



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

I'd like to thank everyone who participated in the Fall Meeting last month! We had over 400 attendees, with 90 in person and the rest online over the course of the two days. I am grateful for everyone's patience as we tried out the hybrid format; we will take all of our lessons learned and feed them forward to future meetings to make sure that we can effectively include as many in the community as possible. If you haven't yet had a chance, we welcome any feedback about the event [here](#). For those who were not able to attend, or who would like to review any of the presentations, they are available online [here](#) (you can access all past events' slides through the 'Past Events' link towards the top right on the events page). Finally, we know there were more questions posted into sli.do than we had time to cover with the various speakers and panelists. Those outstanding inquiries have been captured, and we are working to get answers for you. We will send out a notice when they are available on Confluence.

While we have a more technical summary of the meeting later in the newsletter, I wanted to share some of the more consortium-related findings that I took home from the meeting. It was clear to me that one way we could do a lot of good for the next generation is to help make connections where students can gain hands-on experience in the industry, whether it is through projects at regional laboratories (NASA or others), internships at companies, or even partnerships between different academic institutions. A major goal for us over the next few months is to work directly with our student and academic members to develop our mentoring portal and to understand where LSIC can connect community members (not just students) with opportunities. At a breakout session during the Spring meeting, one of our consortium members referenced the parable of the blind men touching an elephant, where each feels a very different part and tries to describe it, but each has a very different idea of what it might look like because they only know their piece. Similarly, consortium members from industry, academia, and government all see different issues related to developing a sustained presence on the Lunar surface. Unless we can speak and understand one another's languages, we will never have the full picture, and we will run into roadblocks. After listening to some of the panelists at the Fall Meeting, it's clear that as we build the workforce for the next 10-20 years, we have even more potential barriers in language and understanding that we need to be aware of, as we will need engineers, scientists, architects, economists, lawyers, and more to work together. While LSIC can't take all of this on, we have many great connections to other groups (many with representation on the current Executive Committee) who we can and will work with to educate our community and move some of these issues forward.



Rachel Klima

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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

CIRCUIT Intern Introduction: Malcolm Gilmore

My name is Malcolm Gilmore and I am a part of the JHU APL CIRCUIT program. I study computer engineering at Morgan State University, an HBCU located in Baltimore MD.



Background

Growing up I'd always been the kid who looked forward to what the future had to bring. I was always obsessed with scifi culture. I'd fantasize about living in a world where technology created a higher quality of life for everyone. When I was 12, the movie Iron Man was released and I instantly fell in love with the idea of creating machines that made things that seemed impossible possible and saved lives. Up until that point I couldn't really put a finger on who I wanted to become. For a long time I thought I wanted to be an astrophysicist, but as someone who is hands-on, I found it difficult to study sciences in which most everything was conceptual. I wanted to improve life for people in the most direct way possible, and so I decided that I would be an inventor, and I'd study computer/electrical engineering.

Why am I here?

When I was 17 years old a documentary about one of my favorite video games was released in preparation for an upcoming sequel (Deus Ex Mankind Divided). There was a special where they interviewed a few scientists working at Johns Hopkins APL in Baltimore. It was about a prosthetic arm that had sensors that had been created to interface with the brain and give the patient feeling in the prosthetic arm. I thought it was the most incredible technology I had ever seen, and I told myself that I wanted to be an inventor capable of building something just as beautifully designed and implemented.

At the time I was experimenting with transhumanism, the idea that technology works as an extension of humanity. We may die, but we extend ourselves into our creations. I came to the conclusion that although dying is an unfortunate inevitability on our journey as human beings, perhaps we can extend beyond being human into something greater. Perhaps our consciousness can be thought of as a pattern, like code, and is substrate independent and capable of being recreated as software. Software from wetware, so to speak.

From these ideas I believed that the APL could be somewhere that I could learn and take a step closer to becoming the inventor that I'd dreamed that I'd become.

