Lunar Surface Innovation CONSORTIUM

Hosted by the Johns Hopkins Applied Physics Laboratory

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LSIC Newsletter

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.

DIRECTOR'S UPDATE

Director's Update

We've had a number of new members join us in the last few months, and I would like to take this opportunity to welcome all of you. If you have questions about LSIC and how to get involved with various aspects, please feel free to reach out to us.

With the upcoming Excavation and Construction Workshop this month, we are nearing the end of our first round of focused workshops/extended meetings for the focus groups. I'd like to thank everyone in the community for all you have contributed to both these workshops and to the ongoing discussions from month to month. While the bulk of our technical discussions and work goes on within the focus groups, we are looking forward to cross-group discussions at the Fall Meeting in November. If you have any topics that you'd like us to try to incorporate into that meeting and haven't yet had a chance to fill out the pre-meeting survey (https://forms.gle/kDJYPD2JcDL8FZbY6), it is still open. Given the COVID trends in the U.S. right now, we realize that you may not be able to answer the questions about attending in-person or remotely right now, but we would love to have any feedback about content that you can provide.

We are currently accepting technical abstracts for the Fall Meeting, and the portal will remain open until August 31st. I urge participants who need extensive internal review to keep an eye on this deadline, as we will not be able to accommodate late abstracts as easily as we have done in the past. Each of our LSIC-wide gatherings provides us a very important opportunity to discuss linkages between focus groups and other high-priority topics that are of common concern among our members so that we can either take direct action as a consortium, or explore ways to better connect our community with other existing groups and resources. If you'd like to read more about the discussions and our key findings from the Spring Meeting, we have posted our report of the event on the Spring Meeting page (http://lsic.jhuapl.edu/News-and-Events/Agenda/index.php?id=124). The findings captured there will be used to help develop future meetings, workshops, and resources.

Rachel Klima
Director, Lunar Surface Innovation Consortium
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Focus Areas

Monthly Telecon Schedule

Dust Mitigation
Third Thursdays at 12PM Eastern

Extreme Access
Second Thursdays at 3PM Eastern

In Situ Resource Utilization
Third Wednesdays at 3PM Eastern

Excavation & Construction
Last Fridays at 3PM Eastern

Extreme Environments
Second Tuesdays at 3PM Eastern

Surface Power
Fourth Thursdays at 11AM Eastern

LSIC General Updates

Excavation & Construction Workshop: 20 August

An Excavation & Construction Workshop will be held on 20 August. The meeting focus will be on high-technology readiness level (TRL) excavation and construction tools and methods to support initial development of the lunar surface. This is currently planned to be a ~2-hour workshop. A draft agenda will be posted soon. To register and find more details, please visit the event page here: http://lsic.jhuapl.edu/News-and-Events/Agenda/index.php?id=139

LSIC Fall Meeting: 03-04 November

The Fall Meeting of the Lunar Surface Innovation Consortium is scheduled for November 3-4th, 2021, and will be held at Bowie State University in Bowie, MD (with most content and some sessions also available online). The abstract portal is currently open, and registration will open in August. This year's technical theme is Autonomy and Robotics. The overarching meeting theme will be used to focus invited presentations and the technical breakout discussions. We encourage abstracts pertaining to these topics, as well as those describing technology developments for any of the LSII focus areas or establishing a sustained presence on the lunar surface. To register, submit abstracts, and find more details, please visit the event page here: http://lsic.jhuapl.edu/News-and-Events/Agenda/index.php?id=148

CIRCUIT Intern Introduction: Jessica Harryman

Each month LSIC will be featuring one of our CIRCUIT interns, to introduce them to the wider LSIC community. This month, we're happy to feature Jessica Harryman.

Who am I? My name is Jessica Harryman and I am a CIRCUIT 2021 intern at the Johns Hopkins Applied Physics Laboratory in Laurel, MD. I am currently a senior at the University of Maryland, Baltimore County (UMBC) where I major in physics with a minor of astronomy.

What have I done in the past? During my time at UMBC, I have served as the President of the Society of Physics Students (SPS) and I have worked with the campus observatory on their podcast. I've had a lot of chances to participate in cutting edge research in the last few years. At UMBC, I perform research on the thermal characteristics of stars through the use of spectroscopy and machine learning techniques. With APL, I have had the chance to do research on Mars and the Moon. Last year, I worked on categorizing the geomorphology of northwest Noachis Terra using images from the CRISM instrument on the Mars Reconnaissance Orbiter (MRO).

