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LSIC Dust Mitigation

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Goals for today’s LSIC Dust Mitigation Focus Group Meeting:

• Provide the LSIC Dust Mitigation FG an introduction the ongoing LSIC Paper effort

• Highlight near-term opportunities to provide feedback on the WIP paper
  • FG Meetings
  • Spring Meeting

• Engage in community discussion to provide inputs to the Dust Mitigation section of the paper
  • “Raise Hand” in Zoom or share in chat during discussion portion
• Decisions we make now are critically important to achieve the 10+ year goals of the Nation on the Moon and beyond

• APL with LSIC is developing a community-derived white paper on the path from early NASA missions to an Enduring Lunar Presence with a robust lunar ecosystem
  • “In satisfying NASA’s baseline objectives, how do we ensure robust participation from industry that also enables a transition away from NASA as a sole customer?”

• Stakeholder alignment – NASA will not achieve goals alone

• Phased development and key early investments/decisions

• Opportunities for “systems of systems” tech demos – terrestrial or lunar
• Structure of the paper:
  • Estimated 10 pages – high level, in family with M2M Objectives and OSTP Cislunar document
  • Identify key infrastructure from industry’s perspective
    • What enables the evolution of the Moon into an exploration proving grounds?
    • What are the technologies that have shared applicability across all stakeholders and how do we best motivate their development?
  • The 6 LSII focus areas are integrated in the process – not independent efforts
  • What combined tech demos could retire key questions?
Early insights from prior engagements/breakouts:

- “The Moon as a proving ground” means many things
  - For proving out **science and exploration technologies**
  - Demonstrates **unity of purpose** and commitment to achieving long-term goals
  - To **test and mature acquisition strategies** that can amplify NASA’s investments and show that we can work in a “whole-of-nation” fashion

- Preliminary take-aways from breakouts:
  - Translational technologies abound and offer multiplier on NASA’s investments
  - Multi-stakeholder involvement provides a key signal of stability for industry
  - If NASA cannot succeed on the Moon, there is little confidence in the community for taking humans to Mars
    - How do we know when we’re ready to move on to Mars?
Overview / Introduction

Stakeholder Needs

- Understanding what upstream influences exist, and how they can be managed, will be critical for reducing ambiguity in the Lunar architecture. Some common upstream influences include:
  - Regulations (applicability), technology (infusion), competitive environment, strategy (amount of risk willing to take)

- Architectures often fail due to upstream influences and stem from how engagement with the stakeholders is carried out. Common failures include:
  - Failure to understand stakeholders needs; failure to consider the cost of regulation compliance; failure to consider technology maturation timelines; technology infusion; failure to estimate demand; knowledge of failures products and systems must endure and still operate
Transition to Industry

• Transition to industry is likely to accelerate after the ARTEMIS campaign

• NASA shifts focus to Mars missions (Moon to Mars)

• Breaks into natural Lunar development phases
  - (Moon)Phase 1 – Artemis I-VIII (to 2031)
  - (To) Phase 2 – Artemis IX – Mars Development (2030s)
  - (Mars) Phase 3 – Mars Development and Lunar Operations as a service (2040s)

• Highlight industry priorities throughout this process – What is important to you that needs to happen now?
  - Identify key gaps where NASA/OGAs need to lead
  - Areas for collaboration between NASA/OGA/Academia

Lunar Goals

Moon to Mars Threshold Objectives

• Support Moon to Mars
  - The Moon is a proving ground for Mars across all domains
    • Technology
    • Policy
    • Systems Engineering
  - Baselined on good faith interpretations of NASA’s current plans

“Desirement”

• There will be a long term sustainable presence on the Moon with substantial commercial involvement – “Commercial Ecosystem”
  - Commercial sale of propellant
  - Lunar Tourism
  - Life off of Earth
  - Extended Science Operations
  - Off-planet field testing
  - Lunar Manufacturing
  - Mission pulls are broad here

How might industry partner and accelerate the M2M process in regards to Dust Mitigation?

DEVELOP: Design, build, and deploy a system, ready to be operated by the user, to fully meet architectural objectives.

DEMONSTRATE: Deploy an initial capability to enable system maturation and future industry growth in alignment with architecture objectives.
Dust Mitigation Section
Cross-Cutting – Dust Mitigation

- Lunar Dust Characteristics
  - Silicate/Aluminosilicate (~80%), Oxide (~20%), trace minerals & metals
  - Wide range of sizes, shapes
    - “dust” is regolith < 20 µm… or is it 100 µm? Or 1000 µm? Depends on source!
    - Measured sizes as small as 0.01 µm
    - Sharp, abrasive
    - Mix of sizes/shapes/components highly dependent on location
  - High adhesion
  - Surface electric fields – Solar Wind, GCRs, high vacuum

- What does lunar dust impact? Everything
  - Equipment maintenance/repair/replacement cycles
    - Abrasion, clogging, seal failures, EM effects
    - Higher variability in MTBF and MTBR
  - Measurement accuracy – requires highly sensitive instruments
  - Visibility
    - Human eyesight, displays, instrument readouts, science
  - Traction
  - Thermal control (insulator)
  - Human Health/ECLSS (inhalation/irritation risks)
  - Resource location
  - Transport
  - Landing
    - Distance from people, resources
    - How to minimize lofting?
  - Activity planning (scheduling, resource allocation)

LSIC Community perspectives on dust mitigation gaps and opportunities

- State-of-the-Art (SOTA) in DM for Phase 2
- Gaps
  - Technologies
  - Requirements/Guidelines
  - Stakeholder Engagement
- Opportunities: How might we bridge these gaps?
Dust Mitigation Community Discussion

• What does the State-of-the-Art (SOTA) in Dust Mitigation need to be for a sustained lunar presence when NASA pivots from Moon to Mars? (Phase 2)

• Gaps: What Dust Mitigation technology, requirements/guidelines, etc. do we need for Phase 2 that does not exist or is not planned right now?

• Opportunities: How might we bridge these gaps?

• Stakeholder Engagement: Who should be communicating, collaborating, etc. but isn’t (yet!)?

• How might industry partner and accelerate the M2M process in regards to Dust Mitigation?

• What is important to you that needs to happen now in order to ensure an Enduring Lunar Presence?