Focus Group Updates

Dust Mitigation

The Dust Mitigation (DM) Focus Group continues to work on revamping our Confluence page to better facilitate collaborations, discussions, and access to resources, including adding additional resource materials, and is in the processing of kick-starting our subgroups to engage the community in different areas of interest. We are planning to formalize the subgroups soon, so be sure to fill out [this survey](#) if you are interested in joining and have not already done so. On November 18th, we held our monthly focus group meeting, where the topic was focused on plume surface interactions. We heard a presentation on the topic from Dr. Wesley Chambers (NASA MSFC), titled “Plume Surface Interaction: Preliminary Observations from a Physics Focused Ground Test.” The discussion highlighted the need for additional in situ measurements, and opportunity that future CLPS missions provide for acquiring additional in situ data from a variety of locations and surface environments on the Moon. Our next monthly meeting on Thursday, December 16th at 12:00 PM Eastern will be a special extended meeting, where we will hear from the finalists from NASA’s [2021 BIG Idea Challenge: Dust Mitigation Technologies for Lunar Applications](#).

Excavation & Construction

The E&C focus group held a successful workshop last month on maintenance and repair for long-term stays on the lunar surface with over 60 participants in four breakout rooms. In November, we processed data generated from this workshop and we will present the preliminary findings in our November monthly meeting on December 1. In addition, this meeting will also feature a talk on ground stabilization and site surveying technology by experts from AECOM. E&C team members also participated in the LSIC fall meeting, moderating two breakout sessions on autonomy and robotics for infrastructure development and maintenance. Relevant data from these sessions is also being processed. Following a Google survey sent out last month, we started working on forming sub-groups to streamline conversation. The LSIC E&C website also underwent major changes in November.

Extreme Access

October was a big month for the Extreme Access focus group, with the LSIC Fall Meeting and the discussions surrounding robotics and autonomous systems on the lunar surface. Our October telecon also had a Technology Spotlight from Isaac Witte, a researcher at JHU APL, discussing Terrain Relative Navigation and optical navigation algorithms for the Dragonfly Missions and applications to low-altitude navigation at the Moon. The PNT and Comms subgroups were also busy collecting feedback on NASA’s proposed Lunar Interoperability Standards for PNT and Comms. Thank you to all who participated in discussions and provided input! The feedback was collected and submitted to NASA early in November. We will continue the discussion of communications at the Moon in December, with a technology spotlight from NASA’s Cathy Sham about spectrum management at the Moon. The second technology spotlight for December will feature Dr. Elliot Hawkes talking about their work on highly mobile self-anchoring robots. Join us for what is sure to be an interesting discussion!

Extreme Environments

The Extreme Environments (EE) Focus Group monthly meeting highlighted the work that our subgroups have been doing the last few months. The tutorials, featured member presentations, technical reviews, etc. that our subgroups have done are sparking new and exciting conversations that progress us to our goals. In December, we will have a brief overview of the fall meeting. In the next few months, we plan to collaborate with the other focus groups and provide environmental input on their technologies in work. 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 month of November was an intense period for meetings. The month began with participation in the LSIC Fall Meeting over November 3 - 4, where the ISRU FG facilitators moderated community discussions on robotic and autonomy needed for ISRU on the lunar surface. Over the following weeks, there were several presentations by members of the ISRU Focus Group at the ASCEND meeting, including one led by Michael Nord on demand and supply of ISRU propellants on the surface of the Moon. Additionally, LSIC FGAPL staff attended the Cis-Lunar Security conference at APL to provide input on the current state and future potential of lunar ISRU for national security applications. Several members also attended the Lunar Surface Science Workshop on November 18, during which considerations for landing site selections, including ISRU, were discussed. Finally, the ISRU Monthly telecom rounded out the month with its meeting delayed to November 24th due to the conferences and workshops. We had a presentation on MMOST (Moon to Mars Oxygen and Steel Technology) from Mark Berggren, Pioneer Astronautics and discussed take-aways from the months' several meetings.

Surface Power

Although themed on autonomy, the LSIC fall meeting was an exciting event for the surface power focus group. Keynote speaker Jim Reuter emphasized the importance of Surface Power in achieving the envisioned future of the lunar campaign, highlight the ongoing VSAT development and announcing that the [Fission Surface Power for development with industry partners](#) would be 40 kW and mobile - excellent technical challenges that will be enabling for the lunar surface and beyond. Due to the Thanksgiving Holiday, November's telecon is rescheduled to 3:00 ET on Dec. 7th, as a [joint telecon with Extreme Environments groups on radiation-hardened power electronics](#).

