



# 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](https://lsic.jhuapl.edu).

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# Director's Update

As we move into 2022, I wanted to take a moment to thank everyone for all you have contributed to our community over the last year. I really enjoyed talking with many of you at the Spring and Fall Meetings, and appreciate everyone's patience as we tried our first hybrid meeting. On that note, if you attended the Fall Meeting at Bowie State either virtually or in person, please do share your feedback. The survey (<https://forms.gle/xhMySuu2jrLD6YPm6>) is relatively short, and we use all comments to feed forward into planning future events. We will probably retain an online component for all future semi-annual meetings, but this could range anywhere from the kickoff mode of strictly livestreaming the plenary sessions, to something more like our Fall meeting where we tried to provide more opportunities for online interactions for those who couldn't attend in person.

With well over 1500 participants receiving this newsletter now, this is also a good opportunity to reflect on some of the events we've held over the last year, which can all be viewed online on our website (accessible here [<https://lsic.jhuapl.edu/Events/archive.php>] or by choosing 'Events' at the top and then clicking 'view past events' on the right). This last year, we really got rolling with focus group workshops to dive deeper into specific technologies. The year kicked off with the multi-day dust mitigation workshop, followed by a workshop on lunar mapping for precision landing. The power group hosted a workshop on power beaming and also joined with extreme environments and dust mitigation to discuss vertical solar arrays. Excavation and construction discussed larger infrastructure elements and the roadmap for their development, and the power and extreme environments groups put together a joint meeting on radiation hardened electronics, prompted in part by questions raised during the Fall Meeting at Bowie State. Dialog from these workshops and other LSIC interactions between the community and NASA has helped shape funding opportunities, and even helped inform some of the NASA technology roadmaps.

In 2022, we will continue to tailor our events to be as responsive to community needs and technological questions as possible. This will likely mean more cross-group work, especially for the case of cross-cutting focus areas like extreme environments and dust mitigation. We will also try to keep developing our online resources, to make sure that those who want to stay apprised of activities but who cannot necessarily participate in real-time can still contribute.

Thank you all, again, and I wish everyone a wonderful new year!!



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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

## Focus Group Updates

### Dust Mitigation

The Dust Mitigation (DM) Focus Group wrapped up an exciting 2021 with a special extended monthly focus group meeting on December 16th, where we heard presentations from each of the finalist teams of NASA's nationwide [2021 BIG Idea Challenge: Dust Mitigation Technologies for Lunar Applications](#). The presenting teams included: Brown University with Rhode Island School of Design, California Institute of Technology, Colorado School of Mines with industry partners, Georgia Institute of Technology, Missouri University of Science & Technology, University of Central Florida with Morphotonics, and Washington State University. Over the course of a year, each team designed, built, and tested novel and innovative dust mitigation (or dust tolerant) technologies that could be used for future lunar applications. The focus group meeting was a great opportunity to learn about the new and innovative dust mitigation solutions, and meet the highly talented teams that developed them.

We thank everyone for being part of our LSIC Dust Mitigation Focus Group and helping make LSIC and our dust mitigation community strong, despite the continuing challenges associated with a global pandemic. We wish everyone a safe and happy New Year, and look much forward to an exciting 2022! Our next monthly meeting will be held on Thursday, January 20th at 12:00 PM Eastern.

### Excavation & Construction

The November monthly meeting, postponed due to Thanksgiving, was held on December 1. It featured an elaborate presentation on design considerations for Moon structures from AECOM experts who collectively have more than 60 years of real-world experience in infrastructure planning and development. This presentation is very informative and can be accessed at [https://lsic.jhuapl.edu/uploadedDocs/focus-files/1063-E&C%20Monthly%20Meeting%20-%202021%2011%20November\\_Presentation%20-%20AECOM.pdf](https://lsic.jhuapl.edu/uploadedDocs/focus-files/1063-E&C%20Monthly%20Meeting%20-%202021%2011%20November_Presentation%20-%20AECOM.pdf). AECOM is one of the premier infrastructure companies in the world and has had a long relationship with NASA. Their presentation reinforced the urgent need to rope in terrestrial infrastructure companies for lunar base development as early as possible. Both NASA and AECOM have expressed interest in collaborating and efforts are underway in this regard. We also finished the report of Maintenance and Repair workshop held in October. It will be posted on Confluence next month. The main findings of this workshop were also presented in the December 1 meeting and they can be accessed at [https://lsic.jhuapl.edu/uploadedDocs/focus-files/1061-E&C%20Monthly%20Meeting%20-%202021%2011%20November\\_Presentation.pdf](https://lsic.jhuapl.edu/uploadedDocs/focus-files/1061-E&C%20Monthly%20Meeting%20-%202021%2011%20November_Presentation.pdf). In January we plan to ramp up efforts for the joint ISRU-E&C workshop on supply and demand of in-situ derived metals to be held on Feb. 23.

