Lunar Surface Innovation
CONSORTIUM

Extreme Environments Focus Group Introductory Telecon

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Today's Agenda

- Introductions
- LSIC and the Extreme Environments Focus Group Overview
- Results of the Pre-Meeting Survey
- Next Steps – What to Expect
- Community Feedback and Discussion

Introductions

- Please provide an introduction (in the chat) to the group including
  - What is your name?
  - Where do you work?
  - What is your interest and/or experience in this focus group?
  - What are specific things you want to get out of the our focus group?

  Note: These chat introductions will be captured and distributed to the focus group

- Dr. Benjamin Greenhagen, Johns Hopkins Applied Physics Laboratory
  - Interest: Expert in lunar thermal environment. Understanding the lunar environment (and reproducing it in the lab) is a prerequisite for developing the technologies we need for a sustained human presence on the Moon
  - Goal: Develop a lunar environment users guide for technology development
- Educational background: Geology -> Planetary Geology -> Spectroscopy
- Moon Activities:
  - Deputy PI on LRO Diviner Lunar Radiometer, Co-I on Lunar Flashlight mission, Co-I on L-CIRiS instrument
  - Fundamental research studying geologic materials in simulated lunar environment
  - Develop thermal infrared instrumentation for lunar and planetary applications
  - Organize the APL Lunar Cohort

LSIC Objectives

1. Harness the creativity, energy and resources of academia, non-profits, industry and government in order for NASA to keep the United States at the forefront of lunar exploration
2. Identify lunar surface technology developments most in need of sponsor support and communicate those to NASA
3. Provide a central resource for gathering and disseminating information, results, and documentation

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LSIC Specific Goals

- Identify technology needs
- Serve without bias
- Develop talent
- Build community
- Serve as an information clearinghouse
- Host regular cross-community meetings
- Lead and coordinate focus groups
- Enable site visits from LSIC and LSII leadership
- Establish mentoring relationships among members

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Charter & Structure

- **Technology** – Accelerate the development of key lunar surface infrastructure capabilities
- **Collaboration** – Enable meaningful partnerships across industry, non-profits, academia, and government that leverage common goals and objectives for establishing lunar surface infrastructure capabilities
- **Communication** – Create information paths and relationships to best match needs with opportunities
- **Future Workforce** – Ensure that the U.S. maintains the workforce needed for sustained space exploration

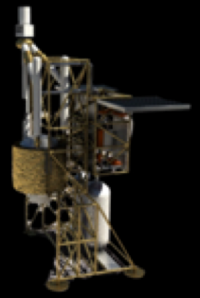
The LSIC is a nationwide alliance of universities, non-profit research institutions, commercial companies, NASA centers and program offices, and other government agencies with a vested interest in our nation's campaign to establish a sustained presence on the Moon.

Focus Group Overview

The role of the focus group is to: (1) Connect academic institutions, non-profits, industry, and NASA to help technology development and build collaborations. (2) Identify critical challenges for sustainable operations on the lunar surface. (3) Enable and facilitate all categories of members.

In Situ Resource Utilization

Collection, processing, storing and use of material found or manufactured on other astronomical objects



Surface Power

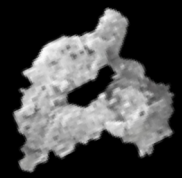
Enable continuous power throughout lunar day and night

Extreme Access

Access, navigate, and explore surface/subsurface areas

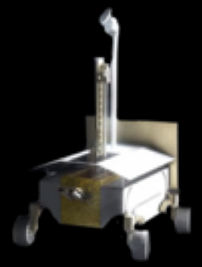
Surface Excavation & Construction

Enable affordable, autonomous manufacturing or construction



Lunar Dust Mitigation

Mitigate lunar dust hazards



Extreme Environments

Enable systems to operate through out the full range of lunar surface and subsurface conditions

Our sponsor STMD develops and performs demonstrations that allow the primary technology hurdles to be retired for a given capability at a relevant scale.

Extreme Environments FG

The role of the focus group is to: (1) Connect academic institutions, non-profits, industry, and NASA to help technology development and build collaborations. (2) Identify critical challenges for sustainable operations on the lunar surface. (3) Enable and facilitate all categories of members.

- What are the lunar extreme environments?
- What are the technology needs to enable survival and operations in the extreme environments?
- Which technologies already exist? How can they be improved?
- Which technologies need to be developed? Is there a pathway to development?
- How can NASA STMD best help you develop your technologies?

