Lunar Surface Innovation CONSORTIUM

Extreme Environments Focus Group June Meeting

July 13, 2021

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JOHNS HOPKINS APPLIED PHYSICS LABORATORY

Lunar Surface Innovation CONSORTIUM

Today's Agenda

- LSIC Updates (5 min – Greenhagen, Fuhrman)
- Surface Environment Prioritization Survey Update and Discussion (20 min – Greenhagen)
- Featured Presentations (25 min – Subgroup Leads)
  - "Subgroup Recent Progress and Future Plans"
- Open floor (time permitting)

LSIC Updates

Who's Who in LSIC-EE

- *18 entries to date*
- *https://lsic-wiki.jhuapl.edu/display/EE/Who%27s+Who+in+LSIC-EE*

LSIC Fall Meeting is confirmed for November 3-4, 2021

- More details to come!

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

- Power Beaming Workshop (7/22-7/23/21)
- http://lsic.jhuapl.edu/News-and-Events/Agenda/index.php?id=142
- Register by 7/14!

LSIC | Surface Power User Survey

- Inventory of potential lunar surface power users and needs
- The information you provide will shape our feedback to NASA, which can **<u>directly influence future solicitations</u> and the direction of the field.**

Responses will be anonymized, and can be updated on Confluence as technologies develop

https://forms.gle/yhvxAv3xoYKMAU587

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Power User Survey

The Lunar Surface Innovation Consortium Surface Power Focus Group is conducting an inventory of potential lunar surface power users and needs. The purpose of this Power User Survey is to capture the power needs of different systems that will be used for lunar exploration and human presence on the Moon.

How much power does it take to accomplish a primary objective of your system? How long does it take to accomplish this primary objective? *

Your answer

What are the power needs of this technology's/system's operation during periods of lunar night (electrical and/or thermal)? Consider shorter and longer durations as appropriate for your relevant lunar environment.

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

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

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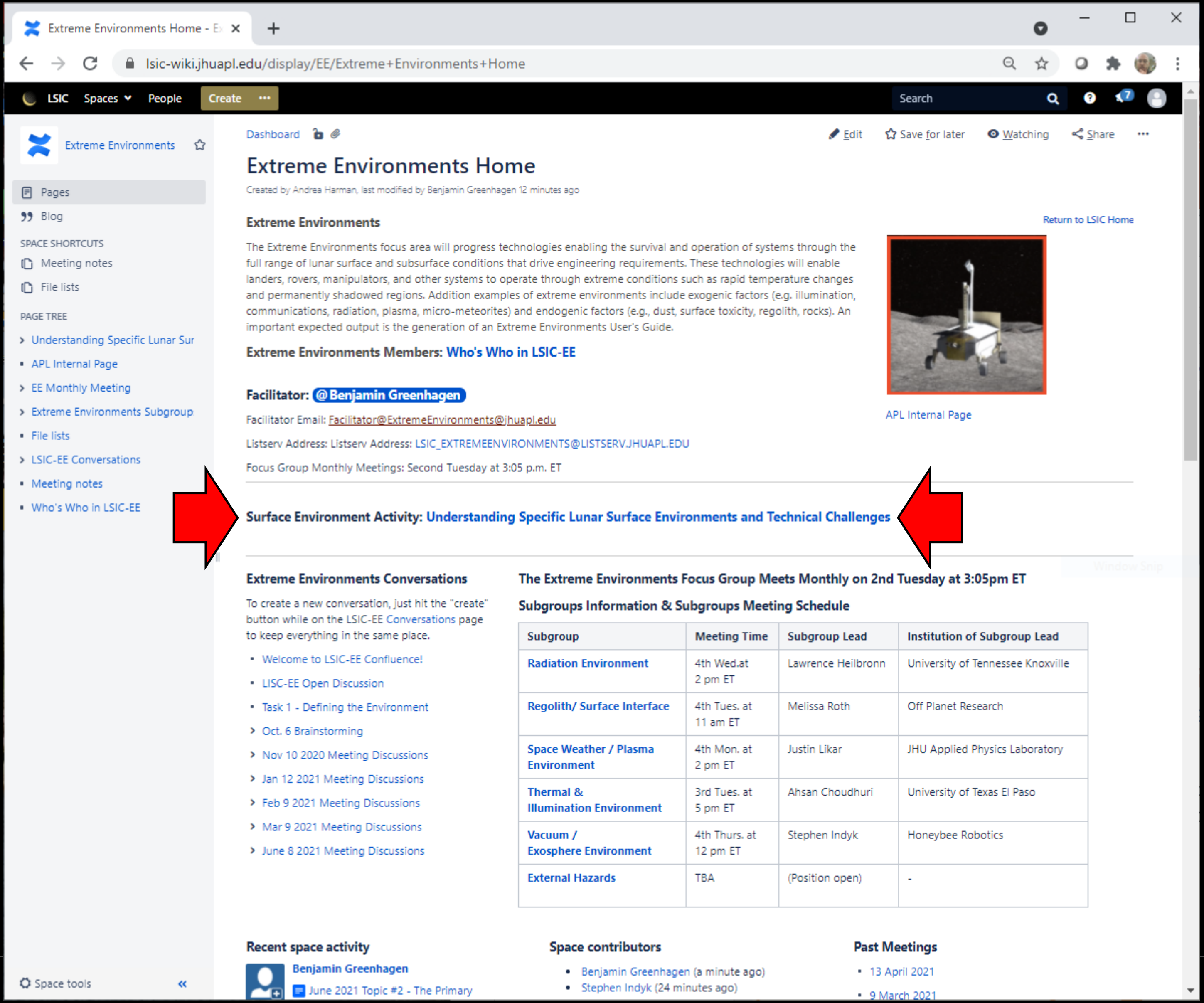
Surface Environment Activity



Extreme Environments Home - E | lsic-wiki.jhuapl.edu/display/EE/Extreme+Environments+Home

LSIC | Spaces | People | Create | Search

Extreme Environments

Pages
Blog

SPACE SHORTCUTS
Meeting notes
File lists

PAGE TREE
- Understanding Specific Lunar Sur
- APL Internal Page
- EE Monthly Meeting
- Extreme Environments Subgroup
- File lists
- LSIC-EE Conversations
- Meeting notes
- Who's Who in LSIC-EE

Space tools

Dashboard | Edit | Save for later | Watching | Share

Extreme Environments Home

Created by Andrea Harman, last modified by Benjamin Greenhagen 12 minutes ago

Return to LSIC Home

Extreme Environments

The Extreme Environments focus area will progress technologies enabling the survival and operation of systems through the full range of lunar surface and subsurface conditions that drive engineering requirements. These technologies will enable landers, rovers, manipulators, and other systems to operate through extreme conditions such as rapid temperature changes and permanently shadowed regions. Addition examples of extreme environments include exogenic factors (e.g. illumination, communications, radiation, plasma, micro-meteorites) and endogenic factors (e.g., dust, surface toxicity, regolith, rocks). An important expected output is the generation of an Extreme Environments User's Guide.