### Extreme Access

The December telecon for Extreme Access was focused on community updates and technology spotlights. We had presentations from Cathy Sham (NASA) about spectrum management at the Moon, Dr. Elliot Hawkes (UCSB) about their work on highly mobile self-anchoring robots, and updates from Maneesh Verma about the activities happening in the mobility subgroup. If you missed it, check out the recordings and slides on the webpage and Confluence page. The January telecon

will be focused on discussions about SpaceROS. We will have two technology spotlights about SpaceROS development and integrating with the Core Flight System. Don't forget there is also an RFI about use cases for SpaceROS currently open, but responses are due in January. Information was sent out to the EA listserv last month.

#### Extreme Environments

The Extreme Environments (EE) Focus Group had a great December meeting along with the Surface Power Group that covered radiation hardened electronics for power applications. We named this fruitful conversation "Cross Talk" and look forward to more collaborations in the future with other LSIC groups. Our original plans for January were to cover the 2 hour meeting we would have in February. This will shift to the following months to ensure we have successful meeting with engaging topics. Our guest speaker for January will be Rich Oeftering covering his work in hibernation systems. 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 FG held its monthly telecom on Dec 17 with a focus on O2 extraction from regolith. Technology presentations were given by Lunar Resources, Sierra Space, and Terraxis on three different approaches for O2 extraction, that was followed up by discussion during the breakout sessions and we briefly discussed formulation of the workshop on metal extraction and utilization "From Regolith to Rebar" that will be held on Feb 23. The Facilities breakout group has completed its evaluations and has disbanded. It will be replaced by the Modularity/Interoperability subgroup.

#### Surface Power

For December, the Surface Power focus group held a joint-telecon with Extreme Environments on rad-hard electronics, with an emphasis on challenges to achieve high-voltages. We had 6 lightning talks and an hour-long open discussion, which can be found on the Surface Power "latest updates" page (<https://lsic.jhuapl.edu/Focus-Areas/index.php?fg=Surface-Power>). In the new year, we plan to continue discussions on modularity and standards, discuss the recent RFP on fission surface power (<https://sam.gov/opp/f2610d99cf174e959eede4b170d86e2d/view>), and reinforce our connections to other focus areas.

# Feature Article

## LSIC Starts Modular Open Systems Approach Discussion for Lunar Exploration

LSIC, through the Surface Power Focus Group (SPFG), has started to collect community feedback on implementing a Modular Open Systems Approach (MOSA) for lunar exploration. This process started in June 2021, with a SPFG themed telecon on standards and interoperability (see June 2021 Surface Power Telecon for meeting recording, available here under “Latest Updates”: <https://lsic.jhuapl.edu/Focus-Areas/index.php?fg=Surface-Power>). Mark Mazzara and Matt DeMinico led a presentation on MOSA and its importance and implementation within the Department of Defense (DoD). In fact, MOSA is now required for all DoD major acquisition programs after January 1, 2019 [1,2].

MOSA, as defined by the DoD, is “a technical and business strategy for designing an affordable and adaptable system” [1]. In effect, MOSA is the practice of enforcing programmatic and engineering design requirements that will ensure a sustainable and interoperable system. Importantly, MOSA does not indicate specific requirements or standards themselves, but rather it requires that critical interfaces are designed to be open and modular. For the DoD, this approach has enabled accelerated innovation, robust competition, and most critically, life-saving repairability and interoperability, while yielding significant cost savings or avoidance, schedule reduction, opportunities for technical upgrades, increased interoperability, including system of systems interoperability and mission integration, and other benefits during their sustainment phase [2].