Why am I here now? This year, I am working with the Lunar Surface Innovation Initiative (LSII) on determining the feasibility of creating a base on the Moon. I work with the Extreme Environments subgroup led by Benjamin Greenhagen. I study the interactions that the environment has with the technology that we plan to put on the Moon as well as with the humans that we want to send there in the near future. Additionally, I am currently working in Dr. Stockstill-Cahill's laboratory where I polish lunar simulants. We use these simulants to examine how the lunar dust may act in certain conditions and scenarios.

Feature Article

Extreme Environments Focus Group Activity on Specific Lunar Surface Environments And Technical Challenges

When designing technology to operate in the lunar environment, an early question should be "which lunar environment?" The lunar surface environment is complex and varies in time and space. Therefore, in many cases it is impractical to design technology for all lunar surface environments. As part of the larger vision of LSIC-EE to enable technologies that can survive and operate in extreme lunar environments, the goal of this study was to define and evaluate specific lunar surface environments and identify clear technical challenges associated with each environment. The activity began in January 2021 when the Focus Group agreed on seven lunar environments to evaluate, including three polar environments and four non-polar environments.

The three polar environments included in the study are: permanently shadowed regions (PSRs), areas of high illumination, and mixed polar environments. PSRs are dark, cold areas found in limited areas around the poles, some of which are the most likely large-scale reserves of volatile-rich regolith. In contrast, although the Moon may not have peaks of eternal illumination, areas of high illumination do receive abnormally longer durations of illumination during seasonal summer. Finally, mixed polar regions represent more typical polar terrains with seasonally variable illumination and abundant small-scale cold traps.

The four non-polar environments included in the study are: Apollo-style environments, topographic margins, lunar pits / lava tubes, and surface anomalies. Apollo-style environments are relatively flat, low- to mid-latitude nearside locations where lessons learned from Apollo are most directly applicable. Topographic margins include high relief impact and volcanic features where significant fractions of sky visibility are blocked by terrain. Lunar pits are steep depressions found in both mare basalts and impact melt ponds with mare pits potentially being skylights into buried lava tubes. Surface anomalies include a range of different phenomenon including magnetic anomalies, thermal inertia anomalies, pyroclastic deposits, and irregular mare patches.

A priority for the activity was to provide as many opportunities for participation as possible. And the organizational structure of the Extreme Environments Focus Group and its five subgroups (Radiation Environment, Regolith / Surface Interface, Space Weather / Plasma Environment, Thermal & Illumination Environments, and Vacuum / Exosphere Environment) is particularly well-suited to evaluate surface environments in this way. Discussions regarding different aspects of the activity occurred at six focus group meetings and dozens of subgroup meetings. Major milestones included the following:

- January / February – Focus Group defined surface environments and variants to study
- February / March – Subgroups provided topical assessments of each surface environment
- April – "Supersize" 2-hour working meeting focused on environmental and technology challenges with Confluence breakout sessions that collected nearly 300 comments and replies
- May / June – Subgroups ranked the surface environments in terms of challenges/stresses to technology development
- June / July – Focus Group voted on which surface environments are the greatest priority for deep dive workshops and follow-up work

Archiving information on Confluence to provide access to all LSIC members was also a priority, and the main archive can be found here: Specific Lunar Surface Environments and Technical Challenges (FYI - password required). This archive currently includes the surface environment descriptions, subgroup assessments and rankings, Focus Group prioritization rankings, and all the materials collected at the April working meeting. This study is currently wrapping up with a draft report due this summer, which will be published on Confluence.

Following up on this study, LSIC-EE plans to host topical deep dive workshops into specific lunar surface environments with the goal of better understanding needs and capabilities in three areas: (1) technology developments, (2) observations and modeling, and (3) testing and facilities.

Findings from the subgroup rankings and Focus Group prioritization survey:

- The subgroup consensus was that polar environments represented greater risk to technology development than non-polar environments. All five subgroups ranked PSRs and/or mixed polar regions as being in the top 2 most challenging environments. On the other hand, Apollo-style environments and surface anomalies generally ranked as less stressing environments.
- Echoing the subgroup rankings, the Focus Group survey responses favored mixed polar regions and PSRs as surface environments to feature in the first deep dive workshop. Comments supporting these environments included the larger technical challenges and programmatic considerations. Lunar pits / lava tubes also received a significant portion of the vote as particularly interesting science locations and potential locations for human habitats.

