Lunar Surface Innovation
CONSORTIUM

# Extreme Environments Focus Group June Meeting

**June 8, 2021**

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# Today's Agenda

- LSIC Updates (2 min – Greenhagen)
- Surface Environment Activity – Survey and Final Steps (5 min – Greenhagen)
- Surface Environment Activity – Subgroup Rankings Discussion (15 min – Greenhagen, Subgroup Leads)
- Featured Presentation (25 min – Moorhead)
  - "The Primary Meteoroid Flux at the Moon and the Lunar South Pole"
- Open floor (time permitting)

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# LSIC Updates

*LSIC Spring Meeting was May 11-12*

- Presentations are now archived online
  - http://lsic.jhuapl.edu/News-and-Events/Agenda/index.php?id=124

*Vertical Solar Array Technologies (VSAT) Meeting was May 27*

- Joint meeting with Surface Power, Dust Mitigation, and Extreme Environments
- Presentations are now archived online (Surface Power page)
  - http://lsic.jhuapl.edu/Focus-Areas/Surface-Power.php

*Upcoming LSIC Workshops ( http://lsic.jhuapl.edu/News-and-Events/ )*

- Power Beaming Workshop (7/22-7/23/21)
- Commercial Lunar Payload Services Workshop (TBD Fall 2021)
- TBD Joint Focus Group Workshop(s) (starting Fall 2021)

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# Surface Environment Activity

*Topic: Identifying and Classifying Specific Lunar Surface Environments*

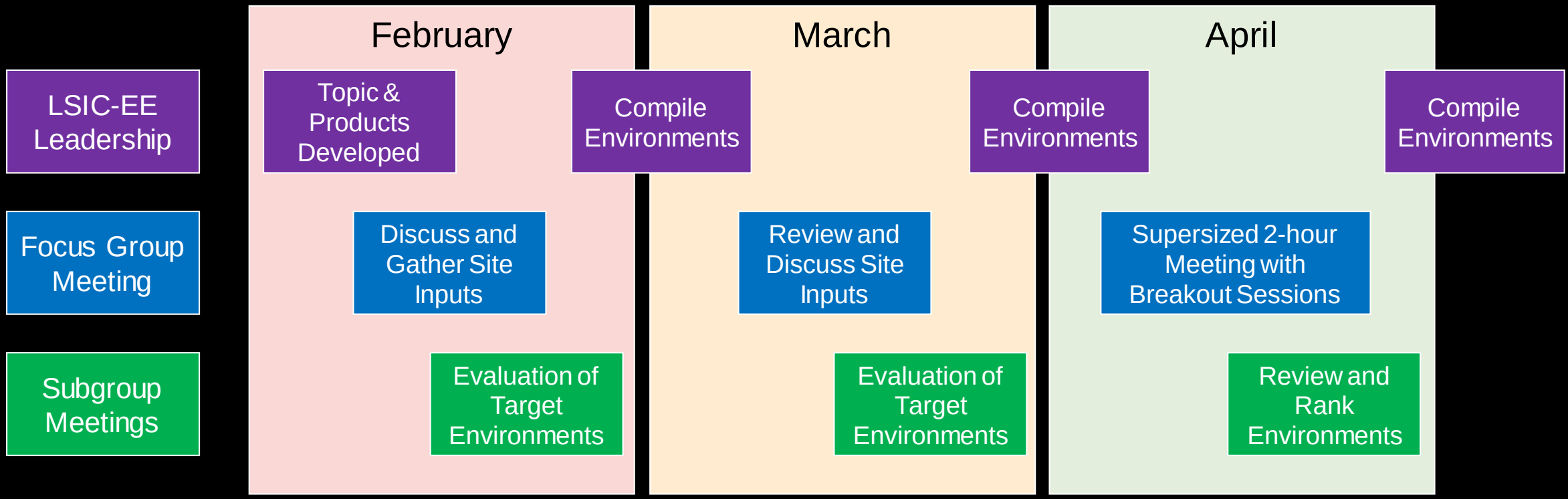
- "Breaking Down the Lunar Environment Monolith"
- How do different environments stress technologies in different ways