- Facilitator:
  - Manage focus group and ensure clear communication. Organize focus group to maintain alignment with NASA STMD expectations, LSII Leadership, and LSIC Executive Committee.
- Task Leads:
  - Lead peers in short-duration, product-focused activities that advance focus group objectives and develop consensus.
- Participant
  - Participate in meetings and tasks. Share your knowledge!

Example FG Technical Categories

- *Thermal Environment (daytime, nighttime, polar, etc.)*
- *Illumination Environment (diurnal, permanent shadow, near-continuous light)*
- *Communication Environment (nearside, farside, subsurface, etc.)*
- *Solar Wind / Plasma Environment (nearside, farside, polar, etc.)*
- *Radiation Environment (surface, subsurface, etc.)*
- *Vacuum Environment (outgassing, sublimation, etc.)*
- *Surface Interactions (dust, regolith toxicity, rocks, etc.)*
- *Other External Hazards (micrometeorites, CMEs, etc.)*
- *Others?*

The ability to survive and operate in extreme environments underlies the all aspects of LSII and many specific topics cross-cut with other LSIC focus groups

Example EE Technical Categories

- *Thermal Environment (daytime, nighttime, polar, etc.)*
  - *Thermal environment relative to volatile stability in polar permanent shadowed regions (ISRU)*
- *Illumination Environment (diurnal, permanent shadow, near-continuous light)*
- *Communication Environment (nearside, farside, subsurface, etc.)*
- *Solar Wind / Plasma Environment (nearside, farside, polar, etc.)*
- *Radiation Environment (surface, subsurface, etc.)*
- *Vacuum Environment (outgassing, sublimation, etc.)*
- *Surface Interactions (dust, regolith toxicity, rocks, etc.)*
  - *Dust environment is intrinsic to Dust Mitigation*
- *Other External Hazards (micrometeorites, CMEs, etc.)*
- *Others?*

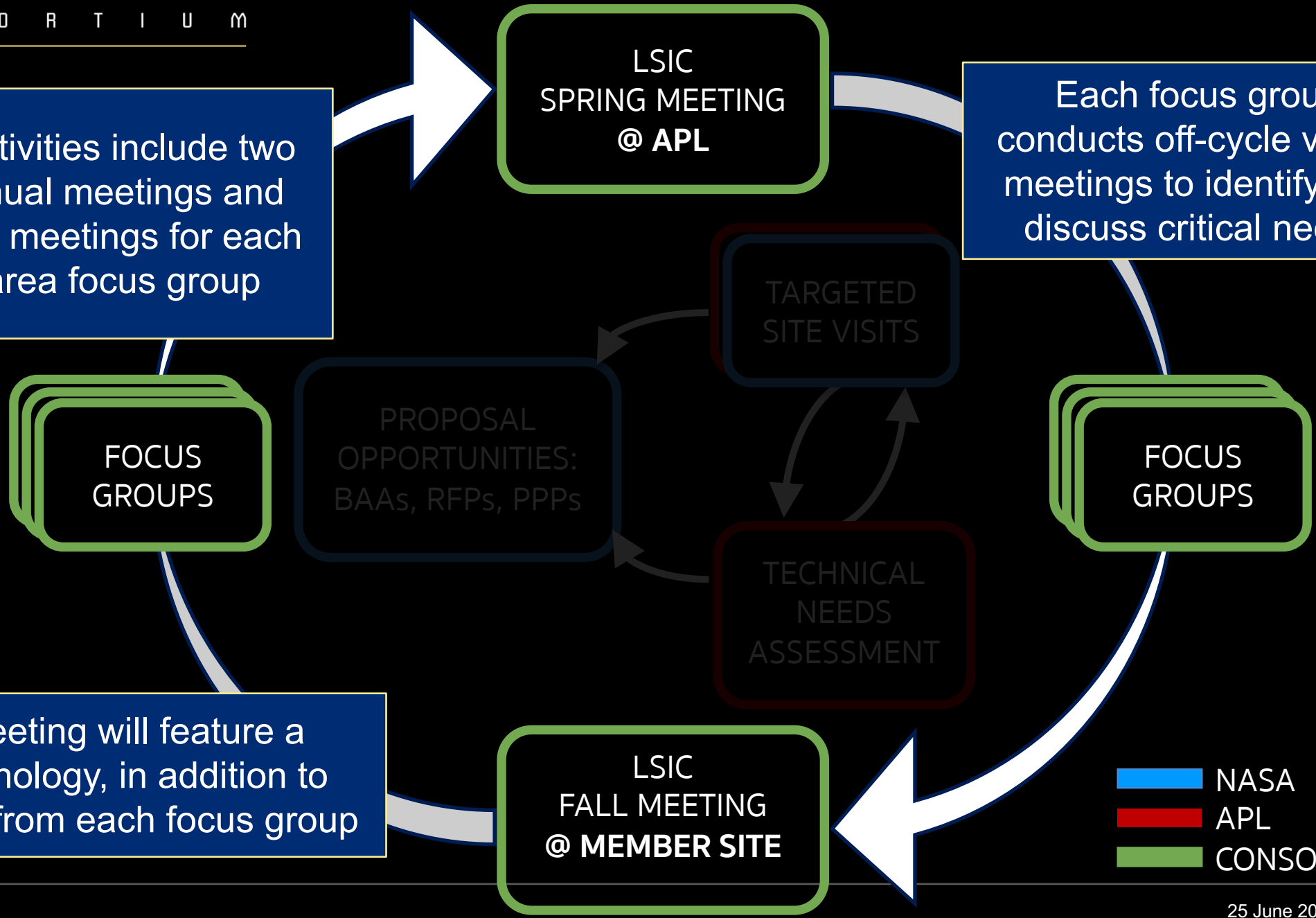
The ability to survive and operate in extreme environments underlies the all aspects of LSII and many specific topics cross-cut with other LSIC focus groups.