NASA astronauts Jeanette Epps, left, and Suni Williams, right, take a selfie as a United Launch Alliance Atlas V rocket with Boeing's CST-100 Starliner spacecraft onboard is seen as it is rolled out of the Vertical Integration Facility to the launch pad at Space Launch Complex 41 ahead of the Orbital Flight Test-2 (OFT-2) mission, Thursday, July 29, 2021 at Cape Canaveral Space Force Station in Florida. (Image Credit: NASA/Joel Kowsky - NHQ202107290022)

Member Spotlight

Advanced Cooling Technologies, Inc.

Advanced Cooling Technologies, Inc. (ACT) was founded in 2003 as a company focused on thermal technology research and development. With funding from NASA's SBIR program, they investigated thermal management solutions for spacecraft, out of which their Constant Conductance Heat Pipe (CCHP) technology was developed. The organization now routinely manufactures heat pipe assemblies, high conductivity plates, phase change material-based heat sinks for space industry.

The past few years have seen significant growth for ACT, including the acquisition of TekGard earlier this year. Now, as a division of ACT, TekGard specializes in the development of environmental control units (ECUs) and liquid cooling chillers for customers such as the U.S. Army. This and other technologies make up a mature portfolio that enable ACT to serve both space and terrestrial applications within several industries, including defense. Today, the company has 220 employees, with an R&D group of 35. ACT continues its strong focus on early-stage technology development, having a strong collaboration with NASA and the Department of Defense, the Department of Energy, as well as the military.

ACT was involved in space technology development from its very beginning. Currently it boasts both a robust research & development division as well as its many available product lines. With the amount of fielded technology successfully deployed by ACT, they have amassed over 50 million hours of combined flight time. One of their significant achievements has been the development of Space Copper Water Heat Pipes (SCWHP), transitioning a common heat pipe for military and consumer electronics (including most laptops) and making it usable for space applications. Another important technology is Phase Change Material (PCM) heat sinks for military, aerospace, and industrial thermal management applications.

Recently, ACT won an SBIR grant related to mining ice on the Moon's surface. They'll be working with the NASA Johnson Space Center to develop a thermal management system for a lunar ice-mining vehicle. This work investigates using waste heat from RTGs to extract ice and using the Moon's freezing temperatures as a heat sink for water harvesting. This work also includes a collaboration with Honeybee Robotics, who will be providing the drill for ice extraction, which ACT will integrate in their thermal based water harvesting system. ACT's thermal concept of water harvesting from lunar soil is based on waste heat management for ice sublimation, vapor deposition and refreezing in cold traps passively, using heat pipe radiators. The project P.I. Dr. Kuan-Lin Lee calls it "an exciting opportunity to develop technologies for future lunar missions".

NASA's VIPER program is another project that ACT participates in, having developed the thermal management system for the rover. This mission will gather important information about lunar resources and water ice extraction prospects, further augmenting the company's efforts in space and on the lunar surface. Hardware is under development for NASA's Artemis program as well. ACT will be working alongside companies like Astrobotic, developing thermal management systems for the multitude of landers and robotics destined for lunar exploration on NASA missions.

Even with a track record of success there are challenges when breaking new ground, and ACT is no exception. While VIPER will gather more data about lunar ice and lunar regolith thermal properties, there's not much information currently available, which is a major challenge to work being done today. Another specific issue ACT is working to overcome is the limitations of 3D

printing technologies to fabricate thermal drills and other technologies. Size limitations on currently available technology is a problem they are working to overcome.

Looking ahead, ACT is excited about continuing to increase the TRL of their thermal management technologies for space applications. Their goal is to continue demonstrating some of their prototype technologies at larger scale, aiming to transition the technology to NASA with engineering demonstration units and hardware for incorporation into more future missions. “Performing within these types of programs we develop, demonstrate and mature technologies to a stage advanced enough such that there’s a high chance that we can stay in the process all the way to the end” said Calin Tarau, Principal Engineer in Research and Development at ACT. The team hopes that funding for spaceflight R&D continues to be upbeat to keep the momentum on development of such technologies.

