



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.

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Director's Update

Hello LSIC Community! We are now in full swing with planning for the Spring Meeting, which will be held as a hybrid event in person at APL and online. We're excited to share that NASA Associate Administrator Robert Cabana will be our keynote speaker for the event. We're also looking forward to digging deeper into NASA's strategic technology plans and learning how our focus groups can help move us forward to the Moon. More details about the event, including registration and the abstract portal, are available online here: <https://lsic.jhuapl.edu/Events/Agenda/index.php?id=200>

In other news, we were able to meet with the Executive Committee in both January and February. We are working to formalize some of the committee processes, to ensure that they are set up to evaluate our progress and help us set goals for the next year, when we meet in May.

We've also begun planning for this year's Fall Meeting, and are looking for institutions interested in hosting. The Fall Meeting is intended to focus on a specific technology area in depth, and also provides member institutions an opportunity to highlight their research and technology developments. If your institution is interested in hosting, please fill out an interest form online here: <https://lsic.jhuapl.edu/Events/Hosting-a-LSIC-Fall-Meeting.php>. For this year only, we have a relatively rapid turn-around time, so any organizations interested in hosting for 2022 need to express their interest by March 31st. Specific requirements for the event space are listed on the page, but we're looking for locations with features relevant to LSIC's focus areas, reasonably close to airports and hotels, and capable of holding up to 300 attendees (or 100 attendees with COVID restrictions). We are currently planning that all future meetings will be hybrid in format, so technology to support such events will need to be available. We appreciate anyone who's interested in bringing the LSIC community into their home, and look forward to working with you to create a special event!



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

Fourth Wednesdays at 2PM Eastern

Extreme Environments

Second Tuesdays at 3PM Eastern

Surface Power

Fourth Thursdays at 11AM Eastern

LSIC General Updates

Spring Meeting Abstracts Due 04 March

The LSIC 2022 Spring Meeting will concentrate on understanding NASA's plans and technology investments relevant to building a sustained presence on the lunar surface. We invite abstracts from the community 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. Abstracts are limited to 1 page in length, and should clearly describe the technology or project aim, relevant methodologies, and key findings or recommendations. Abstracts will be reviewed by the technical organizing committee and, if accepted, may be selected for presentation as a poster or a poster plus a lightning talk. Additional information and the submission portal are available here: <https://lsic.jhuapl.edu/Events/Agenda/index.php?id=200>

Modular Open Systems Approach (MOSA) Working Group Update

The LSIC Modular Open Systems Approach (MOSA) working group is underway to discuss how MOSAs can be used for lunar exploration. Building on prior LSIC community MOSA telecons, the team has documented the community's feedback on what technologies could benefit from MOSAs here on the LSIC Confluence: <https://lsic-wiki.jhuapl.edu/x/4YAxAg>. This page also lists the points of contact for our group. Our next step is to determine critical interfaces to standardize and identify what standards already exist that we can adopt or leverage. Additionally, we are collecting what MOSA-like activities and programs already exist in the community. If you are interested in joining the MOSA working group please sign-up here: <https://forms.gle/RQ816yqYLL1BvRUF8> to get the latest updates and information on upcoming LSIC MOSA events.

Note: If you don't have access to the LSIC Confluence, please email Andrea Harman (ams573@alumni.psu.edu) to get signed up.

Focus Group Updates

Dust Mitigation

The Dust Mitigation (DM) Focus Group held its monthly focus group meeting on February 10th. Following up on January's topic of "passive dust mitigation", February's topic focused "active dust mitigation". The meeting featured presentations by Dr. Kristen John from NASA STMD, who provided an update on "DuSTI Outbrief: Dust Mitigation Characterization of Coatings and Pliable Cleaners", and Dr. Christopher Wohl from NASA Langley Research Center on "Updates from the LO-DuSST Team." The Lunar Occupancy-Dust Surface Separation Technologies (LO-DuSST) team is developing technologies for coupled passive and active methods for reducing lunar dust adherence to solar arrays, confined systems, drive shafts, and ISRU equipment. These presentations initiated great discussion on gaps and needs for passive and active dust mitigation solutions. In addition to the featured presentations, we also heard from James Mastandrea, Surface Power Focus Group staff member, on the newly established LSIC-wide Modular Open Systems Approach (MOSA) Working Group. The MOSA WG will document community feedback on recommended lunar MOSA activities.

