Lunar Surface Innovation CONSORTIUM

LSIC Newsletter Volume 1 Issue 3 - September 2020

The Lunar Surface Innovation Consortium is administered by the Johns Hopkins Applied Physics Laboratory, and operates in collaboration with the NASA Space Technology Mission Directorate under the Lunar Surface Innovation Initiative. Its purpose is to harness the creativity, energy, and resources of the nation to help NASA keep the United States at the forefront of lunar exploration. To find out more, sign up to participate, or access past additions of this newsletter, please visit lsic.jhuapl.edu.

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Focus Area Monthly Telecon Schedule

Dust Mitigation
Third Thursdays at 12PM Eastern

Extreme Access
Second Thursdays at 3PM Eastern

Excavation and Construction
Last Friday at 3PM Eastern

Extreme Environments
Second Tuesdays at 3PM Eastern

In Situ Resource Utilization
Third Wednesdays at 3PM Eastern

Surface Power
Fourth Thursday at 11AM Eastern

Director's Update

The past month has had a flurry of activity as we finalized the Confluence wiki site and began ramping up preparations for the Fall Meeting. If you have not yet had a chance to request an account for Confluence, please email Andrea Harman (ams573@alumni.psu.edu) and she will get you set up. The Confluence site will become a key repository for focus group communications in between monthly telecons. For those who prefer to minimize their email list traffic, the site will provide a window into focus group discussions and a way to stay up-to-date on upcoming meetings. This will also be the home of the member capabilities database.

Hopefully everyone has already made a note of the Fall Meeting, scheduled for Oct 14-15. Although we are disappointed to not be able to hold this in person at ASU, as originally planned, we have been working together with them to design an engaging and productive virtual program. If you have technology that you would like to showcase in a poster session, please remember to submit an abstract at http://lsic.jhuapl.edu/Events/102.php?id=102 by September 11th.

Rachel Klima
Director, Lunar Surface Innovation Consortium
SES-LSIC-Director@jhuapl.edu

If you'd like to participate in a focus area's monthly telecon, please sign up on the LSIC website here: lsic.jhuapl.edu/Events/survey.php

ISRU Supply and Demand Virtual Workshop: 17 September 2020

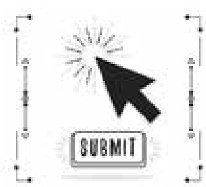
Join the LSIC In Situ Resource Utilization (ISRU) focus group on Thursday, 17 September 2020 from 12PM to 5PM EDT for an ISRU Supply and Demand virtual workshop. The event will provide a forum where supply and demand needs will be discussed, with the goal of developing communication within the industry. Another important outcome will be fostering a notional community understanding of the quantities of ISRU products that will be desired and available in the near-future cislunar economy. The keynote speaker at the event will be NASA Chief Economist Alexander MacDonald. information about the other esteemed speakers is available on the event website here: http://lsic.jhuapl.edu/Events/103.php?id=103

CALL FOR INFORMATION

Participants are encouraged to share resources (whitepapers, posters, etc.) to help advance the conversation about ISRU supply and demand – please consider contributing at the event link above!

LSIC Virtual Fall Meeting: 14-15 October 2020

Join us for LSIC's fall meeting from 14-15 October 2020, which will feature keynote addresses, working sessions, and technical poster presentations. The event will center on the interrelationships between the six LSIC focus areas, especially in the context of surface power. More details are available on the event website here: http://lsic.jhuapl.edu/Events/102.php?id=102



ABSTRACT SUBMISSION DEADLINE: 11 SEPTEMBER

LSIC also invites abstract submissions describing technical capabilities within the six LSIC focus areas, as well as those that identify lunar surface technology needs and readiness assessments of relative systems and components. For more details, and to submit your abstract, please visit the event webpage (linked above).

Capabilities Database – Contribute Your Information

LSIC is beginning to develop a database of capabilities, expertise, and facilities within the community to encourage collaboration and cooperation. We're inviting companies, institutes, and organizations of all types to share information about their specialties. This information will first be shared on LSIC's Confluence page, with the potential to be shared more publicly in the future (respondents will be asked whether they are comfortable sharing their information more widely). To submit your information, please visit the online form here: https://forms.gle/m4uNdVsdBoBbxW1h6

LSIC Wiki Powered By Confluence Is Up and Running

LSIC's wiki space, powered by Confluence, is now live! Any LSIC member interested in participating in the conversations on that platform are welcome to contact Andrea Harman (ams573@alumni.psu.edu) to have a no-cost account created for them. Information housed in Confluence will include more detailed notes from monthly meetings, ongoing conversations and discussions amongst and among the focus groups, as well as updates and communications directly from LSIC leadership. Training is also available for those who are interested.

In the coming months we will be introducing you to LSIC's six focus groups. This month we are sharing information about the Extreme Environments group and their facilitator, Benjamin Greenhagen.