APL Internal Page

Extreme Environments Members: Who's Who in LSIC-EE

Facilitator: @Benjamin Greenhagen

Facilitator Email: Facilitator@ExtremeEnvironments@jhuapl.edu

Listserv Address: Listserv Address: LSIC_EXTREMEENVIRONMENTS@LISTSERV.JHUAPL.EDU

Focus Group Monthly Meetings: Second Tuesday at 3:05 p.m. ET

Surface Environment Activity: Understanding Specific Lunar Surface Environments and Technical Challenges

Extreme Environments Conversations

To create a new conversation, just hit the "create" button while on the LSIC-EE Conversations page to keep everything in the same place.

- Welcome to LSIC-EE Confluence!
- LISC-EE Open Discussion
- Task 1 - Defining the Environment
- Oct. 6 Brainstorming
- Nov 10 2020 Meeting Discussions
- Jan 12 2021 Meeting Discussions
- Feb 9 2021 Meeting Discussions
- Mar 9 2021 Meeting Discussions
- June 8 2021 Meeting Discussions

The Extreme Environments Focus Group Meets Monthly on 2nd Tuesday at 3:05pm ET

Subgroups Information & Subgroups Meeting Schedule

Subgroup	Meeting Time	Subgroup Lead	Institution of Subgroup Lead
Radiation Environment	4th Wed.at 2 pm ET	Lawrence Heilbronn	University of Tennessee Knoxville
Regolith/ Surface Interface	4th Tues. at 11 am ET	Melissa Roth	Off Planet Research
Space Weather / Plasma Environment	4th Mon. at 2 pm ET	Justin Likar	JHU Applied Physics Laboratory
Thermal & Illumination Environment	3rd Tues. at 5 pm ET	Ahsan Choudhuri	University of Texas El Paso
Vacuum / Exosphere Environment	4th Thurs. at 12 pm ET	Stephen Indyk	Honeybee Robotics
External Hazards	TBA	(Position open)	-

Recent space activity

Benjamin Greenhagen
June 2021 Topic #2 - The Primary

Space contributors

- Benjamin Greenhagen (a minute ago)
- Stephen Indyk (24 minutes ago)

Past Meetings

- 13 April 2021
- 9 March 2021

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

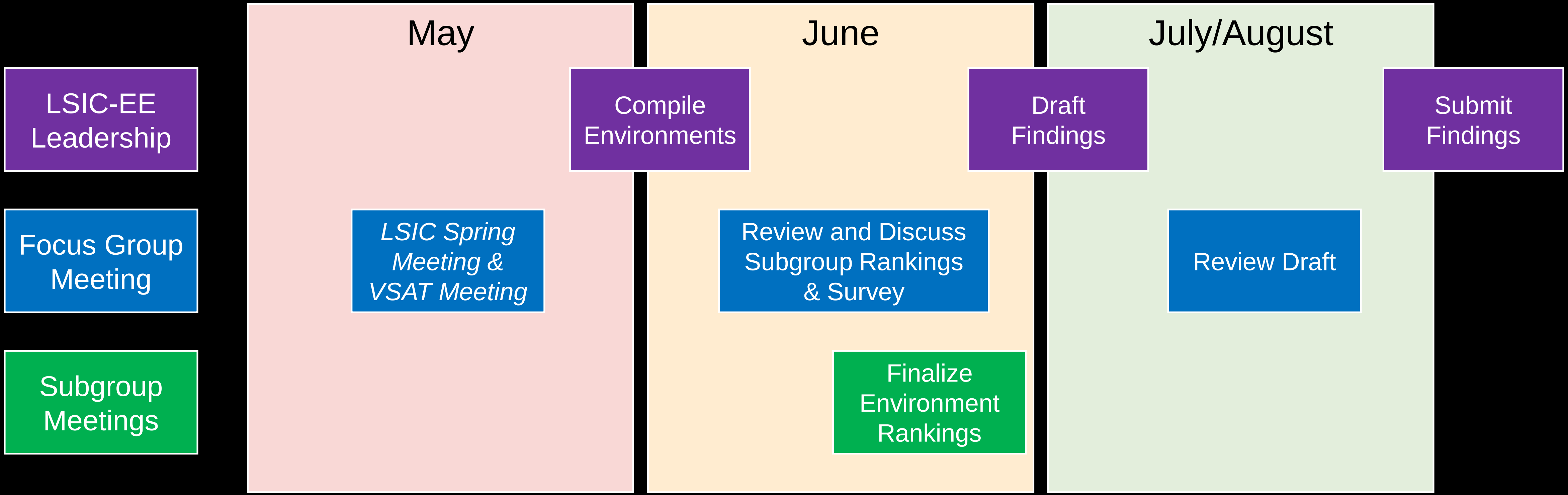
Surface Environment Activity

Activities to Complete Before the LSIC Spring Meeting

	February	March	April
LSIC-EE Leadership	Topic & Products Developed; Compile Environments (end of February)	Compile Environments (end of March)	Compile Environments (end of April)
Focus Group Meeting	Discuss and Gather Site Inputs	Review and Discuss Site Inputs	Supersized 2-hour Meeting with Breakout Sessions
Subgroup Meetings	Evaluation of Target Environments	Evaluation of Target Environments	Review and Rank Environments

Surface Environment Activity

Activities to Complete After the LSIC Spring Meeting



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Subgroup Environment Rankings