Our next focus group meeting will be held on Thursday, March 17th at 12:00 pm EST.

Excavation & Construction

The highlight of this month was the E&C – ISRU joint metal workshop held on 23 February. It was a great success with over 400 registrants bringing together NASA as well as the supply and demand sides of in-situ derived metals for lunar construction. There was an open and frank discussion between the different sides, not just on metals, but also on lunar development strategy and sustainability. The idea of a public-private initiative to develop a lunar proving ground to rapidly test bold concepts was one of many that came out of this meeting. In the coming weeks we will prepare a report summarizing the findings of this workshop. A follow-up workshop continuing this discussion was also recommended, which is under consideration.

Extreme Access

The Extreme Access Focus Group is continuing planning for responses to our annual goal and our joint workshop with the Extreme Environments focus area in early summer. In particular, this month's PNT subgroup focused conversations on technology needs for exploring deep PSRs, and comms and mobility continued their ongoing discussions of technology needs and roadmapping ideas for exploration. We also introduced the cross-focus-group MOSA activities spinning up throughout LSIC. The main EA telecon included a Technology Spotlight from Alexandria Terry (National Geospatial Intelligence Agency) on the lunar reference frame for navigational safety. If you missed it, the presentation is available in the meeting recording on Confluence. Next month, we will have an update on the activities from the Communications subgroup and a Technology Spotlight from Brad Buckles (NASA) about RASSOR and ROS. We look forward to seeing you there!

Extreme Environments

In February, the Extreme Environments (EE) Focus Group had a great presentation on Illumination Conditions at the Lunar Poles including describing tools being developed at APL given by Ben Bussey and Angela Stickle. Our March monthly meeting will be held one week off our regular schedule (on March 15) to be mindful of conferences relevant to the community. This March "Cross Talk" discussion will explore instances where regolith, dust, and space weather meet. While our Extreme Environments subgroups have specific concerns relevant to their subject matter, there are numerous hazards to keep in mind that bridge them together. This will be a special 1.5-hour discussion. Also, planning is underway for our EE/EA workshop this summer so keep an eye out for details. As always, if community members have ideas for what they would like to see or discuss, please reach out to any member of EE leadership.

ISRU

The ISRU focus group held its first monthly meeting of the year on 19 January, with presentations centered around water ice prospecting in PSRs and refinement of extracted water ice. Clive Neal of Notre Dame introduced a pair of Lunar Surface Science Workshops on defining and implementing an International Lunar Resource Prospecting Campaign. Ann Parsons of NASA GSFC presented on the BECA active source neutron water ice prospecting instrument, and Curtis Purrington of the Colorado School of Mines described the rotary drum concept for the extraction of water from icy regolith. Subsequently, the water ice prospecting subgroup has begun working on developing a measurement traceability matrix as an initial step in defining a lunar water ice prospecting campaign, led by Laszlo

Kestay, USGS and Micheal Poston, GIT and Adeel Khan. The ISRU February meeting focused on in-space servicing and maintenance by design for ISRU technologies, with presentations on MOSA by Matt Deminico, of NASA GRC

and on In-Space Services as applied to lunar technologies, by Jill McGuire of NASA GSFC. On February 23, the ISRU focus group also co-hosted with the Excavation & Construction focus group the Regolith to Rebar workshop to bring the ‘supply side’ industries specializing in deriving metal products from the regolith together with ‘demand side’ industries interested in construction on the Moon using these products.

Surface Power

In February, the Modularity Opens Systems Approach (MOSA) working group expanded beyond Surface Power to combine with other efforts across the LSIC. While the Surface Power Focus Group will continue to be involved, this “spin-off” working group will focus on interoperability and modularity across the broader LSIC. Surface Power staff member James Mastandrea will be coordinating the effort (<https://lsic-wiki.jhuapl.edu/x/4YAxAg>) and to join the MOSA working group sign up here: <https://forms.gle/RQ816yqYLL1BvRUF8>.

With the MOSA working group moved out of Surface Power, our monthly telecon was focused inward, gathering topics of interest to the community over the next year. Six subgroup sessions were held to collect potential topics, communicate community activities, and further assess potential hurdles in the path to sustainable surface power.