Focus Group Feature: 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. Meeting notes and recordings can be found on the LSIC website here: http://lsic.jhuapl.edu/Focus-Areas/Extreme-Environments.php

Facilitator: Benjamin Greenhagen

Dr. Benjamin Greenhagen is a planetary scientist at Johns Hopkins Applied Physics Laboratory. He is an expert in thermal infrared instrumentation and leads investigations into thermal emission from airless bodies. He also participates in a wide range of active missions and projects. He engages in the community and encourages professional and personal development at all career stages.

Extreme Environments Sub-Group Leads

The Extreme Environments focus area has four sub-groups for specific challenging environments on the Moon. They are Thermal Environment, Illumination Environment, Radiation Environment, and Vacuum Environment. Our feature article this month, "You'd Have To Be A Lunatic To Move Here," provides details about each, and the sub-group leads are introduced here.

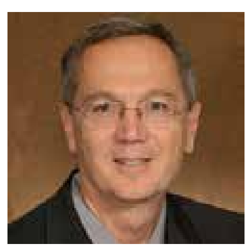
Illumination Environment: Craig Peterson

Craig Peterson has over 40 years of NASA, Industrial, other government agency, and academic experience and education, the majority of which are directly related to space missions and space technology development, primarily at the Jet Propulsion Laboratory. He recently accepted a position as systems engineer for TransAstronautica Corporation.

Thermal Environment: Ahsan Choudhuri

Dr. Ahsan Choudhuri directs the UTEP NASA Center for Space Exploration and Technology Research. Professor Choudhuri's teaching and research interests are in the area of combustion, propulsion, and high temperature materials synthesis.

Radiation Environment: Lawrence Heilbronn



Lawrence Heilbronn is the John D. Tickle professor in the Nuclear Engineering Department at the University of Tennessee. He is a nuclear physicist with 30 years of experience conducting ground-based experiments relevant to space radiation transport and shielding.

Vacuum Environment: Stephen Indyk

Stephen Indyk is a senior Engineering Manager and flight operations lead for Honeybee Robotics. He is a science team member for both Mars Science Laboratory (MSL) and Mars Exploration Rover (MER) missions with over eight years of flight operations experience.

You'd Have To Be A Lunatic To Move Here

An Overview Of The Extreme Environments On The Lunar Surface

In photographs, the Moon appears calm and peaceful in its palette of greys. But the dynamic reality of visiting the lunar surface and overcoming its many extremities is a challenge that the LSIC Extreme Environments Focus Group is working to chart a path through. To accomplish this goal, they have further divided into sub-groups that are addressing a number of distinct environments on the Moon where future missions may operate. This article aims to explore some of those topics, even as the list continues to grow (leads are still needed for the solar wind and plasma environment as well as external hazards sub-groups, so reach out to Ben Greenhagen if you're interested!).

Thermal Environment

Featuring a temperature ranging from below 20 K to above 400 K, the thermal characteristics of the lunar surface not only provide some of the coldest places (such as the floor of the Moon's Hermite Crater) in our Solar System but also scorching heat, with regular swings between the extremes. This is a huge obstacle to everything from establishing a safe habitat for humans to simply maintaining the materials making up man-made components on the surface. A literature review is currently underway as the sub-group prepares to create a lunar surface temperature map which would guide planning of activities and placement of infrastructure on the lunar surface.

Illumination Environment

Even before we consider the Permanently Shadowed Regions (PSRs) at the lunar poles, the lunar surface experiences 13.5 Earth day cycles of constant sunlight alternating with the same duration of darkness with only the nearside illuminated by earthshine (which is currently insufficient for "solar" power). At the poles, which are currently favored sites for a sustained presence on the Moon, there can be considerable variability in light even over just a few kilometers based on the terrain.

Radiation Environment

The radiation environment on the surface of the Moon has three primary, naturally occurring sources, which are Galactic Cosmic Rays (GCRs), Solar Energetic Particles (SEPs), and albedo particles resulting from GCR and SEP interactions in the lunar regolith. How local variations in topography affect the albedo needs significant study. A fourth potential source of radiation is human-made, resulting from the installation of radioisotope or fission surface power systems. Another topic under discussion is accurately predicting and providing timely warnings of solar particle events, allowing for shielding of equipment and safe sheltering for humans.

Vacuum Environment

The lunar surface exists in a vacuum, with the nightly surface pressure at 3e-10 Pa, and a composition primarily derived from solar wind of helium, neon, hydrogen, and argon. The vacuum itself is a complicating factor in a number of other extreme conditions. For example, it affects the thermal environment by inhibiting convection, though conduction and radiation still occur. Electrostatics also behave differently in a vacuum, which has major repercussions for dust mitigation. The vacuum also makes welding extremely difficult, and significantly limits options for lubrication on the Moon, further complicating the development of infrastructure and a sustained presence. One of the sub-group's main priorities

Most mountains on the Earth are formed as plates collide and the crust buckles. Not so for the Moon, where mountains are formed as a result of impacts as seen by NASA Lunar Reconnaissance Orbiter.

to address knowledge gaps in this area is discussing and identifying terrestrial testing facilities and available simulants. Further defining the state of the art by searching through existing literature is also underway.