Find out more about ACT on their website here: https://www.1-act.com/

On July 29, 2021, Boeing’s CST-100 Starliner spacecraft and the United Launch Alliance Atlas V rocket begins rollout from the Vertical Integration Facility to the launch pad at Space Launch Complex-41 on Cape Canaveral Space Force Station in Florida. Starliner will launch on the Atlas V for Boeing’s second uncrewed Orbital Flight Test (OFT-2) for NASA’s Commercial Crew Program. OFT-2 is an important uncrewed mission designed to test the end-to-end capabilities of the new system for NASA’s Commercial Crew Program. (Image Credit: NASA/Kim Shiflett - KSC-20210729-PH-KLS01_0011)

Community Bulletin Board

Mission Control Space Services Awarded Opportunity To Fly Tech With Emirates Lunar Mission (ELM)

Submitted by Kaizad Raimalwala, Mission Control Space Services

Mission Control Space Services has been awarded an opportunity to fly AI software technology to the surface of the Moon. They will demonstrate a cutting-edge AI-integrated flight computer on the Emirates Lunar Mission (ELM), an international micro-rover mission led by the Mohammed Bin Rashid Space Centre in the United Arab Emirates, launched on a SpaceX rocket and delivered to the Moon by ispace of Japan in 2022. Their cloud-based Mission Control Software platform will be used as part of the ground segment to allow their distributed science team to participate in real-time. Click here to read more: https://missioncontrolspaceservices.com/projects/emirates-lunar-mission/

Maleth Program, First Space Mission For The Government Of Malta, To Launch In August

Submitted by Joseph Borg, University of Malta

29th August 2021 will herald a new historic entry in space to one of the World's smallest nations - Malta. The Maleth program led by Professor Borg and his team in Malta will be sending the country's first ever biomedical science experiment to the International Space Station on board the SpaceX CRS-23 mission. This will launch from Cape Canaveral as part of NASA's contract research supply missions as agreed with SpaceX. Project Maleth will carry human tissue samples from diabetic foot ulcers together with the microbiome present and will have them investigated under the effects of spaceflight and microgravity. The tissue samples will be then analyzed for both their genomic (DNA) and transcriptomic (RNA) changes as opposed to ground-based conditions on Earth. More details in the following link: https://foreignandeu.gov.mt/en/Government/Press%20Releases/Pages/Malta-to-send-scientific-experiment-to-the-International-Space-Station.aspx

Call For Abstracts For 18th Biennial Earth And Space Conference

Submitted by Chris Dreyer, Colorado School Of Mines

The 18th biennial Earth and Space Conference will be held in Denver, Colorado USA April 25-28, 2022. Attendees will explore the cutting edge in engineering, science, construction, and operations for extreme environments on Earth and beyond. The Conference is an excellent opportunity to connect with experts and share knowledge in civil engineering, aerospace engineering, and extreme environments on Earth and in Space. The Conference organizers are soliciting papers for presentation at the Conference. Abstracts are being accepted now through August 31, 2021, with draft and final manuscripts being due in November 2021 and March 2022 respectively. To submit an abstract, please visit the submittal website at: https://learn.mines.edu/earthspace2022/abstracts

If you have questions or need assistance, please contact Learn@mines.edu

NASA News

NASA Announces Nuclear Thermal Propulsion Reactor Concept Awards

13 July 2021 (21-091): NASA is leading an effort, working with the Department of Energy (DOE), to advance space nuclear technologies. The government team has selected three reactor design concept proposals for a nuclear thermal propulsion system. The reactor is a critical component of a nuclear thermal engine, which would utilize high-assay low-enriched uranium fuel. The contracts, to be awarded through the DOE's Idaho National Laboratory (INL), are each valued at approximately $5 million. They fund the development of various design strategies for the specified performance requirements that could aid in deep space exploration. Click here to read more: https://www.nasa.gov/press-release/nasa-announces-nuclear-thermal-propulsion-reactor-concept-awards

NASA Launches Entrepreneurs Challenge to Identify Innovative Ideas

12 July 2021 (21-093): NASA is announcing its 2021 Entrepreneurs Challenge to invite fresh ideas and new participants that will lead to new instruments and technologies with the potential to advance the agency's science mission goals. The agency's Science Mission Directorate is seeking novel ideas that focus on priority areas for the commercial sector. The Entrepreneurs Challenge aligns with NASA's goal to foster innovation and develop new technologies at lower costs while sourcing ideas from across the country with an emphasis on reaching out to underserved communities. Click here to read more: https://www.nasa.gov/press-release/nasa-launches-entrepreneurs-challenge-to-identify-innovative-ideas