After the June 2021 telecon, the LSIC SPFG held two MOSA-specific meetings to start gathering feedback from the LSIC community on MOSA (see Figure), with many who attended these meetings voicing their support of MOSA for lunar exploration activities. At these meetings, we conducted brainstorming sessions on which aspects of lunar exploration could be open and standardized. This initial list included robotics and landers, power, software, system architectures, hardware, connectors, communications, units of measurement, sensors, safety equipment, human-machine interfaces, repairability and maintenance, disposal, in-situ resources utilization (ISRU) equipment, construction equipment, human operations, and labelling. Additionally, we started to collect standards that already exist for some of these systems, such as the International Deep Space Interoperability Standards, which includes interoperability standards on eight discipline areas, including Power Standards [3].

Many other LSIC focus groups have also expressed interest of MOSA within their foci. To that end, additional working groups LSIC-wide are being established for 2022 with the goals of determining which systems would benefit from the approach, performing system decompositions to identify critical interfaces, and identifying which requirements need to be in place to ensure interoperability. These findings will be documented in a public report. More information about this working group and how to get involved will be sent to the focus groups in January 2022.

[1] <https://www.dsp.dla.mil/Programs/MOSA/>

[2] <https://www.law.cornell.edu/uscode/text/10/2446a>

[3] <https://www.internationaldeepspacestandards.com>

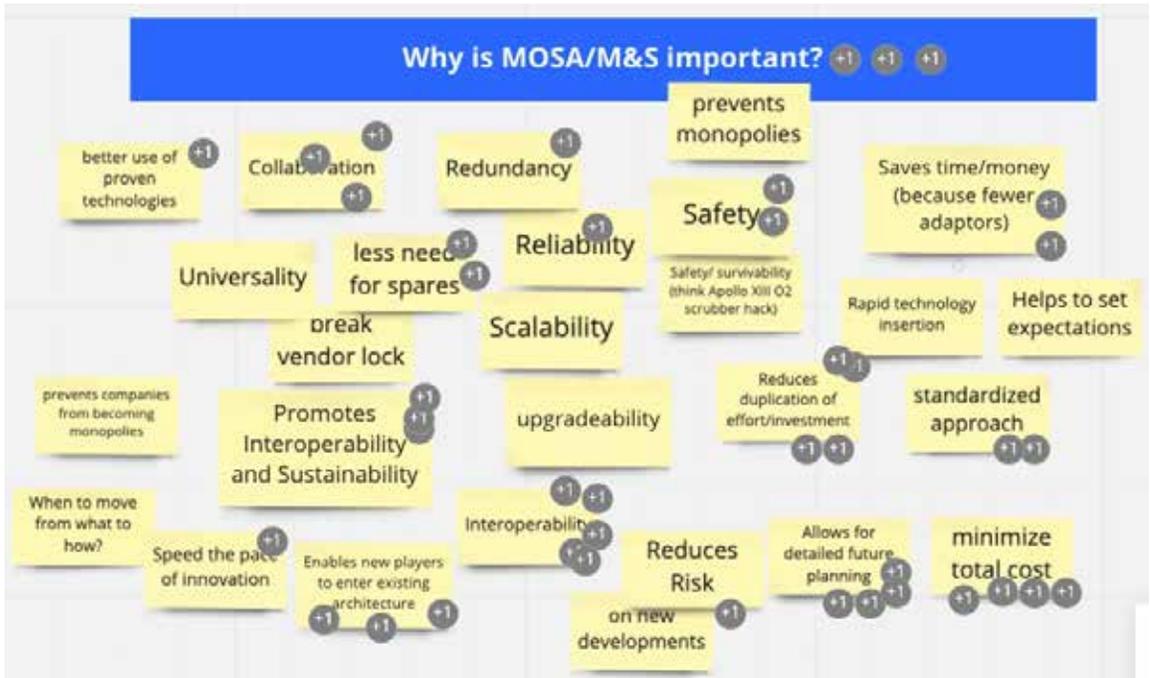


Figure 1. A subset of the Miro board that was used during the MOSA brainstorming sessions. This aspect of the Miro board demonstrates the community's input on why MOSA and Modularity & Standards are important.