The entirety of humanity's combined experience venturing outside on the lunar surface is little more than three Earth days – the challenge is to build upon that limited familiarity to establish a long-lasting presence that will continue to be refined as more information is returned from missions in the near and far future. The Moon serves as an essential test-bed for testing, validating, and scaling up critical technologies needed for in-situ resource utilization industrial plants to support human settlement on Mars. In many ways the Moon's environment produces more significant challenges than Mars! Surface temperatures on Mars are more stable and less extreme than the lunar surface. Even the dust on Mars is easier – which is why succeeding on the Moon is such an important part of establishing a long-term extraterrestrial presence.

Member Feature: Resilient Extra-Terrestrial Habitats Institute (RETHi)

Have you ever wondered what might happen if a meteorite struck your lunar habitat? The RETHi team has – their primary mission is to develop the technologies needed to create Resilient Extra-Terrestrial Habitats (RETH), a goal that keeps them thinking about everything from basic maintenance to catastrophe response for off-world structures.

The Resilient Extra-Terrestrial Habitats Institute (RETHi, pronounced reth-EYE) is celebrating its first birthday this September. RETHi is a NASA-funded Space Technology Research Institute (STRI) headquartered at Purdue, with over 40 team members from the University of Connecticut, Harvard University, and the University of Texas at San Antonio. Two corporate partners also support their work, Collins Aerospace of Connecticut and ILC Dover of Delaware. The Institute Director is Dr. Shirley Dyke, professor of mechanical and civil engineering at Purdue.

The institute's mission is working to understand the design principles and methods that will result in resilient and autonomous habitat systems. Their research is not simply to deliver a single design, but to provide NASA with a suite of tools to design complex habitat systems. "We're not catching them a fish, we're teaching them to fish," says Resilience Team Leader Karen Marais.

Three main research thrusts currently make up the research being pursued by RETHi. They are:
• Resilience: Anticipating, and avoiding or adapting to possible threats
• Awareness: Building networks of sensors that can actively learn, detect, and diagnose issues
• Robotics: Developing autonomous robots that can operate independently and/or collaborate with humans

The Resilience thrust blends several engineering disciplines together to explore how habitats can be made to withstand disruptions in lunar and Martian environments. Over the past year, they've been working to develop the computational capabilities required to capture complex behaviors and perform necessary trade studies. They've also been working to capture and measure resilience to facilitate a comparison between various habitat design concepts.

Ilias Bilionis, also of Purdue, heads up the Awareness thrust and their work to understand how habitats can sense their environments and potential hazards. They are focused on developing the ability to detect anomalies such as faulty power generation systems, defective thermal management systems, meteoroid strikes, or any unexpected system changes. That is enabling them to establish a command

and control that will facilitate research over the next 10-20 years into systems where humans and robots can make decisions about maintaining a habitat – together.

The third research thrust, Robotics, has a direct role in providing interventions that build capacity toward both resilience and awareness. Their work is advancing the robotic features so that they can take corrective action. This group, led by Justin Werfel of Harvard University, is determining how robots will work side-by-side with human crew (increasing the capabilities of robots to execute tasks for people), and maintain a habitat without a human presence (such as making the layout more robot-navigable). Their goal for the coming year is to continue defining and prioritizing gaps between what humans can currently do, and what robots can't accomplish yet.

The past year's efforts are starting to produce real-world results, as the three research thrusts are coming together to perform hybrid simulations using a cyber-physical test bed that couples physical and numerical models in real time to simulate outdoor environments on the lunar surface. RETHi is ordering the first components of the physical test bed. The past year's progress is indicative of a bright and productive future for this STRI!

For more information, visit RETHi online at https://www.purdue.edu/rethi or email the team at rethi@purdue.edu.

Image courtesy of the European Space Agency (ESA). "Lunar base made with 3D printing"

Current & Upcoming Funding Opportunities

The **Lunar Surface Technology Research (LuSTR) Opportunities** have been released, with proposals due September 9th. Proposals must be led by an accredited U. S. university, but teaming and collaboration with other types of institutions are permitted. Awards are expected to be in the range of $1-2 million. For more information, please review the announcement at: https://nspires.nasaprs.com/external/solicitations/summary.do?solId={0BA38320-8F63-2EAF-D97B-0AB42AF17C35}

The Watts on the Moon Centennial Challenge request for information (RFI) commenting period closed near the end of July. Further details and rules for the challenge will be distributed on the LSIC_announce listserv as soon as they are available. To view the RFI, please visit: https://beta.sam.gov/opp/49229d99c461439287ead92292c96e23/view?keywords=80MSFC20LST0701&sort=-relevance&index=opp&is_active=true&page=1