Lunar Surface Innovation
CONSORTIUM

Extreme Environments Focus Group August Telecon

August 11, 2020

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Today's Agenda

- NASA Point of Contact Presentation (Mark Hilburger)
- Task 1 Overview (Ben Greenhagen)
- Task 1 Subgroup Updates
  - Communication Environment (Marshall Eubanks)
  - Thermal Environment (Ahsan Choudhuri)
  - Illumination Environment (Craig Peterson)
  - Radiation Environment (Lawrence Heilbronn)
  - Vacuum Environment (Stephen Indyk)
- Fall Meeting Update & Discussion

Capabilities Database Survey: https://forms.gle/GXb7TuVYa23qnVp96

- See “Strategic Technology Plan Overview 8.11.2020.pdf”

Task 1 Overview

Goal: Define lunar extreme environments relevant to enabling systems to survive and operate throughout the full range of lunar surface conditions

- *Capture primary environment characteristics and variability on the Moon.*
- *Identify environmental challenges to technology development.*
- *Include all environment categories intrinsic to survival and operation.*

- Kickoff Product: Quad chart presented at a FG monthly telecon (*July 14 or later*). Signals the start of the task.
- Review Product: Short presentation that defines the environment category based on the work of the subgroup. Guides ~15 minute discussion at a FG monthly telecon (*August 10 or later*).
- Archive Product: Revised version of the Review Product and 1-2 pages of text for the focus group wiki.

Task 1 Subgroup Updates

- *Communication Environment (Marshall Eubanks, tme@space-initiatives.com)*

- *Thermal Environment (Ahsan Choudhuri, ahsan@utep.edu)*
  - *Alternate: Mahamudur Rahman*
- *Illumination Environment (Craig Peterson, craig@transastracorp.com)*
- *Radiation Environment (Lawrence Heilbronn, lheilbro@utk.edu)*
- *Vacuum Environment (Stephen Indyk, SJIndyk@honeybeerobotics.com)*

Please contact subgroup leads to get involved!

Communications Environment

Lead: Lead: Marshall Eubanks, Space Initiatives Inc. tme@space-initiatives.com

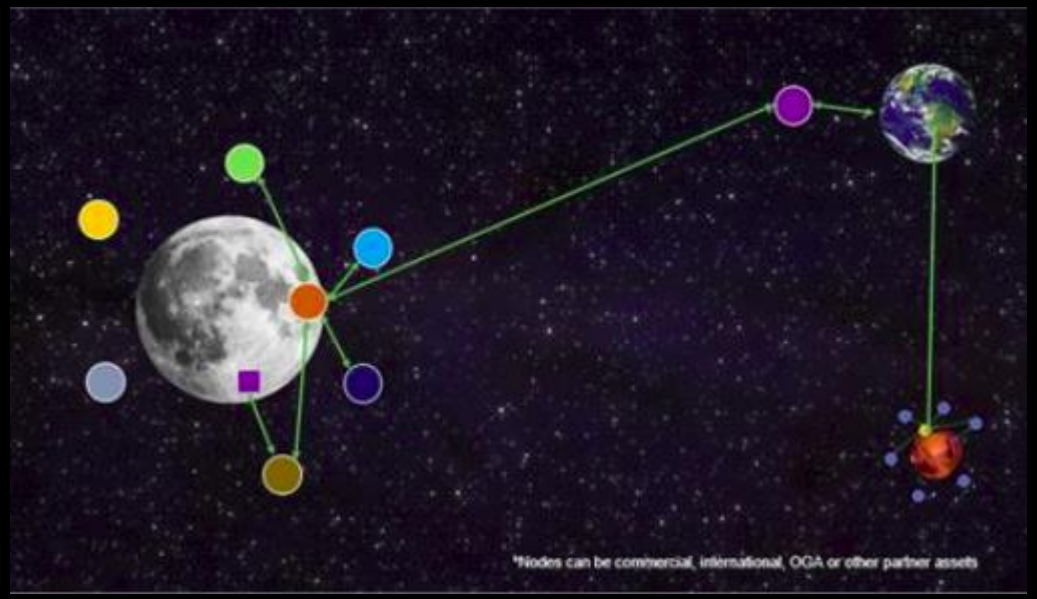
- *Working on Lunar Penetrators and Communications networks under an Air Force Contract.*

- *Supporters:*
  - *Craig Peterson, Trans Astra Corp*

Participants:

- *Ben Greenhagen, JHU APL*
- *Angeliki Kapoglou*
- *Charles Radley, Space Initiatives Inc*

Communications Environment



Lunar Network Communication (GSFC LunaNet)

Communication To and From the Lunar Surface is not a solved problem.

Extreme environments mean extreme communications needs.