LSIC Director and FG Contacts

LSIC Director: Rachel Klima, SES-LSIC-Director@jhuapl.edu
http://lsic.jhuapl.edu

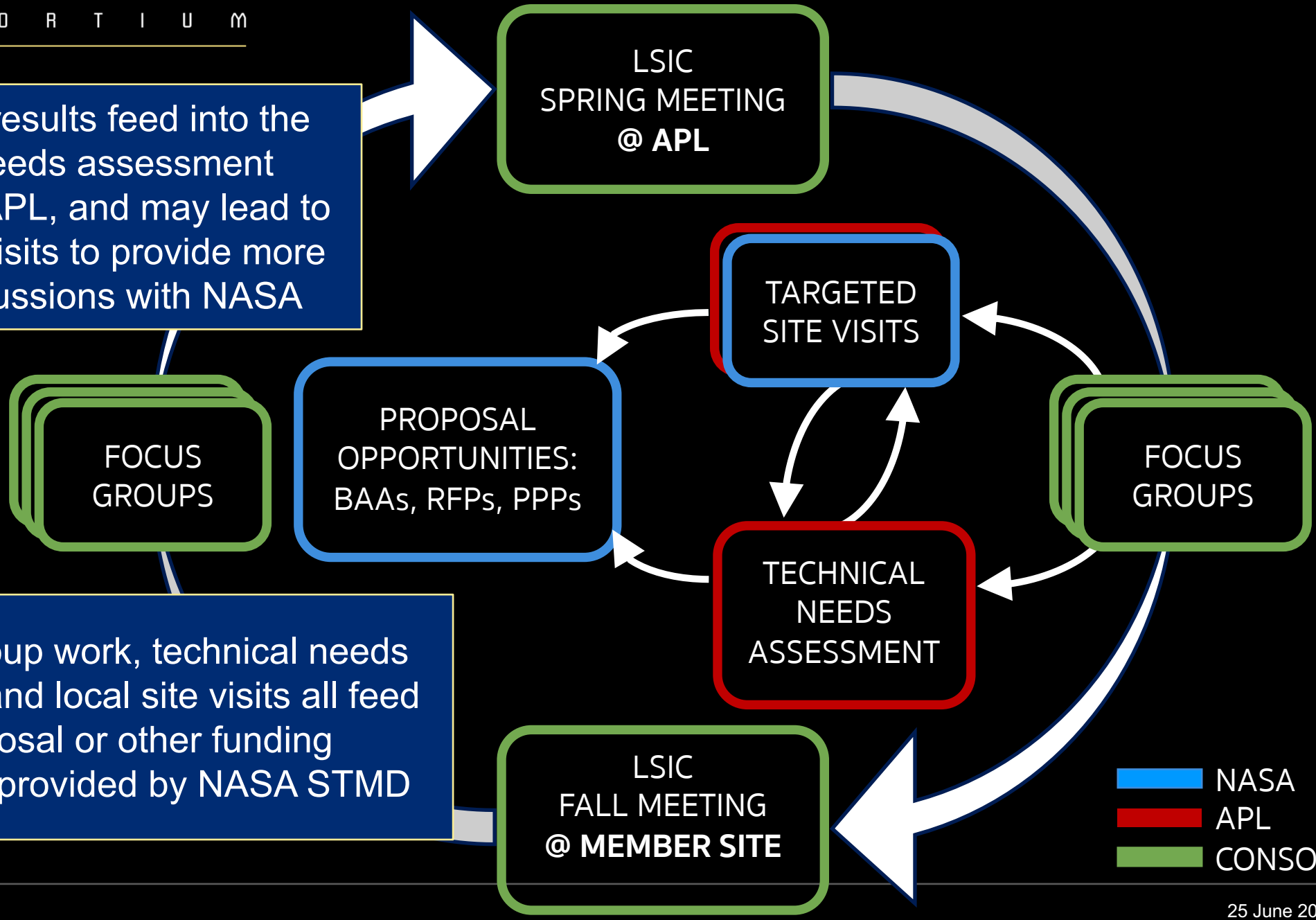
Focus Group Area	Listserv address	Lead Facilitator
In-Situ Resource Utilization	LSIC_ISRU@listserv.jhuapl.edu	Karl Hibbitts
Surface Power	LSIC_Power@listserv.jhuapl.edu	Wes Fuhrman
Extreme Environments	LSIC_ExtremeEnvironment@listserv.jhuapl.edu	Ben Greenhagen
Extreme Access	LSIC_ExtremeAccess@listserv.jhuapl.edu	Angela Stickle
Excavation and Construction	LSIC_ExcavationConstruction@listserv.jhuapl.edu	Athonu Chatterjee
Dust Mitigation	LSIC_DustMitigation@listserv.jhuapl.edu	Jorge Núñez