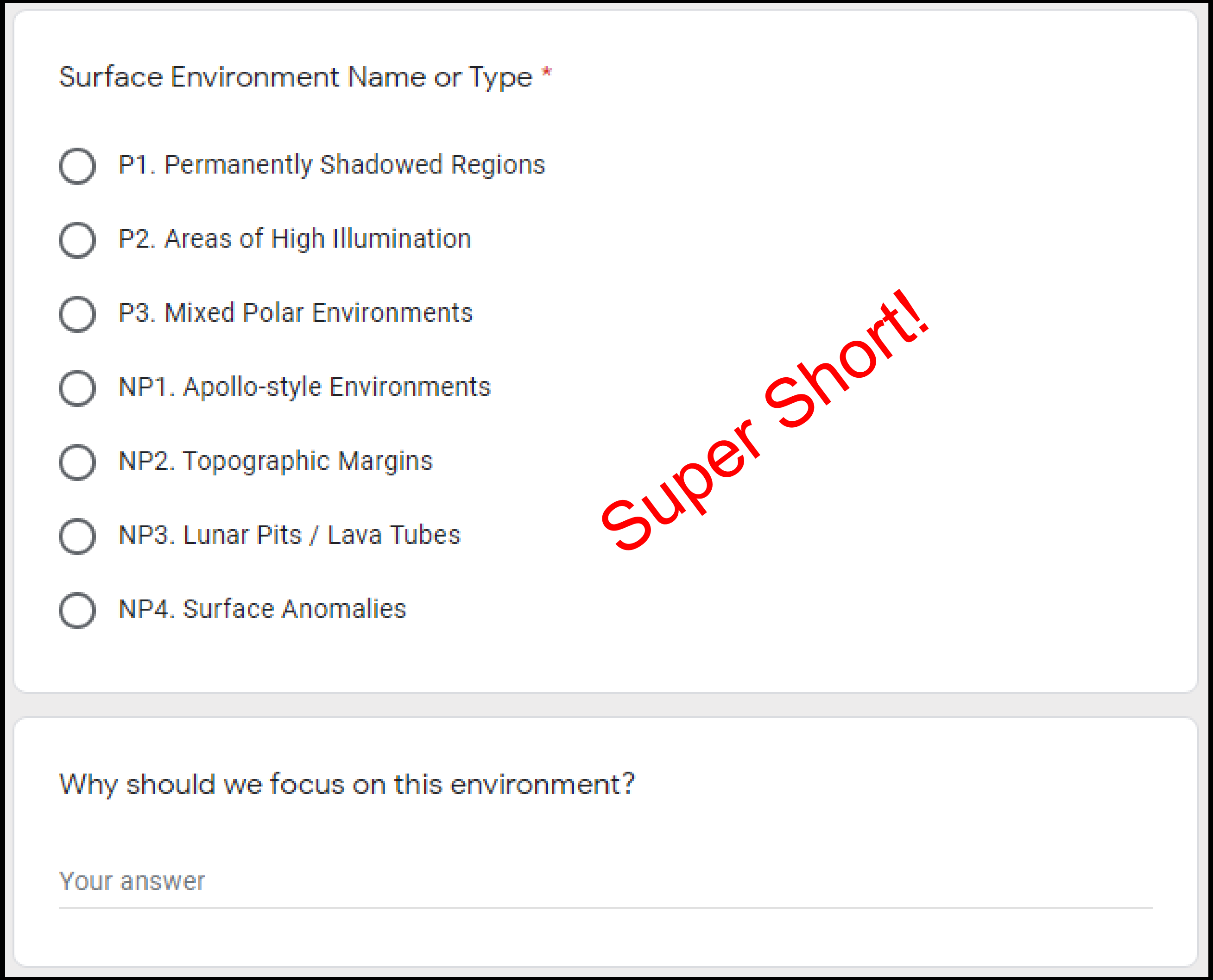
Summary of all Subgroups (https://lsic-wiki.jhuapl.edu/pages/viewpage.action?pageId=13340355)

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) & 6 (I)	5

Surface Environment Survey

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
- 54 responses to date (Voting open through the end of this week)!



Surface Environment Name or Type *

- P1. Permanently Shadowed Regions
- P2. Areas of High Illumination
- P3. Mixed Polar Environments
- NP1. Apollo-style Environments
- NP2. Topographic Margins
- NP3. Lunar Pits / Lava Tubes
- NP4. Surface Anomalies

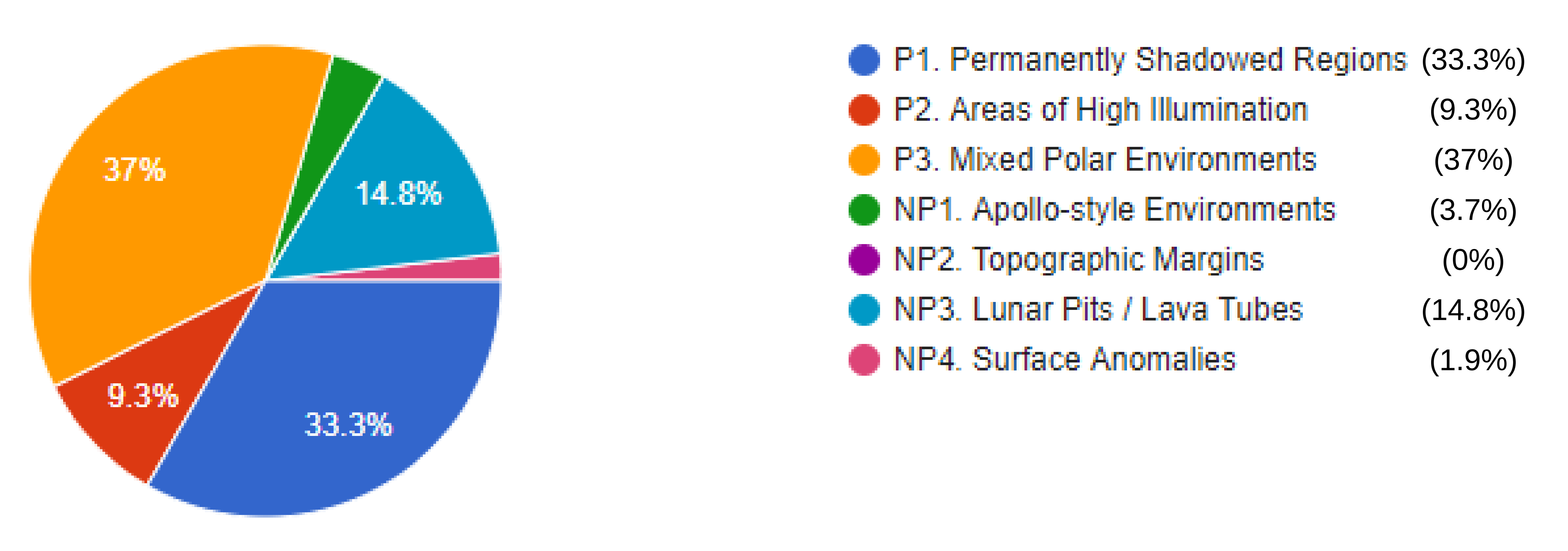
Super Short!