| Polar Environments | Environmental Variations |
|---|---|
| Permanently Shadowed Regions (PSRs) | • PSRs with significant reflected illumination<br>• PSRs without significant reflected illumination<br>• PSRs with volatiles in the near-surface regolith<br>• PSRs with desiccated near-surface regolith |
| Areas of High Illumination (>55% Illumination) | • Naturally high illumination<br>• Mobility-enabled high illumination |
| Mixed Polar Environments | • Illuminated terrain with rover-accessible macro cold traps (10s to 100s+ meter PSRs)<br>• Illuminated terrain with rover-accessible micro cold traps (1 - 10 meter PSRs)<br>• Occasionally illuminated terrain with subsurface volatile stability<br>• Polar pits or lava tubes (hypothetical) |

| Non-Polar Environments | Environmental Variations |
|---|---|
| Apollo-style Environments | • Maria<br>• Highlands |
| Topographic Margins | • Crater features (rims, peaks, floor fractures)<br>• Volcanic features (vents, domes, riles) |
| Lunar Pits & Lava Tubes | • Mare basalt features<br>• Impact melt features |
| Surface Anomalies | • Irregular Mare Patches<br>• Regolith Texture Anomalies (High/Low Dust, Pyroclastic, etc.)<br>• Magnetic Anomalies |