Consortium activities include two large semiannual meetings and off-cycle virtual meetings for each technology area focus group



The Fall meeting will feature a specific technology, in addition to status reports from each focus group

Focus group results feed into the technical needs assessment performed by APL, and may lead to personal site visits to provide more in-depth discussions with NASA



The focus group work, technical needs assessment, and local site visits all feed into proposal or other funding opportunities provided by NASA STMD

Survey – Categories of Members

- *Academic – 11 / 35 (31.4%)*
- *Non-Profit – 7 / 35 (20.0%)*
- *Industry – 10 / 35 (28.6%)*
- *Government – 7 / 35 (20.0%)*

Survey had 35 responses to the survey, similar to the 42 responses to the meeting time Doodle Poll.

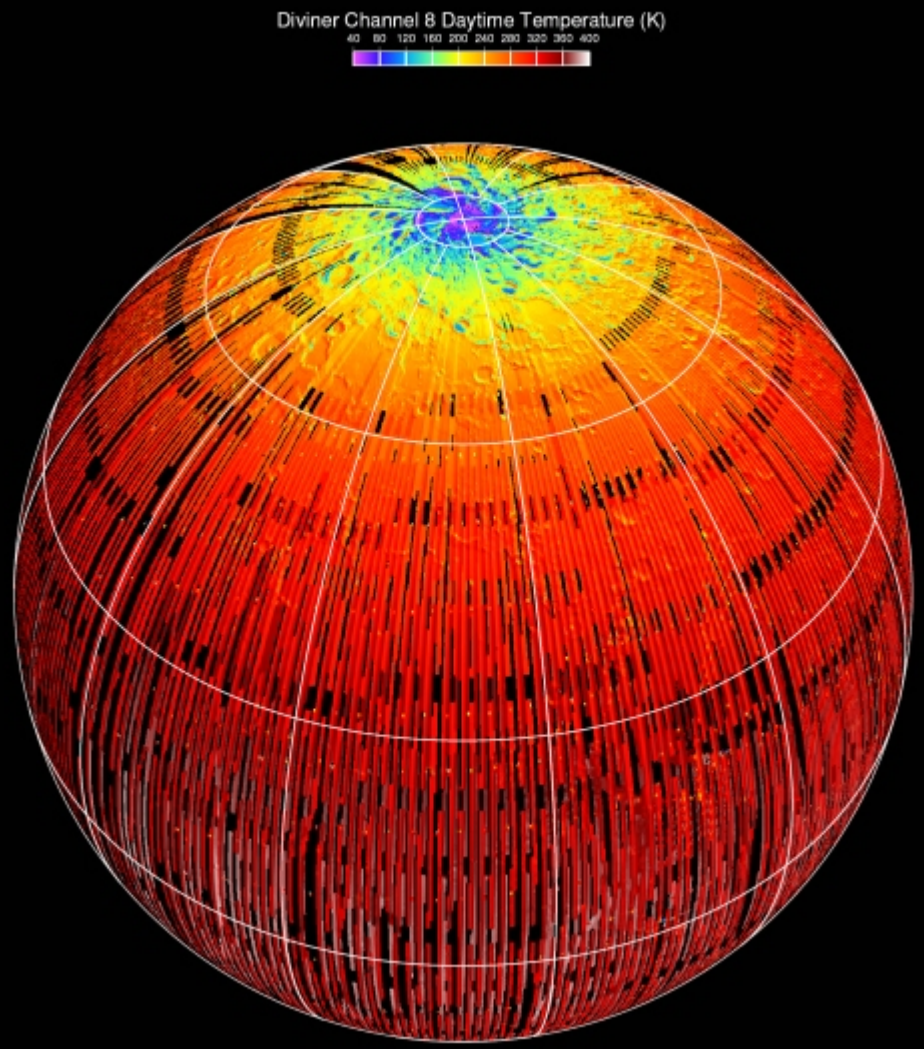
But our listserv has 196 members so we'd like to improve participation.

Survey – Primary Interest

- *Thermal Environment – 5 / 35 (14.3%)*
- *Illumination Environment – 2 / 35 (5.7%)*