# Member Spotlight

## Open Lunar Foundation

Open Lunar Foundation sprang from roots in Silicon Valley, growing from a community of people who were dedicated to bringing a technology, innovation, and values mindset to space exploration. In the beginning, individuals got together informally on a monthly basis, talking about how to practically bring a values-forward approach and set positive precedents for lunar exploration. Out of these get-togethers, the Open Lunar Foundation was born. The Foundation has continued to expand from those beginnings to keep their values and approaches in the wider conversations about lunar development globally.

The baseline long-term mission of the organization is to enable peaceful and cooperative human presence on the Moon for the benefit of all life. “It’s a fairly heady goal,” laughed Jessy Kate Schingler, Director of Policy and Governance, “on a practical level, we focus on overall public goods and infrastructure for the Moon, which will galvanize greater access and stakeholderhood for what’s happening there, as well as encourage more diversity and activity on the lunar surface.”

When asked to define the phrase ‘public good’ in this context, Schingler explained that it refers to resources that are available to and shared by all in a society. “In the lunar context,” she went on, “what’s interesting is that there’s no municipality to create power utilities or arrange trash collection. We’re going to have to figure it out on our own as a community.” Open Lunar believes that by treating shared services on the lunar surface as public goods, it’s positioning everyone to think about how that community of lunar stakeholders can govern their operations and, eventually, their economy.

The foundation has a small full-time team, and an impressive network of partners from academia and industry who collaborate on projects and research, provide mentorship, and act as thought ambassadors within their own organizations. The “town square” of Open Lunar is their Slack group, where participants chat, share news and resources, work on projects, and ultimately create insights and value together. Open Lunar also has a part-time fellowship program that brings together specialists on topics of lunar policy, architecture, engineering, and more from around the world. The fellowships create time and space for participants to make progress on provocative ideas towards a shared lunar future, maturing them to where they are ready to be presented in writing, talks, and papers as beacons of thought leadership for the space industry and beyond. All this and more is available through a library on their website here: <https://www.openlunar.org/our-work>

Another successful project driven by Open Lunar, this time in partnership with other convenors, is the Moon Dialogs, which is dedicated to exploring international governance and coordination mechanisms for the lunar surface. A premier output of the Moon Dialogs is their Research Salon series, held every Full Moon, which develops relevant scholarship on lunar issues, as well as providing a ‘community of practice’ for policymakers, researchers, and nations across many areas of expertise. You can find more information about the Moon Dialogs here: <https://www.moondialogs.org/>

While many in the lunar development community are familiar with tech demos, Open Lunar has put their own spin on the practice with an approach they call ‘policy demos’. Policy demos explore an area that doesn’t have precedence or governance around it yet, where the community can see that some agreements or protocols will be necessary in the future. The demo tests approaches to policy

coordination and development that could support cooperation for the undefined area in question. An example is the lunar regolith samples that Open Lunar are purchasing in 2022. It's a small amount – about a teaspoon – but it will showcase how regolith on the lunar surface should be managed and governed. An independent legal trust has been set up, and the regolith will be held there for the purpose of exploring what good stakeholderhood looks like. Defining the management of this micro sample will have important implications for the macro reality of regolith on the lunar surface – what does good stewardship mean, and how can conservation be balanced with development that benefits the global community? Open Lunar has recruited a team of 11 individuals: scientists, engineers, policy experts, lawyers from indigenous communities, and space lawyers to discuss these questions and make recommendations. The trust will then assert policy positions with respect to the regolith based on those recommendations, and those findings can be used to help shape the larger conversation about the wider ecosystem of lunar resources. You can find more on this at the website: <https://breakingground.space/>

The Open Lunar Foundation sees LSIC as another forum where the domestic and international community can find ways to work together technologically in terms of what's happening with lunar activity and how to get involved, finding out about existing opportunities, and to collaborate with one another. In particular they're excited to see conversations about standards, which have begun to percolate in some of LSIC's subgroups and have been brought up as an area ready for collaboration at past LSIC events.