Feature Article

LSIC Fall Meeting Overview

The Lunar Surface Innovation Consortium (LSIC) 2021 Fall Meeting was held on November 3-4, 2021 at Bowie State University in Bowie, MD. The objective of this meeting was to provide a forum for NASA and the space technology community to discuss technology development for establishing a sustained presence on the lunar surface, focusing in particular on investments, needs, and concerns associated with autonomy and robotics. Attendance included 416 people representing over 125 institutions that met over the course of two days. Over one third (39%) of those who registered for the meeting had not previously attended an LSIC event. The meeting was run in a hybrid format, with questions being taken only via a digital tool to try to provide a more equitable experience for online attendees.

Bowie State University, founded in 1865, is the first Historically Black College and University (HBCU) established in Maryland. The Fall Meeting, sponsored through a partnership with SAIC, provided an opportunity to share the work that Bowie and SAIC have done to involve students in space research, and also introduce some of the opportunities in the space industry to the students at Bowie State. Presentations from Bowie State and SAIC highlighted how industry can work with academia to foster opportunities in the growing space sector.

The meeting featured an update on the Space Technology Mission Directorate by Jim Reuter, NASA Associate Administrator for Space Technology, as well as technical presentations on Trustworthy AI and Autonomy, NASA Autonomous Systems & Robotics: Roadmap and Investments, and a discussion about an effort kicking off to understand the supply and demand issues relating to technologies needed to survive the lunar night. Panel discussions focused both on community building and technical issues related to robotics and autonomy. On the first day, a venture capitalist panel shared their experience in investing in space or related technology, including their considerations when evaluating companies to invest in. A second panel included members from government, industry, and academia to discuss efforts to foster innovation across sectors. Panels on the second day focused on autonomy and robotics, with the first describing flight demonstrations that are in development, and the second discussing robotics and autonomy in the context of the bigger picture of establishing lunar infrastructure. Videos of the event can be accessed at <https://lsic.jhuapl.edu/Events/Agenda/index.php?id=148>.



Jim Reuter, NASA Associate Administrator, speaks at Day 1 of the LSIC Fall Meeting held at Bowie State University. (Image credit: Design By Valentine)



Group photo of Day 2 attendees of the LSIC Fall Meeting (Image credit: Design By Valentine)

Breakout discussions centered on evaluating the autonomy and robotics-related concerns related to the scenario presented in NASA’s Break the Ice Challenge (see the RFI later in the newsletter for an opportunity to provide feedback for the second stage of that challenge!), asking the question: What robotic or autonomy capabilities are critical to establish, operate, and maintain the infrastructure assumed in that challenge? Three in-person groups and four online groups discussed the issues separately, but most had two high-level findings in common:

- Some of the most critical technology gaps for autonomous operations on a Lunar base are free space optical communications and radiation hardened computer hardware. *Government needs to prioritize investment in communications and position, navigation, and timing (PNT) as well as ensuring standards for these are developed.*
- An understanding of the resources available and their extractability is critical, and currently lacking. *A resource prospecting campaign for water ice reduces risk and focuses the direction of technology development to build towards a sustained presence on the Moon.*



Mark Fuerst, Program Manager Director for SAIC, and Dr. Anika Bissahoyo, Assistant Vice President for Research at Bowie State University, participate in a feature of host organization Bowie State. (Image credit: Design By Valentine)



Attendees participate in the poster session. (Image credit: Design By Valentine)



Louisiana State University student Ilerioluwa Giwa traveled to the Fall Meeting to present his research on 3-D printing using lunar regolith and recycled materials. (Image credit: Design By Valentine)

Member Spotlight

Paragon Space Development Corporation

Paragon Space Development Corporation was started in 1993 by a five-person team that included two members of the Biosphere 2 experiment. Grant Anderson, Paragon's current President and CEO, was one of those original founders and was an engineer at Lockheed Martin working on the International Space Station program. Paragon's initial work was primarily fueled by government investments such as NASA's SBIR (Small Business Innovation Research) program, and today, the company has graduated to formal contracts for work with NASA's human spaceflight initiatives with major primes as well as defense and commercial contracts. Their core focus area is life support in extreme environments, which includes air constituent control, water processing, thermal control, and in-situ resource utilization (ISRU). Lunar dust mitigation has also been growing in importance in recent years and will further enable Paragon's technologies to be used in challenging environments such as the surface of the Moon. The company boasts more than 200 employees, with headquarters in Tucson, AZ and satellite offices in Denver, CO and Houston, TX.