Feature Article

Power User Survey

By: Jodi Berdis, LSIC Surface Power Focus Group staff member

NASA intends to revisit the Moon in the mid-2020s and establish sustainable lunar exploration with commercial and international partners by the 2030s. As part of this initiative, technology development and demonstrations must focus on establishing sustainable power throughout lunar illumination cycles. A comprehensive understanding of the power needs of various lunar technologies is therefore required in order to ensure the necessary power technologies are developed to support lunar surface activities.

In order to assess the current state of knowledge regarding the power needs of lunar technologies in development, the LSIC Surface Power Focus Group conducted a Power User Survey to capture the power needs of the technologies and systems that will be used for lunar exploration and sustained human presence on the Moon. Results from this survey can also inform the other LSIC Focus Groups and allow them to reassess their own power estimates, which will lend to more cohesion and uniformity across LSIC. For NASA's Science Technology Mission Directorate (STMD), understanding the state of the community's needs will enable more appropriate gap/closure plans, targeted solicitations, and technology investments.

The Power User Survey requested various usage and power needs from technology developers, including voltage requirements, power delivery methods, operations during lunar night, and thermal energy requirements. We found that several technologies reported large power demands (10's of kW to MW) to accomplish their primary objectives. In one year of continuous work, technology developers reported that 50,000 tons of regolith could be excavated using 430 kW, 100 tons of O₂ could be produced with 1 MW, and 100 tons of H₂O could be produced with 100 kW. During the lunar night, ~65% of responders intend to be fully operational. This may become challenging, as power availability will decrease substantially during periods of darkness. Technology developers may need to reassess the amount of power they will require during lunar night, and should consider viable options for minimizing their power demands during hibernation. Higher fidelity information on power needs throughout the lunar night are needed before a full assessment can be performed.

In order to fulfill lunar mission requirements, the Surface Power community will need estimates of the technology requirements on the lunar surface, i.e., how much O₂ and H₂O will need to be produced, and how much roadway and construction must be completed. Power technologies must be developed to be scalable in order to meet anticipated mid-term needs. Given the power scales reported, reasonable primary increments to consider are 10 kW, 50 kW, and 200 kW, with the requirement of distribution to be resolved.

Based on the results from this Power User Survey, the preliminary recommendations to NASA STMD include:

- Appropriate scales of power will enable lunar activities in all arenas. Reasonable primary increments to consider are 10 kW, 50 kW, and 200 kW.
- Technology developers may need to reassess their minimum power requirements, especially during periods of darkness, and should thoroughly consider viable options such as hibernation.

- Rather than simply trying to meet the power demands as stated, STMD should consider examining system-wide solutions for austere operations during periods of darkness. This can inform, for example, secondary energy storage and non-solar generation (e.g. fission surface power) necessary for sustained presence.
- High-level requirements are needed in order to assess if the yearly outputs of technologies in development are sufficient for mission success. STMD should communicate status updates of roadmaps as transparently and rapidly as possible to enable the community to target appropriate scales for development. For instance, landing site selection would enable comprehensive integration studies of many of the technologies reported here.

The Power User Survey will remain open indefinitely, in order to continue capturing the power needs of the LSIC community. Power users are encouraged to update the information for a technology that they have previously reported, and/or add a new technology using this Google Form: <https://forms.gle/dcvvgpNTEUjH1UAr5>. Read the full Power User Survey Report on Confluence: <https://lsic-wiki.jhuapl.edu/x/ZIzL>.

Member Spotlight

Astrobotic

In 2007, Astrobotic was founded in pursuit of the Google Lunar X Prize. While no-one won the competition, the company gained momentum from the interest generated from it. Creating a standalone business from that beginning meant pursuing the ability to get to the Moon while concurrently convincing the world to buy commercial transportation to the lunar surface, building the market along with the service. The past three years especially have seen tremendous progress toward their goals, with upwards of millions in NASA contracts staked on Astrobotic's capability to fly to and land on the lunar surface. Their first mission, Peregrine Mission One will fly later this year, achieving the first concrete step along Astrobotic's path to make the Moon accessible to the world.