# Surface Environment Activity

*Activities to Complete Before the LSIC Spring Meeting*



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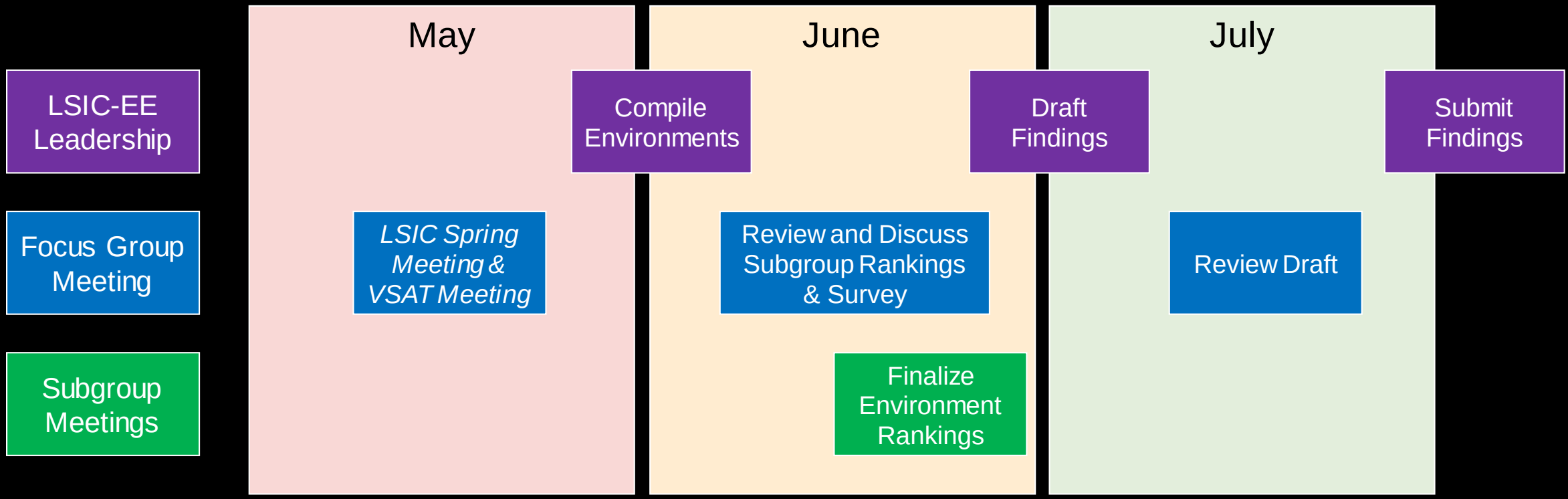
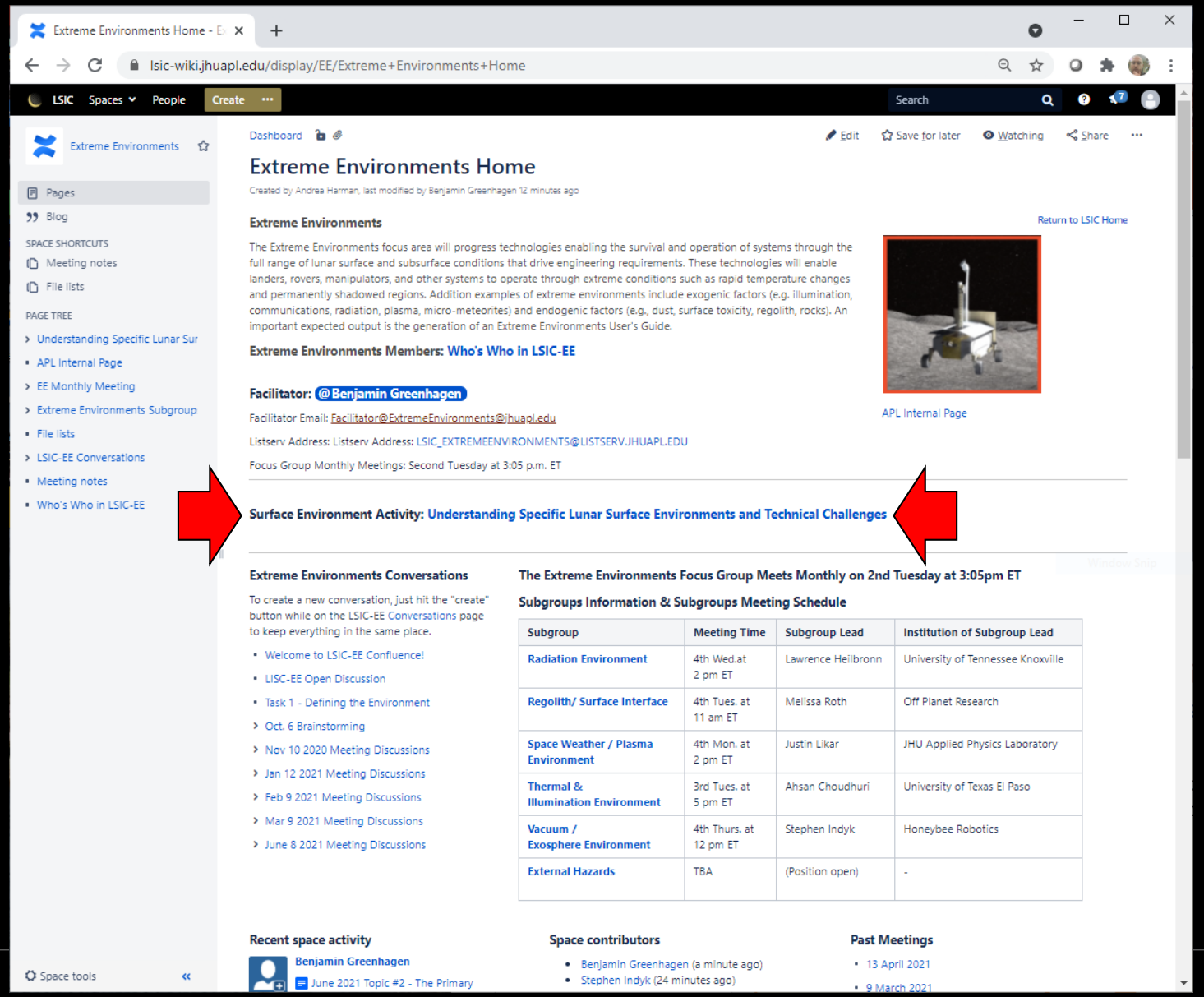


# New Activity Home on Confluence




https://lsic-wiki.jhuapl.edu/display/EE

# Surface Environment Activity

*Survey*

- Vote for the environment(s) you think we should prioritize for our next FG workshop(s) or working meeting(s)
- https://forms.gle/QiKzFjLvLnXhdGgN8
- Vote early and vote often (please try to respond by the end of this week)!