Why should we focus on this environment?

Your answer

Surface Environment Survey

- Voting Results (54 responses)



https://lsic-wiki.jhuapl.edu/display/EE/Focus+Group+Environment+Prioritization

Surface Environment Survey

- #7 – NP2. Topographic Margins (0 of 54 responses / 0.0%)
  - <no comments>

- #6 – NP4. Surface Anomalies (1 of 54 responses / 1.9%)
  - "shear curiosity"

- #5 – NP1. Apollo-style Environments (2 of 54 responses / 3.7%)
  - "Not ranked as most challenging by many subgroups, but maybe that means it's a target for early [crewed] exploration - more achievable!"
  - "Narrative is vital for global public involvement... By going to Apollo 11 region, US/NASA can boost morale, remind the world of Apollo heritage, and conduct good science and technology..."

Surface Environment Survey

- #4 – P2. Areas of High Illumination (5 of 54 responses / 9.3%)
  - "Best location for permanent settlements"
  - "…First Artemis missions should occur in full solar illumination sites, so crew and mission ops can clearly see landing site and have plenty unobstructed PV power, though kilopower could also be deployed and tested as part of Artemis"
  - "This is a good starting point from the power generation and distribution standpoint."
  - "As part of hybrid power generation schemas, areas of high illumination show promise as bases for solar power stations."
  - "Evaluate the areas most likely to contain hazards due to e.g. charging that can impact astronauts"

Surface Environment Survey

- #3 – NP3. Lunar Pits / Lava Tubes (8 of 54 responses / 14.8%)
  - "habitability + Radiation safety"
  - "This can solve myriad issues for habitation, radiation shielding, impact shielding, subsurface information, etc...“
  - "Pits and Tubes are often sited as locations for Human Habitats (particularly for radiation protection), but there doesn't appear to be any systematic mapping of such or characterization in order to determine feasibility.”
  - "These regions are scientifically very interesting and are also the most likely sites for human habitation on the Moon. Exploring them will be technically demanding and will require the development of a number of new (or at least new-on-the-Moon) technologies.“
  - “…The interior of the [Mare Tranquilitatis] pit (talus pile) may be a location to sample for undisturbed regolith to collect solar activity records, vital to building a much better Climate Change model for Earth, perhaps?"
  - "EA group is focusing on lava tubes and PSRs this year, would be helpful to have the synergy between the two groups"

Surface Environment Survey

- #2 – P1. Permanently Shadowed Regions (18 of 54 responses / 33.3%)
  - "Lunar PSRs represent the most extreme cold environment in the solar system inside the orbit of Neptune. That makes these spots unique. Near the South Pole, these regions also lie on or near the ancient crater rim for the South Pole - Aitken Basin, and so might contain samples of the SPAB impactor. This implies that the southern PSRs might be able to address a multitude of lunar science questions, and thus represent a uniquely valuable spot to visit.“
  - "PSRs have a variety of cold temperatures - interesting/appealing for science sensors and enabling new missions. They also contain ice water, which is ideal for rapidly enabling lunar base capabilities."
  - “…PSR however are the most extreme conditions we currently would need to face."
  - "Because these areas are the least researched and likely to contain ice."
  - "presence of water, least characterized environment"
  - "Best chance of finding volatiles here"
  - "lower temp makes it a good candidate for various types of ice“
  - "highest scientific interest"

Surface Environment Survey

- #2 – P1. Permanently Shadowed Regions (18 of 54 responses / 33.3%) - continued
  - "ISRU and Extreme Thermal Environment"
  - "Need more data and is likely where resources for human are located and be needed"
  - "NASA wants to extract and even process material in this environment; one we know very little about"
  - "it is an area that NASA has high expectations of regarding beneficial exploration"
  - "Science and ISRU ice implications“
  - "The most technological challenges and uncertainty"
  - "Need to characterize both thermal and regolith environments in order to determine impacts to EVA suit designs.“
  - "EA focus group is focusing on PSRs this year, would be nice to have input from EE"

Surface Environment Survey

- #1 – P3. Mixed Polar Environments (20 of 54 responses / 37.0%)
  - "Upcoming Artemis missions are slated for mixed polar environments. As it has a mix of polar and non-polar regions, it will also allow advancements across several environments. It also has the added challenge of transitioning between these two extremes.“
  - "I think MPEs are the most likely environment we will begin exploring and building in, so understanding them will best prepare us for crewed exploration.“
  - "I feel that this type of environment (mixed Polar) will be what we are dealing with in the upcoming Artemis landings."
  - "I believe this will be the prioritization for robotic and human exploration inline with the "follow the water" philosophy and the ability to sustain human presence."
  - "The variability of water content and shielding from local topographic features make it an interesting location to measure how the radiation environment changes as a function of those properties“
  - "radiation flux"

Surface Environment Survey

- #1 – P3. Mixed Polar Environments (20 of 54 responses / 37.0%) - continued
  - "Mixed polar seems to have the most challenges (judging by the subgroup rankings), perhaps not surprisingly as its challenge might be thought of as a superset of P1 and P2 with the added challenge of effects caused by moving between areas of various degrees of illumination."
  - "Interfaces between cold/shadow and hot/illuminated locations provide a lot of unique opportunities and challenges."
  - "Highlights complex environments that may be encountered during planned or envisioned polar activities.“
  - "Mixed Polar would be a nice/comprehensive 'proofing ground' for many technologies.“

  - "Understanding the environmental issues that will significantly effect commercialization operations.“
  - "combination of human operations and PSR mining and science operations"

  - "Polar environments, especially the south, provides probably a good balance of resourses (according to mineral maps), water ice, visibility of earth (psycological effect + communications), at high altitudes access to solar light.“
  - "accessibility to solar fluence, water and other resources“

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- NP3. Lunar Pits / Lava Tubes
- NP4. Surface Anomalies

Super Short!

Why should we focus on this environment?