The company's overall goal has always been to open space up for everyone, starting with the Moon. The core business driving Astrobotic's growth has been a lunar delivery service, where payloads (or cargo) are integrated with a lander which is flown to the Moon, where Astrobotic would continue to provide power and communications for customers. The Peregrine lunar lander will have 16 payloads, 10 from NASA and 6 from a variety of other clients. "We are so excited to be right on the precipice of the big dream we've been pushing for the past 15 years," shared John Thornton, Astrobotic's CEO. He originally joined the company as an engineer, working up the ladder to become CEO eight years ago.

167 employees currently make up the company's workforce, with alumni from almost every big space company in the U.S. "Astrobotic hasn't flown in space yet," explained Thornton, "but Astrobotic's people have flown many, many missions before." Mixing their experience with the rest of the workforce's raw robotics talent has made their world-class space robotics program possible.

Astrobotic has three core service offerings. The first, and what they're known for most, is lunar delivery – getting payloads up to the Moon for \$1.2 million per kilogram. This is a true end-to-end delivery service, where Astrobotic secures a launch, builds the lander to deliver the payloads, provides power and communication, and operates the mission. Their Peregrine lander is scheduled to touch down on the Moon this year with a manifest made up of scientific instruments, technologies, and mementos from six different countries, representing dozens of science teams and hundreds of individuals. Mobility services are their second offering, where payloads are deployed and driven across the lunar surface. Astrobotic's mobility platforms are Cuberover®, which can deliver cubesat-scale service across the surface, and the larger Polaris, which can house a drill platform similar to VIPER. Space technology capabilities are their third area of concentration with offerings ranging from terrain relative navigation (TRN) to simulation for landing and exploration to mission planning software. That final area is where Astrobotic branches out to other markets outside of the Moon to continue seeking new Earth and space-bound applications for their technologies.

Looking ahead, this will be a big year for Astrobotic with their Peregrine lander planning to touch down at Lacus Mortis, a region near the pole of the Moon. Depending upon how the timing works out, it could be the first commercial landing on the lunar surface, and the first time the US has returned in the nearly 50 years since Apollo. "But what's most exciting," shared Thornton, "is that this is just the beginning – the first of many missions to the Moon." NASA currently has several lunar missions planned, with Astrobotic involved in two. Astrobotic is planning for a future with regular lunar access, anticipating missions going once or twice per year, in an incredible opening of opportunities to

push the boundaries of science and exploration. Astrobotic sees the Moon as a training and proving ground for ‘living off the land’ of another planetary body in anticipation of future missions to other planets and bodies in the solar system.

Astrobotic has been encouraged by NASA’s efforts to build a pipeline of lunar science payloads, with the promise of numerous commercial missions to the Moon. The recent PRISM call is especially exciting to them as an example of how scientists have a much greater chance of getting their experiments on the lunar surface. “Typically, a scientist might get one shot in their entire career, but with NASA planning for two missions a year, we’ll see routine, regular access as we never have before,” stated Thornton. In planning for this new future, Astrobotic also sees LSIC helping by providing a forum for the community to come together and talk about the realities of advancing science and exploration, using the first resources on the Moon, and what could be unlocked in terms of potential for other sites in space.

That expectation of future success doesn’t discount the very real challenges faced by Astrobotic and other organizations looking to reach the Moon. “Only three nations have landed on the Moon, and they’ve all been superpowers. Astrobotic is planning to do what only global superpowers have done before,” explained Thornton. Building a firm, fixed-price capability to deliver payloads to the lunar surface instead of past government-funded models for space exploration is a trial Astrobotic continues to work through. They’re walking the line between capability and affordability, working to bring value to their customers while expanding the horizon of space access. The COVID-19 pandemic has been another source of difficulties, affecting the company’s suppliers and staff, miring up the supply chain as it has for industries and consumers globally. Despite that, they’re still confident about flying this year – and the promise of future success in opening access to the Moon.