*Review Draft Findings*

- *Findings will be on Confluence*
- *Brief discussion at July Focus Group Meeting, July 13th*

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# Subgroup Environment Rankings

*Summary of all Subgroups ( https://lsic-wiki.jhuapl.edu/pages/viewpage.action?pageId=13340355)*

| Specific Environment | Radiation | Regolith / Surface | Space Weather / Plasma | Thermal & Illumination | Vacuum / Exosphere |
|---|---|---|---|---|---|
| **P1. Permanently Shadowed Regions** | 5 (Tier 2) | 1 (Tier 1) | 4 (Tier 2) | 1 (Both) | 1 |
| **P2. Areas of High Illumination** | 4 (Tier 2) | 6 (Tier 3) | 6 (Tier 3) | 3 (T) & 7 (I) | 6 |
| **P3. Mixed Polar Environments** | 2 (Tier 1) | 2 (Tier 1) | 1 (Tier 1) | 2 (T) & 3 (I) | 1 |
| **NP1. Apollo-Style** | 1 (Tier 1) | 7 (Tier 3) | 7 (Tier 3) | 5 (Both) | 7 |
| **NP2. Topographic Margins** | 3 (Tier 1) | 5 (Tier 2) | 3 (Tier 2) | 6 (T) & 4 (I) | 3 |
| **NP3. Lunar Pits / Lava Tubes** | 6 (Tier 3) | 4 (Tier 2) | 5 (Tier 3) | 4 (T) & 2 (I) | 4 |
| **NP4. Surface Anomalies** | 7 (Tier 3) | 3 (Tier 2) | 2 (Tier 1) | 7 (T) & 5 (I) | 5 |

# Subgroup Environment Rankings

*Radiation Environment Subgroup ( https://lsic-wiki.jhuapl.edu/display/EE/RadEnv+lunar+surface+environments+ranking)*

| Specific Environment | Radiation | Notes |
|---|---|---|
| **NP1. Apollo-Style** | 1 (Tier 1) | highest GCR flux, shelter needed for SEP event, largest source of background/interference for instruments |
| **P3. Mixed Polar Environments** | 2 (Tier 1) | highly variable rad environment due to variable local shielding, regolith composition affects albedo neutron spectrum |
| **NP2. Topographic Margins** | 3 (Tier 1) | local variations in rad environment due to variations in shielding provided by topographical features (crater walls, etc.) |
| **P2. Areas of High Illumination** | 4 (Tier 2) | highest GCR dose of polar sites, but less uncertainty in predicted dose |
| **P1. Permanently Shadowed Regions** | 5 (Tier 2) | same comment as P3, but variability and associated uncertainty less than P3 |
| **NP3. Lunar Pits / Lava Tubes** | 6 (Tier 3) | Shielding inside lava tubes is very thick, very low doses. Interesting to look at dose inside near entrance, though. |
| **NP4. Surface Anomalies** | 7 (Tier 3) | Magnetic field strengths too low to affect ionizing radiation environment |

# Subgroup Environment Rankings

*Regolith / Surface Interface Subgroup ( https://lsic-wiki.jhuapl.edu/display/EE/RSI%3A+Landing+Sites+Rankings )*

| Specific Environment | Regolith / Surface | Notes |
|---|---|---|
| **P1. Permanently Shadowed Regions** | 1 (Tier 1) | Extreme conditions w/ potential volatile reactions and physical differences. Temperatures may exceed expected thermal performance of suit materials. |
| **P3. Mixed Polar Environments** | 2 (Tier 1) | Need to transition between extremes. Potential interaction with volatiles. |
| **NP4. Surface Anomalies** | 3 (Tier 2) | Many unknowns, especially for properties. |
| **NP3. Lunar Pits / Lava Tubes** | 4 (Tier 2) | Many unknowns, but likely very different compared to surface regolith. While water ice may not be stable in the tube entrances at lower latitudes, sulfur may be. The expected sharp boulders may pose hazardous for spacesuits. |
| **NP2. Topographic Margins** | 5 (Tier 2) | Challenges for navigation but fewer unknowns. |
| **P2. Areas of High Illumination** | 6 (Tier 3) | Less characterized but longer days to maintain properties and less frequent ESD than NP1. |
| **NP1. Apollo-Style** | 7 (Tier 3) | Fairly well characterized. |