In terms of opportunities and challenges Open Lunar sees more broadly, they're excited by the lunar community's overall movement towards a sustained human presence on the lunar surface, and everything that goes along with supporting that. In particular they're looking forward to observing the emergence of local decision-making capacity among those who are the earliest to go to the Moon – how they develop their own sense of agency and autonomy, and how that relates to the support they'll receive from Earth. Seeing how everyone navigates those challenges as a whole will say a lot about what has been learned about good governance and stakeholderhood of new places, which is especially important as we all move towards a space faring future. The other side of this coin are the challenges that Open Lunar sees on the horizon. "Humanity tends to think it's too early to think about potential challenges until it's too late – then we're reacting rather than thinking deeply about what's happening on the Moon," stated Schingler. She pointed out that there's a lot of lunar missions planned for the next year, and there are major issues like addressing the asymmetry of some of the key players in terms of size and resources, as well as the need to establish a framework for deciding what kind of payloads get to go to the lunar surface, how they interact with each other, and how they're disposed of. Their work will continue to support developing recommendations for situations like these, as they state in their goal, in the interest of 'enabling peaceful, cooperative human presence on the Moon for the benefit of all life'.

# NASA News

## **NASA's 2021 Included Mars Landing, First Flight, Artemis, More**

*Dec 21, 2021 (RELEASE 21-174):* In 2021, NASA completed its busiest year of development yet in low-Earth orbit, made history on Mars, continued to make progress on its Artemis plans for the Moon, tested new technologies for a supersonic aircraft, finalized launch preparations for the next-generation space telescope, and much more – all while safely operating during a pandemic and welcoming new leadership under the Biden-Harris Administration. Click here to read more: <https://www.nasa.gov/press-release/nasa-s-2021-included-mars-landing-first-flight-artemis-more>

## **NASA Selects Education Projects to Help Broaden STEM Participation**

*Dec 9, 2021 (RELEASE 21-170):* NASA has selected a diverse group of projects from museums, science centers, library systems, and other informal education organizations across the country as NASA Informal Education Community Anchors. The projects all received Teams Engaging Affiliated Museums and Informal Institutions (TEAM II) Community Anchor Awards. Designation as a community anchor recognizes an institution as a local community resource. These projects will bring space exploration to traditionally underserved areas and broaden student participation in the fields of science, technology, engineering, and math (STEM). Click here to read more: <https://www.nasa.gov/press-release/nasa-selects-education-projects-to-help-broaden-stem-participation>

## **NASA Awards Artemis Contract for Future Mega Moon Rocket Boosters**

*Dec 2, 2021 (RELEASE 21-160):* NASA has awarded the Booster Production and Operations Contract (BPOC) to Northrop Grumman of Brigham City, Utah, to build boosters for the agency's Space Launch System (SLS) rocket to support nine SLS flights. Northrop Grumman, the lead booster contractor, has produced booster motors for the first three Artemis missions and is casting the motors for the fourth lunar mission. Click here to read more: <https://www.nasa.gov/press-release/nasa-awards-artemis-contract-for-future-mega-moon-rocket-boosters>

## **NASA Selects Companies to Develop Commercial Destinations in Space**

*Dec 2, 2021 (RELEASE 21-164):* NASA has signed agreements with three U.S. companies to develop designs of space stations and other commercial destinations in space. The agreements are part of the agency's efforts to enable a robust, American-led commercial economy in low-Earth orbit. The total estimated award amount for all three funded Space Act Agreements is \$415.6 million. The companies that received awards are:

- Blue Origin of Kent, Washington, for \$130 million
- Nanoracks LLC, of Houston for \$160 million
- Northrop Grumman Systems Corporation of Dulles, Virginia, for \$125.6 million

Click here to read more: <https://www.nasa.gov/press-release/nasa-selects-companies-to-develop-commercial-destinations-in-space>

## **Public Provides NASA Ideas for Engaging Untapped Communities**

*Dec 2, 2021 (RELEASE 21-144):* NASA is currently reviewing 195 comments it received from the public aimed at addressing the barriers that potentially limit underserved communities' participation in the agency's mission. On June 15, NASA issued a request for information (RFI) entitled, "Advancing Racial Equity and Support for Underserved Communities in NASA Programs, Contracts and Grants." The agency described the purpose and goals of the RFI at a July 13 public meeting. Click here to read more: <https://www.nasa.gov/press-release/public-provides-nasa-ideas-for-engaging-untapped-communities>

# Funding Opportunities

## Tech Development

- 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

- 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

- 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>