industry is critical, but it has to make money**
  - **The States can bring everything together**
- **Roles states can play**
  - **Education**
  - **Promotion (e.g., tax structures for business)**
  - **Recruitment and incubation of space business**
  - **Build infrastructure**