# Subgroup Environment Rankings

*Space Weather / Plasma Subgroup ( https://lsic-wiki.jhuapl.edu/display/EE/SWPE%3A+Surface+Environment+Rankings )*

| Specific Environment | Space Weather / Plasma | Notes |
|---|---|---|
| **P3. Mixed Polar Environments** | 1 (Tier 1) | Large uncertainties; potential for transient environments. |
| **NP4. Surface Anomalies** | 2 (Tier 1) | Big uncertainty & variable; not very well understood |
| **NP2. Topographic Margins** | 3 (Tier 2) | Potential gradients expected across adjacent surfaces / regions (large dV -> risk of ESD) |
| **P1. Permanently Shadowed Regions** | 4 (Tier 2) | Technically very challenging but generally better understood |
| **NP3. Lunar Pits / Lava Tubes** | 5 (Tier 3) | Unlikely to be much charging in tubes; pits may fit elsewhere |
| **P2. Areas of High Illumination** | 6 (Tier 3) | High photocurrent; comparatively well-studied |
| **NP1. Apollo-Style** | 7 (Tier 3) | Large absolute charging expected (e.g. kV night side during magnetotail passage); comparatively well known, however. Similar comments regarding terminator |

# Subgroup Environment Rankings

*Thermal & Illumination Subgroup ( https://lsic-wiki.jhuapl.edu/display/EE/Lunar+Surface+Environment+Ranking )*

| Specific Environment | Thermal | Illumination | Notes |
|---|---|---|---|
| **P1. Permanently Shadowed Regions** | 1 | 1 | |
| **P3. Mixed Polar Environments** | 2 | 3 | |
| **P2. Areas of High Illumination** | 3 | 7 | |
| **NP3. Lunar Pits / Lava Tubes** | 4 | 2 | Radiator Design/Heat Rejection Challenges |
| **NP1. Apollo-Style** | 5 | 5 | |
| **NP2. Topographic Margins** | 6 | 4 | |
| **NP4. Surface Anomalies** | 7 | 5 | |

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# Subgroup Environment Rankings

*Vacuum / Exosphere Subgroup ( https://lsic-wiki.jhuapl.edu/display/EE/VEE+Lunar+Surface+Environment+Ranking )*

| Specific Environment | Vacuum / Exosphere | Notes |
|---|---|---|
| **P1. Permanently Shadowed Regions** | 1 | Many unknowns with PSR environment. |
| **P3. Mixed Polar Environments** | 1 | Difficult to deal with technology challenges for a transient environment. Many unknowns with PSR environment. Exploring Mixed Polar Environments has to encounter two difficult environmental condition sets. |
| **NP2. Topographic Margins** | 3 | Transitions have more and more complex requirements. |
| **NP3. Lunar Pits / Lava Tubes** | 4 | May provide complex atmospheric conditions due to exploration interactions. Will out-gassing material from exploratory system become trapped in this space and affect any instrument measurements? |
| **NP4. Surface Anomalies** | 5 | Complex, but likely similar vacuum environment conditions to what is currently understood. |
| **P2. Areas of High Illumination** | 6 | Better understood conditions, most likely fewer surfaces with out-gassing properties. |
| **NP1. Apollo-Style** | 7 | Studied and best understood environment of this environment set. |

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# Featured Presentation

- The Primary Meteoroid Flux at the Moon and the Lunar South Pole
  - Althea Moorhead, NASA Meteoroid Environment Office, MSFC


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