The past ten years have seen increasing opportunities for commercial applications of their products. Much of the work driving that growth has been in the areas of commercial space stations and life support for exploration vehicles. Most recent examples include contracts for the Environmental Control & Life Support Systems (ECLSS) for Northrop Grumman's HALO program and Dynetics' Human Landing System. A particularly impressive example of how their work has grown and developed was the StratEx Record-breaking Space Jump in 2014, when Alan Eustace (a former Google Executive) made a space jump at an exit altitude of 135,890 feet. Paragon's StratEx team led this feat which set three world records and was a finalist for the 2014 Collier Trophy from the US National Aeronautic Association. The StratEx self-contained suit and recovery system can be seen at the Smithsonian National Air and Space Museum's Steven F. Udvar-Hazy Center. Paragon has found additional success in spinning off World View Enterprises, whose work supports increasing access to and utilization of the stratosphere for scientific, commercial, and economic purposes.

A more traditional example of Paragon's work in the ISRU realm, is their ICICLE project (ISRU Collector of Ice in a Cold Lunar Environment), currently supported by a NASA SBIR Phase 2 award. Water mined from extraterrestrial sources, such as lunar craters, contains impurities that are both difficult to separate from water and detrimental to many possible downstream processes and users of the water. The ICICLE component is a cold trap that utilizes a regulated freeze distillation process along with optimized internal geometry for high water collection efficiency and low contaminant retention from upstream water extraction sources. ICICLE provides one-step collection and coarse purification of extracted water in environments including the Moon, Mars, and asteroids.

Another effort of Paragon's is IHOP (ISRU-derived water purification and Hydrogen Oxygen Production), their flagship ISRU system. It combines the critical ISRU functions of water purification and electrolysis into an integrated system optimized for lunar water processing as well as Mars. IHOP receives water from mixed ices found in Permanently Shadowed Regions (PSRs) on the lunar poles, purifies the water of co-located toxic and corrosive volatile contaminants, and generates hydrogen and oxygen from the electrolysis of that water. The product hydrogen and oxygen can be used as propellant for lunar transportation vehicles (ascent and landers), reusable cislunar transports, as well as human missions to Mars and beyond. Technologies that can make use of the IHOP consumable products include fuel cells, crew atmosphere revitalization, and crew potable

water. IHOP is another example of Paragon's NASA-funded work and is supported by a NextSTEP-2 ISRU Technology contract.

A fruitful partnership with Thin Red Line Aerospace (TRLA) has seen many successful collaborations, including a project called CELSIUS (Cryogenic Encapsulating Launch Shroud and Insulated Upper Stage) which insulates cryogenic propellant storage to reduce the amount of boiloff and keep it cold in the space environment. TRLA has also worked with Paragon on some of their deployable structures work, such as EPT (Ellipsoidal Propellant Tank) which deploys as a small package that expands for a large volume of propellant storage.

Paragon recognizes that a lot of what needs to be done for ISRU is related to ECLSS, which encompasses oxygen generation, humidity and temperature control, as well as water purification and recycling. For both ISRU and ECLSS, Paragon pursues the creation of closed loops for resource management and recuperation, just like some of the founders' original experience with Biosphere 2. With the Moon and Mars as current targets for exploration, the importance of stretching existing resources and attaining new sources can't be overstated, and Paragon's various products all work towards those goals. They've recognized NASA's focus on ISRU over the past decade and have seen their own work, as well as that of other players in the industry, really start to bear fruit that will make the next steps into space exploration more feasible. They hope to see more NASA Commercial Lunar Payload Services (CLPS) calls for technology demonstration payloads in the future, as well as 'next-step' funding mechanisms to continue developing their suite of technologies to achieve NASA's goals for extended lunar missions and beyond.