Your answer

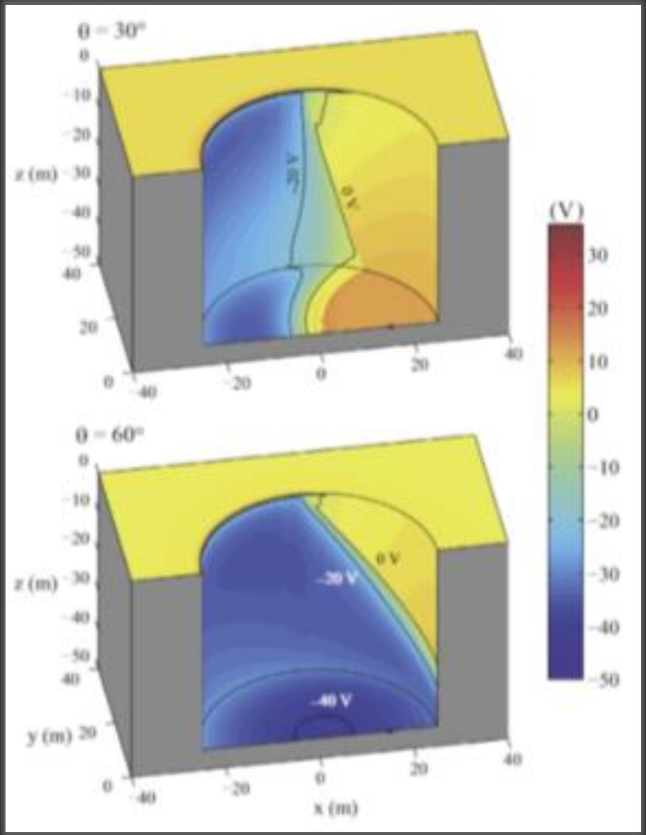
Featured Presentations

- Subgroup Recent Progress and Future Plans
  - Justin Likar, Space Weather / Plasma Environment
  - Melissa Roth, Regolith / Surface Interface
  - Ahsan Choudhuri, Thermal & Illumination Environments
  - Stephen Indyk, Vacuum / Exosphere Environment
  - Lawrence Heilbronn, Radiation Environment

SWPE overview

- *The Space Weather and Plasma Environments (SWPE) subgroup focuses on ambient and human-induced plasma environments which influence electric potentials and the risk of electrostatic discharging on the lunar surface, humans, and engineering interfacing therewith*
- *The resultant effects, specifically potential differences between adjacent objects are also dependent upon surface features / properties such as Solar Zenith Angle (SZA), regolith properties, terrain, geology, latitude, magnetic fields, and more*
- *The range of potentials may be as broad as +100 V to -1000 V with rapid fluctuations likely and excursions possible*
- *Risks to sustained habitation range from “nuisance” – tribocharging (dust, contamination, …) or limited lifetimes of EEE parts to “catastrophic” – critical systems failures (solar arrays) or injury to humans*
- *The SWPE subgroup enjoys natural synergies and collaborations with other Extreme Environments subgroups. For example:*
    - *Plasma electrostatics, regolith electrical properties, tribocharging, and weathering (with the Regolith / Surface Interface subgroup)*
    - *GCR and SPE characterization, nowcasting, and forecasting (with the Radiation subgroup)*
    - *Solar arrays (with the Surface Power group)*

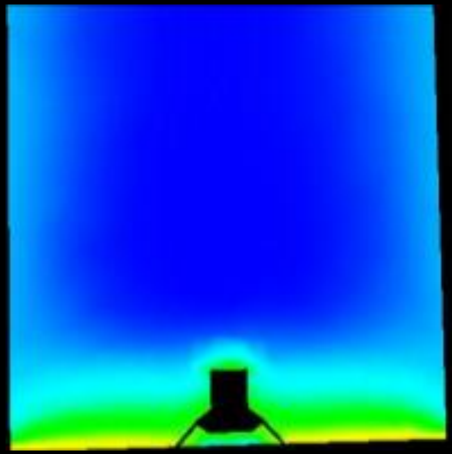
Highlights



[1]Selected modeled lunar surface potentials as function of SZA; topographical feature mimics lava tube skylight or crater (e.g. diameters & depths 50 m to 100 m)

- *Established boundaries associated with the SWPE SG*
  - *What **is** and what **is not** within scope*
- *Supported / supporting ExEnv related taskers*
  - *Surface environment definitions*
  - *Surface environment prioritizations / rankings*
- *Established vibrant Confluence presence & recurring meeting cadences*
  - *Growing reference & resources list*
- *Commenced / commencing collaborations across FGs & SGs*
  - *Notable synergies include Surface Power, Radiation and Regolith*
- *Growing list of Subgroup Contributors:*
  - *B. Alterman (SWRI); D. Barker (NASA); A. Cocoros (APL); M. Deminico (NASA); M. Donegan (APL); J. Gillis-Davis (UW); B. Greenhagen (APL); D. Han (MST); L. Heilbronn (UTK); A. Paez (NASA); D. Pappa (NASA); L. Parker (USRA); J. Porter (APL); M. Poston (SWRI) N. Prasad (NASA); L. Regoli (APL); M. Roth (Off Planet Research); J. Schaf (Moog); K. Somervill (NASA); T. Stubbs (NASA); K. Stockstill-Cahill (APL); T. Viviano (NASA); E. Willis (NASA); M. Zimmerman (APL)*

Look ahead (Summer into Fall)



SPIS-Dust simulations of plasma potentials near lunar lander; values removed [Kuznetsov, I. (2016)]

12 cm plasma source operating at MST [Folta, B. (2020)]

- *Identify gaps in existing environmental specifications, requirements, models*
  - *Identify uncertainties / bounds & propagate to engineering quantities of interest (e.g. potentials, fields or charge densities)*
- *Identify existing ground test capabilities as well as gaps & opportunities*
  - *Low energy plasmas; HC plasmas; RF plasmas*
  - *Triboelectric charging (dust)*
- *Identify existing physics / engineering modelling capabilities as well as gaps & opportunities*
  - *"Physics" properties of interest include densities, (plasma) temperatures, cross sections, …*
  - *"Engineering" interest includes such derived properties such as potentials, electric fields, yields, charge rates, charge densities, …*
- *Identify existing targeted sensors, alert systems and nowcasting / forecasting capabilities as well as gaps & opportunities*
  - *What is currently available & what is desired (needed) at the characteristic time scales necessary to support planned operations & habitation*

Regolith/Surface Interface

RSI Resource Guide
https://lsic-wiki.jhuapl.edu/pages/viewpage.action?pageId=6260391

TABLE OF CONTENTS (Click on Section Titles to jump to that Section)