- *Communication Environment – 4 / 35 (11.4%)*
- *Solar Wind / Plasma Environment – 2 / 35 (5.7%)*
- *Radiation Environment – 4 / 35 (11.4%)*
- *Vacuum Environment – 2 / 35 (5.7%)*
- *Surface Interactions – 13 / 35 (37.1%)*
- *Other External Hazards – 0 / 35 (0.0%)*
- *Write-in Primary Interests – 3 / 35 (8.6%)*
  - *Seismicity and induced seismicity (from meteorite impact)*
  - *Subsurface ice stratigraphy*
  - *Environmental requirement definition to drive power system technology needs*

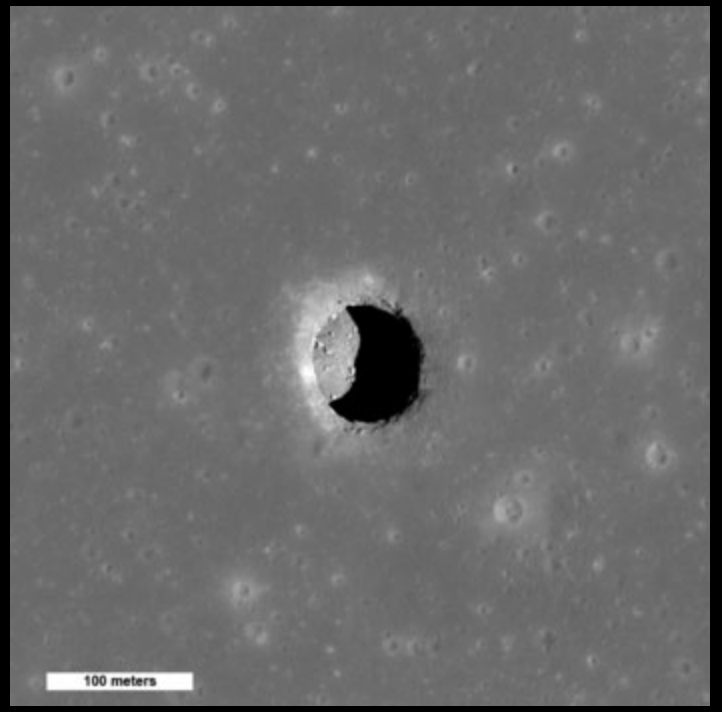
Survey – Additional Interests

- *Thermal Environment – 19 / 31 (61.3%)*
- *Illumination Environment – 14 / 31 (45.2%)*
- *Communication Environment – 7 / 31 (22.6%)*
- *Solar Wind / Plasma Environment – 10 / 31 (32.3%)*
- *Radiation Environment – 13 / 31 (41.9%)*
- *Vacuum Environment – 11 / 31 (35.5%)*
- *Surface Interactions – 12 / 31 (38.7%)*
- *Other External Hazards – 8 / 31 (25.8%)*
- *Write-in Primary Interests – 1 / 31 (3.2%)*
  - *Regolith characteristics*