NASA News

NASA Opens Second Phase of \$5 Million Lunar Power Prize Competition

02/23/2022 \ NASA News

https://www.nasa.gov/directorates/spacetech/centennial_challenges/second-phase-open-of-5-million-lunar-power-prize-competition.html

NASA successfully retests Artemis 1 moon rocket core stage engines after fault

02/21/2022 \ Space.com

<https://www.space.com/artemis-i-moon-rocket-engine-tested>

NASA Selects Three US Universities to Develop Lunar Infrastructure Tech

02/18/2022 \ NASA HQ

https://www.nasa.gov/directorates/spacetech/strg/lustr/NASA_Selects_Three_US_Universities_to_Develop_Lunar_Infrastructure_Tech

Program Manager Applies Leadership, Vision to Build SLS Moon Rocket

02/18/2022 \ NASA News

<https://www.nasa.gov/exploration/systems/sls/profiles/Honeycutt.html>

NASA opens Nighttime Precision Landing Challenge to help future moon missions

02/17/2022 \ Space.com

<https://www.space.com/nasa-nighttime-precision-landing-challenge>

South Dakota tribal college part of NASA plan to build housing for use on the moon and Mars

02/11/2022 \ South Dakota News Watch

<https://www.sdnewswatch.org/stories/south-dakota-tribal-college-part-of-nasa-plan-to-build-housing-for-use-on-moon-and-mars/>

KSAT to support NASA LunIR mission

02/09/2022 \ SpaceNews

<https://spacenews.com/ksat-lunir-ground-network/>

Hermes will be NASA's mini-weather station for tracking solar activity

02/06/2022 \ Popular Science

<https://www.popsci.com/space/nasa-hermes-mission/>

Fired Up: Engines and Motors Put Artemis Mission in Motion

02/03/2022 \ NASA News

<https://www.nasa.gov/exploration/systems/sls/fired-up-engines-and-motors-put-artemis-mission-in-motion.html>

Funding Opportunities

Tech Development

- Early Career Faculty 2022
<https://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7bBF27BB84-C93F-9D37-4FFE-8790D23AD076%7d&path=&method=init>
 Notices of Intent due: March 2, 2022; Proposals due: March 31, 2022
- NASA Small Business Innovation Research (SBIR) / Small Business Technology Transfer (STTR) 2022 Phase I Solicitation
<https://sbir.nasa.gov/solicitations>
 Proposals due: 09 March 2022
- Announcement for Partnership Proposals (AFPP) to Advance Tipping Point Technologies
<https://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7b9987D88F-0A12-5203-FC25-423773FAF134%7d&path=&method=init>
 Mini proposals due: March 31, 2022; Final proposals due: July 28, 2022
- Space Technology Announcement of Collaboration Opportunity (ACO)
<https://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7bA9C79925-6F41-69E8-4BE0-5325903D777C%7d&path=&method=init>
 Mini proposals due: March 31, 2022; Final proposals due: July 28, 2022
- NASA TechLeap Prize: Nighttime Precision Landing Challenge No. 1
<https://www.precisionlanding1.nasatechleap.org/>
 Registration due: May 5, 2022 at 5 p.m. PDT; Applications due: May 19, 2022 at 5 p.m. PDT
- Watts on the Moon Challenge, Phase 2
https://www.nasa.gov/directorates/spacetech/centennial_challenges/watts-on-the-moon/index.html
 Registration due: June 15, 2022 at 5 p.m. EDT

Student Tech Development

Moon to Mars eXploration Systems and Habitation (M2M X-Hab) 2023 Academic Innovation Challenge

On February 18, 2022, the National Space Grant Foundation released a solicitation calling for proposals on behalf of NASA to develop space capabilities and technologies. The Moon to Mars eXploration Systems and Habitation (M2M X-Hab) 2023 Academic Innovation Challenge is a university-level challenge designed to develop strategic partnerships and collaborations with universities. It has been organized to help bridge strategic knowledge gaps and increase knowledge in capabilities and technology risk reduction related to NASA's vision and missions. The competition is intended to link with senior- and graduate-level design curricula that emphasize hands-on design, research, development, and manufacturing of functional prototypical subsystems that enable functionality for space habitats and deep space exploration missions. NASA will directly benefit

from the challenge by sponsoring the development of innovative concepts and technologies from universities, which will result in novel ideas and solutions that could be applied to exploration. Details and the full solicitation may be found at the National Space Grant Foundation Announcement page at <https://spacegrant.org/programs/xhab>.

- **Over the Dusty Moon Challenge (Colorado School of Mines & Lockheed Martin)**
<https://www.overthedustymoon.com/>

June 2022: In-person challenge

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