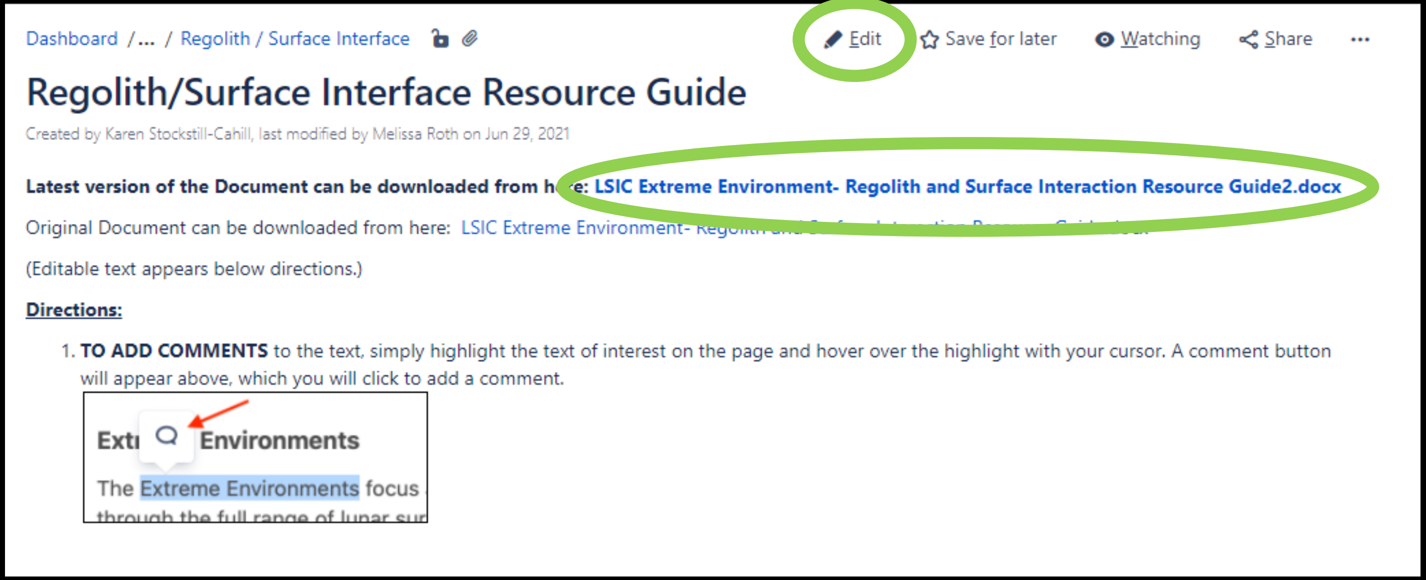
Monthly Meetings: 4th Tuesday of every month, 1 p.m. ET

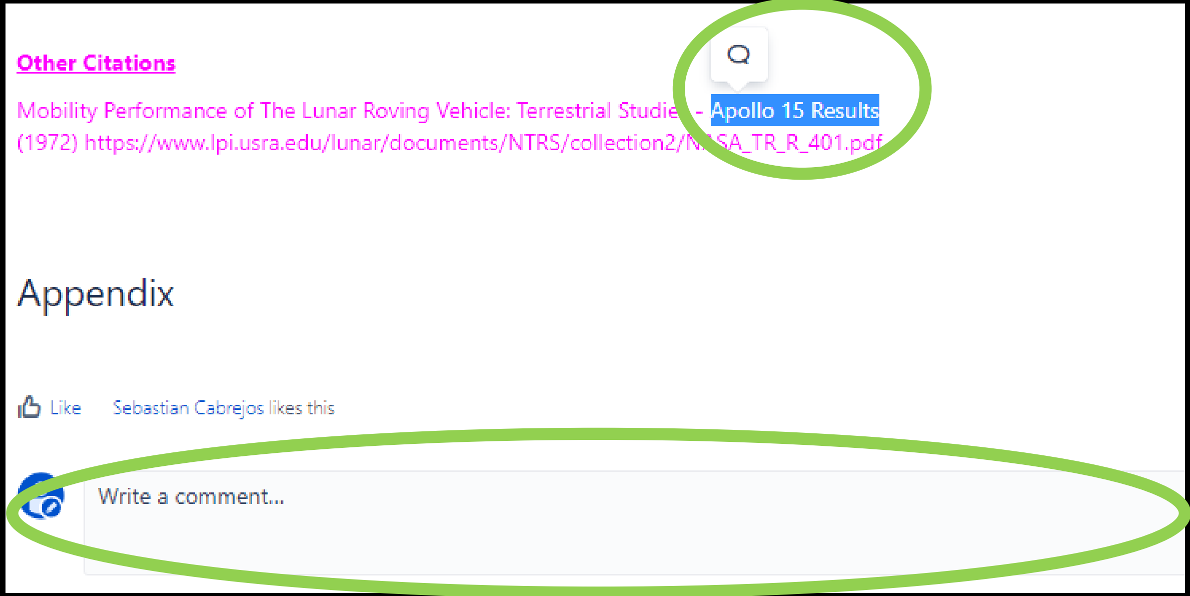
Subgroup Lead Email: melissa@offplanetresearch.com

Regolith/Surface Interface

There are five ways to participate:

1. **Edit the page**
2. **Download the latest Word Doc. and track changes**



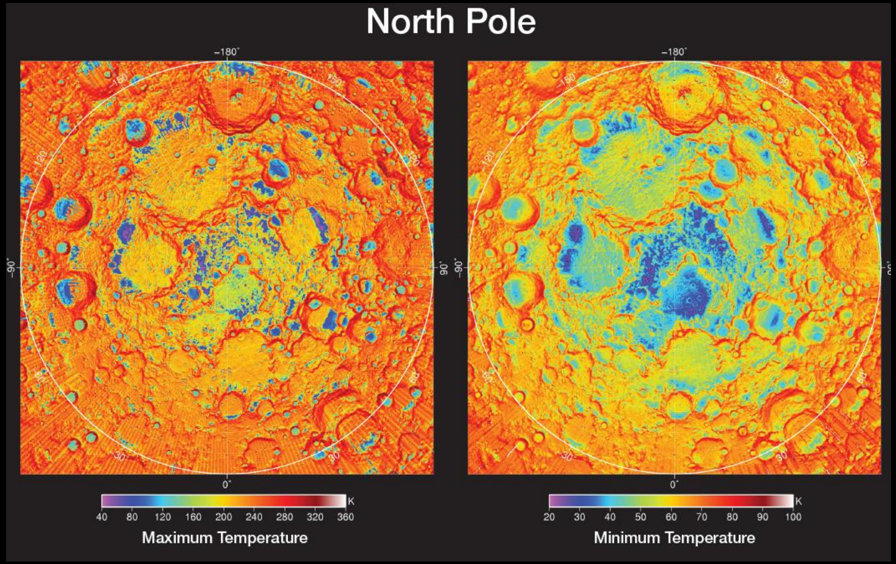


3. **Highlight a section to comment on someone else's work**
4. **Comment at the bottom of the page**
5. **Email me to work off Confluence**