Survey – Additional Environments

- *Seismicity (moonquakes) and induced seismicity by meteoroid impact*
- *Subsurface Ice Stratigraphy. This is very important for lunar ISRU, esp wrt water ice mining.*
- *Sub-surface accessibility (lava channels, lava tubes)*
- *It's connected to the plasma environment, but I would add the surface charging expected in shadowed environments.*
- *Geography (huge vertical terrain differences)*
- *Electrostatics*



Survey – Nickname

- *ExEnv*
- *E^2 or E^3 or E2G, and then have the Extreme Access Group be EA or EAG*
- *LuSEE (Lucy)*
  - *LuEE (Louis/Louie)*
  - *LSEE (L-S-Double-E or L-See)*
- *The Extremophiles*

Please comment any thoughts in chat or send me an email!

Next Steps: Value to You

- Communication and information
- Access to contextual information related to lunar environments
- Understanding the technology landscape and development plans for other sectors
- Early identification and collaboration with developers of emerging technologies
- Influence into setting of standards together with greater community
- Ability to identify technology gaps and suggest technical priorities for NASA
- Partnerships for maturation and implementation of new technology
- Recruiting of new talent
- Frequent communications with sponsor
- Visibility into technology development

Next Steps: Communication

- Mailing list
  - Can be used to share information regarding activities and topics of interest to the focus group
  - The listserv goes to all participants (196 and counting)
  - We will set up smaller, focused lists as needed
- Surveys
  - Collect information for focus group activities
  - Sign-up to lead/participate in specific tasks
- Monthly Zoom teleconference (examples)
  - Contain short presentations from task leads or participants
  - Working session to advance focus group goal
  - Open forum for brainstorming
  - Lightning round updates from various participants
  - Opportunity to voice issues to be brought to NASA STMD
  - Give NASA POC for Focus Area (once identified) a standing slot for NASA updates
- Wiki (in development)
  - Collection and dissemination of information (describe environments, describe facilities, describe vendors, etc.)
  - The main archive for all focus group activities and FG calendar
  - Provide collaboration space in addition to email list
- Other communication tools?

Please Follow Rules of the Road for all communications

Next Steps: Focus Group Goal

- We will collaboratively decide on a 1-year goal for us to work on as a group
  - Actionable and impactful
  - Specifically relevant to our focus area
  - Doable within 1 year
  - Uses capabilities of focus group members
  - Can be accomplished with existing resources
  - Inspired by current issues
  - Beneficial broadly to all stakeholders

- For discussion at next month's telecom

- Example: Gather information for a lunar environment users guide for technology development
  - Product that could be used by technology developers to understand which environments are impactful to their use case and what are the challenges. Describe what facilities exist for testing and demonstration, how to access them, and what facilities are needed at each phase of development.

Next Steps: What to Expect

- Before our next meeting (next three weeks)
  - Identify task leads and task participants for describing extreme environment technology categories (e.g. thermal environment, illumination environment, etc.)
  - Sign-up via Google form (or email) to be distributed this week

- At our next meeting (July 14th at 3pm)
  - Each lead will present a single quad chart
  - Discussion regarding focus group first year goal
  - Update on communication tools

- After our next meeting (late July / early August)
  - Plan to start discussing specific environments in detail
  - Identify task leads for describing relevant facilities (e.g. charging environment under vacuum)

Discussion

- Please use the raise hand feature (preferred)
- You can also comment in chat

- How can LSIC and specifically our focus group work with your institution?
- What do you want to get from the focus group meetings?
- What kinds of focus groups activities would be most productive?
- What are potential impediments to participating in focus groups?
- What do you see our focus group interacting with the other focus groups?

Focus Areas
- In Situ Resource Utilization
- Sustainable Power
- Extreme Access
- Extreme Environments
- Excavation/Construction
- Dust Mitigation

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