Paragon Space Development Corporation website: <https://www.paragonsdc.com/>

NASA News

NASA's Aviation Tech to Roll Out to Airports, Save Time for Passengers

Nov 24, 2021 (RELEASE 21-162): NASA Administrator Bill Nelson visited Orlando International Airport in Florida Wednesday and met with aviation leaders to discuss implementing aircraft flight scheduling technology developed by the agency that will soon improve dependability for passengers – which is especially important during peak travel times like the Thanksgiving holiday. Click here to read more: <https://www.nasa.gov/press-release/nasa-s-aviation-tech-to-roll-out-to-airports-save-time-for-passengers>

NASA Selects Intuitive Machines for New Lunar Science Delivery

Nov 17, 2021 (RELEASE 21-157): NASA has awarded Intuitive Machines of Houston a contract to deliver research, including science investigations and a technology demonstration, to the Moon in 2024. The commercial delivery is part of NASA's Commercial Lunar Payload Services (CLPS) initiative and the Artemis program. Click here to read more: <https://www.nasa.gov/press-release/nasa-selects-intuitive-machines-for-new-lunar-science-delivery>

NASA Awards Challenge Prizes to Startup Companies

Nov 12, 2021 (RELEASE 21-150): NASA has awarded \$90,000 each to seven entrepreneurial startup companies under its Entrepreneur's Challenge program. The awards will advance new technology concepts ranging from novel materials with properties not found in nature to innovative technologies that will enable small satellite (SmallSat) science missions. Click here to read more: <https://www.nasa.gov/press-release/nasa-awards-challenge-prizes-to-startup-companies>

NASA Outlines Challenges, Progress for Artemis Moon Missions

Nov 9, 2021 (RELEASE 21-151): In the first major Artemis update provided under the Biden-Harris Administration, NASA leadership discussed Tuesday the challenges and progress of America's lunar exploration plans and reiterated a long-term commitment to exploring the Moon and sending astronauts to Mars. The update follows a judge's recent decision to uphold NASA's selection of SpaceX to develop and demonstrate a modern human lunar lander for returning astronauts to the Moon for the first time in more than 50 years. NASA Administrator Bill Nelson spearheaded the conversation, laying out the path forward for early Artemis missions that will pave the way for lunar surface missions. Click here to read more: <https://www.nasa.gov/press-release/nasa-outlines-challenges-progress-for-artemis-moon-missions>

NASA Participates in UN Climate Change Conference

Nov 6, 2021 (RELEASE 21-148): NASA is participating in the 26th United Nations Climate Change Conference of the Parties (COP26) in Glasgow, Scotland, which began Oct. 31, and runs through Friday, Nov. 12. The COP26 summit brings parties together to accelerate action towards the goals of the Paris Agreement and the U.N. Framework Convention on Climate Change. Click here to read more: <https://www.nasa.gov/press-release/nasa-participates-in-un-climate-change-conference>

Funding Opportunities

Request for Information

NASA is seeking additional inputs to the Break the Ice Lunar Challenge rules and questions for Phase 2 of the Challenge, proposed to start in March 2022. The Challenge seeks to incentivize innovative approaches for excavating icy regolith and delivering acquired resources in extreme lunar environmental conditions. The Challenge also seeks to incentivize solutions for maximizing resource delivery while minimizing energy use and the mass of equipment delivered to the lunar surface.

Link to the RFI: <https://sam.gov/opp/3015959e2d0742fe9fa8ccb8bf2356e9/view>

Responses are due by Dec 20th 11:59 PM Eastern.

Tech Development

- NASA Innovative Advanced Concepts (NIAC) 2022 PHASE 2 Call for Proposals

<https://www.nasa.gov/content/apply-to-niac>

Phase 2 Due: December 12th, 2021

- NASA Human-Autonomy Teaming Task Battery Challenge

<https://www.nasa.gov/nasa-hattb>

Deadline: December 29, 2021

- 2022 Breakthrough, Innovative and Game-Changing (BIG) Idea Challenge: Extreme Terrain Mobility Challenge

<http://bigidea.nianet.org/competition-basics/>

Proposal and Video deadline: January 18, 2022

Student Tech Development

- Over the Dusty Moon Challenge (Colorado School of Mines & Lockheed Martin)

<https://www.overthedustymoon.com/>

Deadline for entries Dec 20, 2021: Notification to invitee teams for in-person challenge June, 2022:

In-person challenge

- Breakthrough, Innovative and Game-changing (BIG) Idea Challenge

<http://bigidea.nianet.org/>

Proposals are due Jan. 18, 2022

- Lunabotics Junior Contest

<https://www.nasa.gov/press-release/nasa-challenges-students-to-design-moon-digging-robots>

Entries due January 25, 2022

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