Thermal and Illumination Environment

- *Lead: Ahsan Choudhuri, The University of Texas at El Paso, ahsan@utep.edu*
  - *Associate Vice President for Aerospace Center; Founding Director, NASA MIRO Center for Space Exploration & Technology Research*
  - *Research Interests: Propulsion, Hypersonics, Robotic Landers, Small Spacecraft, and Lunar Surface Operations*
- *Supporters:*
  - *Marshall Eubanks; Space Initiatives Inc*
  - *Ben Greenhagen; Johns Hopkins Applied Physics Laboratory*
  - *CraigPeterson; Trans Astronautica Corporation*
  - *Matt Siegler, Planetary Science Institute*
  - *Kris Zacny, Honeybeer Robotics*
- *Participants:*
  - *Daoru Han, Missouri University of Science and Technology*
  - *Angeliki Kapoglou, European Space Agency*
  - *Michael J Poston, Southwest Research Institute*
  - *Tracie Prater, NASA*
  - *KT Ramesh, Johns Hopkins Applied Physics Laboratory*
  - *Melissa Roth; Off Planet Research*
  - *Howard Runge, Runge Tech*
  - *Doug Stanley, National Institute of Aerospace*
  - *Paul van Susante, Missouri University of Science and Technology*
  - *Md Mahamudur Rahman, University of Texas at El Paso*

Thermal Environment



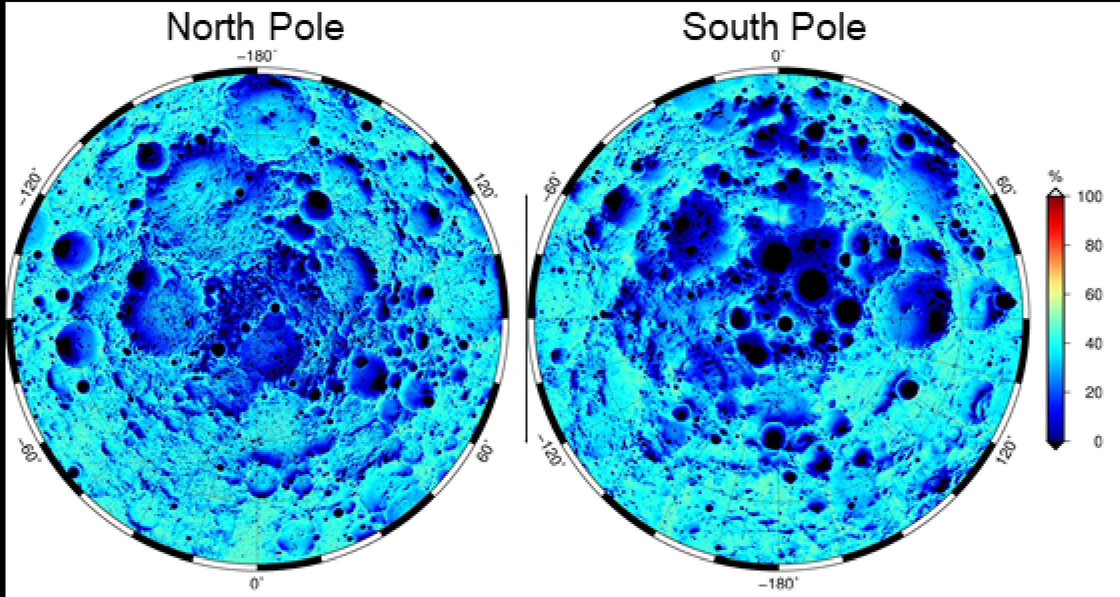
Temperature Variation
Lunar Reconnaissance Orbiter
nasa.gov

- *Primary Characteristics*
  - *Wide Temperature Range: 400 K-40 K*
  - *Heat flux (incident solar flux 0 - 1414 W/m^2; planetary IR flux 0 – 1314 W/m^2; and albedo 0.076 - 0.297)*
  - *Surface Roughness*
  - *Local Topography (e.g. Local time, Elevation Contour)*
  - *Latitude*
  - *Albedo*

- *Environmental Variability*
  - *Equator: 140 K – 400 K; 94 K (average minimum) – 392 K (average maximum); mean 215 K.*
  - *Polar (poleward of 85°): 50 K (average minimum) – 202 K (average maximum); mean 104 K; minimum 25 K in the floor of the Moon's Hermite Crater.*
  - *Thermophysical properties*

- *Challenge to Technology Development*
  - *Low temperature: electronic performance in extreme cold environments*
  - *Brittle phase transitions of metals with abrupt changes in properties, the effects of combined low temperature and radiation*
  - *Thermal cycling: thermal performance and fatigue for 40 K- 400 K thermal cycling in every month*

Illumination Environment



Modeled solar illumination from LRO LOLA

- *Primary Characteristics*
  - For most of the lunar surface there is 13.5 days of constant illumination and 13.5 days of no illumination other than Earthshine (limited to near side).
    - Earthshine is considerably brighter than moonshine and could allow for some operations during night periods on the near side
    - Insufficient for solar power though.
    - Causes extreme temperature variations (127 degrees Celsius to minus 173 C)
  - *There are also permanently shadowed regions (PSR) near the poles maintaining even colder temperatures (minus 253 to minus 163 C)*
  - *Also mostly (up to 90%) illuminated regions (MIR) at >100 C*

- *Environmental Variability*
  - *Illumination varies over the course of the lunar day due to incidence angle (cosine) effects.*
  - *Some minor variability due to terrain*
  - *EXCEPT at THE LUNAR POLES*
  - *At the poles illumination can vary widely over the space of just a few kilometers.*
  - *Illumination at the poles can also vary over a few hundreds of meters elevation change.*

- *Challenge to Technology Development*
  - *Survival during the long night*
    - *Sleep mode during nights?*
  - *Radiation effects from unfiltered sunlight and solar events (CME)*
  - *Temperature cycling on mechanical systems*
    - *Material thermal expansion/contraction*
  - *Obtaining power in the lunar PSRs*
  - *Staying cool in the lunar MIRs*