NASA, Northrop Grumman Finalize Moon Outpost Living Quarters Contract

09 July 2021 (21-092): NASA and Northrop Grumman of Dulles, Virginia, have finalized a contract to develop the Habitation and Logistics Outpost (HALO) for Gateway, which will be a critical way station and outpost in orbit around the Moon as part of NASA's Artemis program. NASA and its commercial and international partners are building Gateway to support science investigations and enable surface landings at the Moon, which will help prepare astronauts for future missions to Mars. Click here to read more: https://www.nasa.gov/press-release/nasa-northrop-grumman-finalize-moon-outpost-living-quarters-contract

Funding Opportunities

Lunar Surface Technology Research Opportunities Solicitation Released

NASA's Space Technology Mission Directorate (STMD) has released "Lunar Surface Technology Research (LuSTR) Opportunities" as an appendix to the SpaceTech-REDDI-2021 solicitation. The LuSTR appendix is available at https://tinyurl.com/LuSTR21.

Only accredited U.S. universities are eligible to submit proposals. Teaming is permitted - see the LuSTR text for complete eligibility requirements, as well as teaming restrictions.

The goal of LuSTR is to accelerate the development of groundbreaking technologies that support and enable lunar surface activities to be conducted under Artemis - the core of NASA's exploration and human spaceflight plans for the next decade. The starting Technology Readiness Level (TRL) of the efforts to be funded as a result of the LuSTR Appendix will be TRL 2 - TRL 4; TRL advancement is required.

LuSTR solicits proposals that are responsive to two Lunar Surface Innovation Initiative focus areas: Excavation/Construction and Extreme Environments. Under these focus areas, LuSTR solicits proposals in response to the following four topics:

- Autonomous Systems for Excavation and Site Preparation
- Lunar Regolith Mineral Beneficiation
- Cold-Temperature Analog Integrated Circuits
- Novel Heat Transfer Fluids

The financial and programmatic support for LuSTR comes from the Space Technology Research Grants Program within STMD. Awards are expected to be of 1-2 years in duration, and total budgets are expected to range between $1M and $2M per award, depending on the scope and duration of the proposed project. Awards are planned to start in May 2022. NASA plans to make up to 4 awards but may make no awards, or may exceed 4, subject to the receipt of meritorious proposals and the availability of funds.

A Principal Investigator (see LuSTR text for restrictions) or Co-Investigator may participate in no more than two proposals in response to this appendix. NASA encourages submission of LuSTR proposals on behalf of women, members of underrepresented minority groups, and persons with disabilities.

All proposals may be submitted via NSPIRES or through Grants.gov by the authorized organizational representative of an eligible organization. Notices of Intent (strongly encouraged) are due by August 20, 2021, with proposals due on or before September 17, 2021, 5 pm Eastern Time.

Comments and questions may be addressed to hq-LuSTR@mail.nasa.gov. Responses will be answered by email and may also be included in the Frequently Asked Questions (FAQs) on the LuSTR NSPIRES page. Anonymity of persons/institutions who submit questions will be preserved.

Tech Development

- NASA TechLeap
https://www.nasa.gov/centers/armstrong/features/techleap-prize.html

  Submission deadline: August 11, 2021

- Lunar Surface Technology Research (LuSTR) Solicitation
https://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7bFC8AA32D-180F-9B49-AE48-7C30FCD68E9B%7d&path=&method=init

  NOIs Due: August 20, 2021 Final Proposals Due: September 17th, 2021

- SpaceTech-REDDI-2021: Tech Flights Solicitation
https://tinyurl.com/NASA-21FO-F1

  Full Proposals due on or before October 4, 2021

- NASA Innovative Advanced Concepts (NIAC) 2022 PHASE II & III Call for Proposals
https://www.nasa.gov/content/apply-to-niac

  Phase 2 Release: October 2021 Phase 3 Release: December 2021

Student Tech Development

- NASA TechRise Student Challenge
https://www.nasa.gov/press-release/new-nasa-student-challenge-offers-hands-on-tech-development

  Educator Workshops: July 28 and August 11, 2021 Student Registration Opens: August 18, 2021

  Submission Deadline: November 3, 2021

For more funding opportunities, please visit LSIC's website here: http://lsic.jhuapl.edu/Resources/Funding-Opportunities.php