- *The entire far side is out of line of sight for direct communications with Earth.*
- *Most extreme regions have their own communication problems.*
- *Permanently Shadowed Regions may be out of line of sight to the Earth or to Lagrange Point Halo orbits. .*
- *Lunar Cave explorers won't even be able to see satellites.*

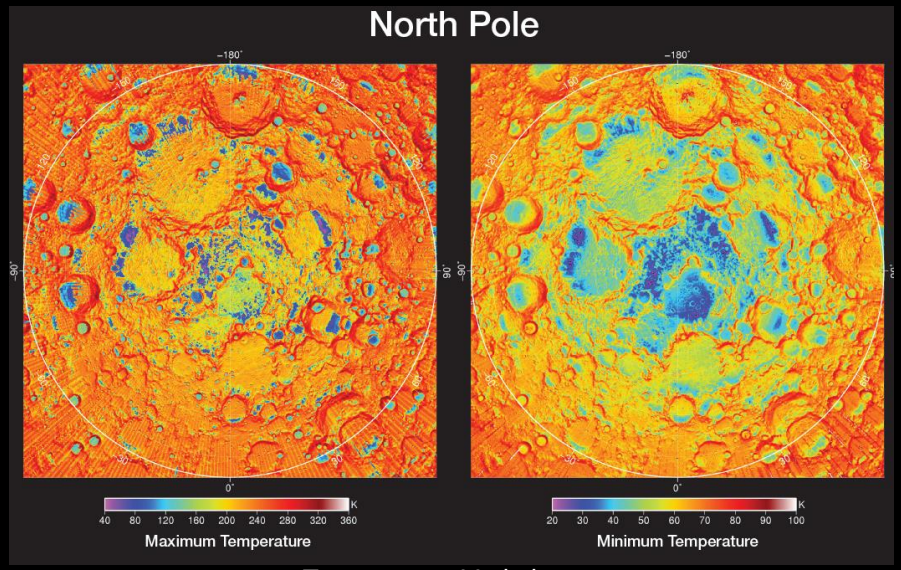
- *Environmental Variability*
  - *A satellite based Luna Network is likely to begin with store and forward satellites in "frozen orbits" or at very high altitudes.*
  - *Can frozen orbits reach all points on the lunar surface?*
  - *Can high altitude relays (e.g., the Chinese Queqiao relay) support, e.g., polar operations?*
  - *What about low frequency Lunar ground and sky waves?*
  - *Little is known about these – can they provide low bit rate long range communications?*

- *Challenge to Technology Development*
  - *How can private companies build the required communications without a Government (US or other) as an "anchor tenant?"*
  - *Can CLPS/PRISM/Artemis use commercial infrastructure? Can a task order structure be set up there?*
  - *How will testing of these ideas be supported?*
  - *How can PNT be incorporated into this? What are requirements?*

Thermal 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*
  - *Craig Peterson; 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)*

- *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*

Notes from 08/04/2020 Meeting

- Monthly WebEx Update Meeting: 4:00p(Center)/3:00p(Mountain)| First Tuesday of Every month until December | Duration: 25 mins | Next Meeting-09/01
- UTEP has assigned a doctoral student to collect and catalog articles on Lunar Surface Temperature | First Report is Due on 08/15
- Team members will forward any information they might have relevant to Lunar Thermal Environment to Ahsan
- We need to have more discussion on the heat flux. Primary discussion item for the 09/01 meeting.
- Target Date for the first summary report: 10/02

Subgroups Without Leads

Desirable to identify leads for these subgroups ASAP

- *Solar Wind / Plasma Environment (nearside, farside, polar, etc.)*
- *Other External Hazards (seismicity, micrometeorites, CMEs, etc.)*

These categories need to be refined to focus on intrinsic aspects of the lunar surface environment and avoid topics primarily covered in other focus groups

- *Surface Interactions (dust, regolith toxicity, rocks, etc.)*
- *Subsurface Interaction (rock/ice stratigraphy, constrained environments, etc.)*

Contact Ben (Facilitator_ExtremeEnvironments@jhuapl.edu) with comments or to volunteer

Fall Meeting Update I

- Dates: October 14th and 15th, 2020
- Venue: Virtual

- Information: The Lunar Surface Innovation Consortium (LSIC) fall meeting will be held virtually on October 14th and 15th. The event will feature interrelationships between the six focus areas identified by the Consortium, especially in the context of surface power. Day one of the meeting (October 14th) will feature key note addresses and LSIC-wide plenary sessions, including a poster session. Day two (October 15th) will delve more deeply into technology areas, including smaller group discussions, focus area-specific technological needs, and interrelationships among the LSIC focus areas.

- Question: What do you hope to get out of the Fall Meeting?
- Question: What are our key focus group interrelationship considerations?

Fall Meeting Update II

- Call for Abstracts: We invite abstracts describing technical capabilities within the six LSIC focus areas, as well as those that identify lunar surface technology needs and assess the readiness of relative systems and components. Other topics of interest include defining the parameters and constraints of the architecture required to support a sustained presence on the lunar surface, as well as economic and policy considerations.

- The abstract submission portal will open on August 17th, and all abstracts are due by 11:59PM EDT on September 11th. Abstracts should be submitted in pdf format, and are limited to 1 page, including any figures and tables, at no smaller than 10-point font (and 1-inch margins). Contributed abstracts will be presented as posters or as short lightning talks. A template will be provided when the submission portal opens.

- Question: Are there abstracts that you'd like to submit that don't fall in those categories?

Open Discussion

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

- What environmental information do you need to proceed with your development?
- What ancillary technologies are preventing you from advancing your target technology?
- Do you have access to the facilities that you need?
- What opportunities do you need to mature your technology?

- General: What kinds of focus groups activities would be most productive?
- General: How do you see our focus group interacting with the other focus groups?

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Year 1 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

- Example: Provide reference for a lunar environment users guide for technology development
  - Product that outlines gaps in capabilities introduced by extreme environments on the Moon. Define the parameter space and associated challenges of environmental factors that are relevant to technology developers for their use case. Describe what facilities exist for testing and demonstration, how to access them, and what facilities are needed at each phase of development.