Thermal and Illumination Environment

- *Tasks: Fall 2020 and Summer 2021*
  - *Completed: Thermal Environment Literature Review Report*
  - *In-Progress Illumination Environment Literature Review Report (Expected Completion: August 2021)*
  - *Completed: DSNE Summary Report Thermal and Illumination Environment*
  - *Completed: Lunar Surface Environment Ranking*

Thermal and Illumination Environment

- *Tasks: Summer 2021 and Fall 2021*
  - *More Detailed Review of Thermal and Illumination Environment for*
    - *Permanently Shadowed Regions (PSRs)*
    - *Mixed Polar Environments*
  - *Hardware Specific Impact Analysis*
    - *Landing Sites*
    - *Surface Mobility Systems*
    - *Mining and Robotic Equipment*
    - *Propellant Production and Storage Systems*
    - *Surface Power Systems*

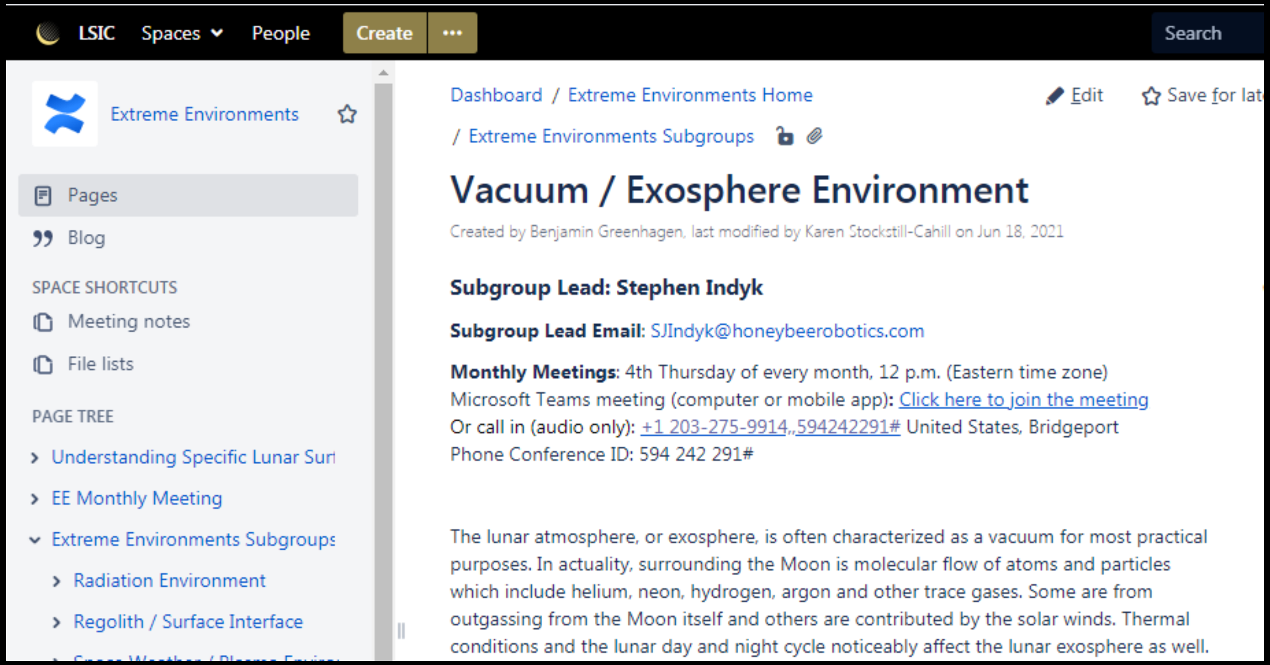
Vacuum Environment

- *Lead:*
  - ***Stephen Indyk, Honeybee Robotics***
  - *sjindyk@honeybeerobotics.com*
    - *Background in mechanism development for planetary environments, including lunar structures*
    - *9 years of experience in Mars rover operations*

- *Supporters:*
  - *Donald Barker; University of Houston*
  - *Marshall Eubanks; Space Initiatives Inc.*
  - *Matt Siegler; Planetary Science Institute*
  - *Kris Zacny (Honeybee Robotics)*

- *Participants:*
  - *Ahsan Choudhuri (University of Texas at El Paso)*
  - *Bonnie Dunbar (Texas A&M University)*
  - *Will Graber (Honeybee Robotics)*
  - *Ben Greenhagen (Johns Hopkins Applied Physics Lab)*
  - *Daoru Han (Missouri S&T)*
  - *Angeliki Kapoglou (ESA)*
  - *Michael Poston (Southwest Research Institute)*
  - *Hunter Rideout (Honeybee Robotics)*
  - *Melissa Roth (Off Planet Research)*
  - *Karen Stockstill-Cahill (Johns Hopkins Applied Physics Lab)*
  - *Paul van Susante (Michigan Tech)*

Confluence



- *Main Confluence Pages*
  - *Findings*
    - *Lunar environment data logger*
  - *Monthly Meetings Notes*
    - *Notes on meeting minutes*
    - *Some chamber trouble shooting*
    - *notes and chamber setup discussions*
  - *Resources*
    - *Citations and papers on vacuum*
    - *exosphere environment*
  - *Vacuum Testing Chamber Guidance*
- *Confluence Structure*
  - *To Get to Vacuum Exosphere Environment*
    - *Dashboard> Extreme Environments Home>*
    - *Extreme Environment Subgroups> Vacuum Exosphere Environment*
    - *https://lsic-wiki.jhuapl.edu/pages/viewpage.action?pageId=1672127*

Melissa Inspired
QR Link!!!

Vacuum Chamber Testing Guidance

- *Focus on dirty environment testing*
- *Goal to provide insight on what is required to test in difficult chamber environments and how it can be done*
- *Describes TRL scale and why someone would use a vacuum chamber for hardware*
- *Recent section edits on chamber hardware including pumps and valves*

- *https://lsic-wiki.jhuapl.edu/display/EE/Vacuum+Testing+Chamber+Guidance*

Upcoming Goals

- *Findings Advancement*
  - *Lunar environment data logger*
  - *Creation of a white paper to escalate visibility*

- *Vacuum Testing Chamber Guidance*
  - *Ongoing text development and review*
  - *Continue development and include feedback for chamber testing*
  - *Develop sections on standard testing documents, e.g., GSFC-STD-7000*

- *Reviewing upcoming documents on chamber testing*
  - *NASA Chamber Testing Standard which is expected to be released in the near future*

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