

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](http://lsic.jhuapl.edu).

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## Focus Area Monthly Telecon Schedule

### Dust Mitigation

Third Thursdays at 12PM Eastern

### Excavation & Construction

Last Friday at 3PM Eastern

### Extreme Access

Second Thursdays at 3PM Eastern

### Extreme Environments

Second Tuesdays at 3PM Eastern

### In Situ Resource Utilization

Third Wednesdays at 3PM Eastern

### Surface Power

Fourth Thursday at 11AM Eastern

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

## Director's Update

Thank you to everyone who joined us and helped make the Fall Meeting a success! We appreciate your willingness to try new technologies. If you haven't already done so, we would be grateful if you could take a few minutes and fill out this post-meeting survey ([https://docs.google.com/forms/d/e/1FAIpQLSfreZ8x29zRsXDvOn8Ner0XAo7roDx9X91flk6pS6x7fOKMfg/viewform?usp=sf\\_link](https://docs.google.com/forms/d/e/1FAIpQLSfreZ8x29zRsXDvOn8Ner0XAo7roDx9X91flk6pS6x7fOKMfg/viewform?usp=sf_link)), so we can incorporate your feedback to make future meetings (especially virtual meetings) as engaging and useful as possible.

On the second day of the meeting, we had nine different breakout groups discussing envisioned futures with different levels of power availability, including technology needs and critical concerns. We are in the process of going through the Miro boards and notes to synthesize the feedback, and will post all of it on Confluence this month. This input will help us strategize how to proceed with virtual focus group workshops in the winter, as well as how to make monthly focus group meetings as beneficial as possible.

This month we will convene our first Executive Committee meeting and continue working to refine our website to provide better access to critical information. Please don't forget to email Andrea ([ams573@alumni.psu.edu](mailto:ams573@alumni.psu.edu)) if you have community-relevant information that you'd like posted on Confluence.

### **Rachel Klima**

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Innovation Consortium  
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## Funding Opportunities

### REQUESTS FOR REVIEWERS

#### **“Honey I Shrunk the NASA Payload, the Sequel”**

(<https://www.herox.com/NASAPayload2>)

NASA is seeking for potential reviewers for the “Honey, I shrunk the NASA Payload, the Sequel” Challenge. Payloads that were selected in the ideation phase have an opportunity to propose the payload for development. Should a team be successful in the build of a payload that is TRL 5 (NASA technology readiness level), they will have the



opportunity to be incorporated into a future Commercial Lunar Payload Services (CLPS) mission. We are looking for reviewers with experience in instrument development for flight purposes. Reviews will happen between January 4 -25, 2021. This is an exciting opportunity that impacts industry and academic partners interested in participating in future CLPS missions. Anyone who is interested in being a reviewer should contact Valerie Scott ([Valerie.j.scott@jpl.nasa.gov](mailto:Valerie.j.scott@jpl.nasa.gov)).

### TECH DEVELOPMENT OPPORTUNITIES

**Lunar Vertical Solar Array Technology** (<https://nspires.nasaprs.com/external/solicitations/summary/init.do?solId={68A7EFE3-1B4F-5AA1-A169-119D97C8DB8F}&path=open>)

Seeking proposals for the design and prototype fabrication of autonomously deployable and relocatable lunar surface solar arrays for future missions during the “Sustainment Period” of lunar South Pole exploration. Contracts resulting from this Appendix will include a Base period focused on design and analysis tasks to ensure basic feasibility of the proposed system, and an Option period that focuses on the build and test of a prototype of the proposed system concept.

**Proposal Deadline: 14 December 2020**

**Watts on the Moon Centennial Challenge** (<https://www.herox.com/WattsOnTheMoon>)

Teams will propose solutions for energy distribution, management, and/or storage that address NASA technology gaps and can progress toward flight readiness and future operation on the lunar surface. Such solutions may also have important synergies with terrestrial energy needs, and this Challenge is expected to help advance similar technologies for terrestrial application and commercialization.

**Phase 1 Registration and Submission Deadline: 25 March 2021**

### STUDENT TECH DEVELOPMENT OPPORTUNITIES

**NASA Space Technology Graduate Research Opportunities - Fall 2021 (NSTGRO21)** (<https://nspires.nasaprs.com/external/solicitations/summary.do?solId={2BC591E9-FFFA-4B1C-19A2-9283E5018B99}&path=&method=init>)

NSTGRO is focused on graduate student research and development of advanced and innovative space technologies critical for our Nation to meet its goals to explore and understand the Earth, our solar system, and the universe.

**Proposal Deadline: 02 November 2020**

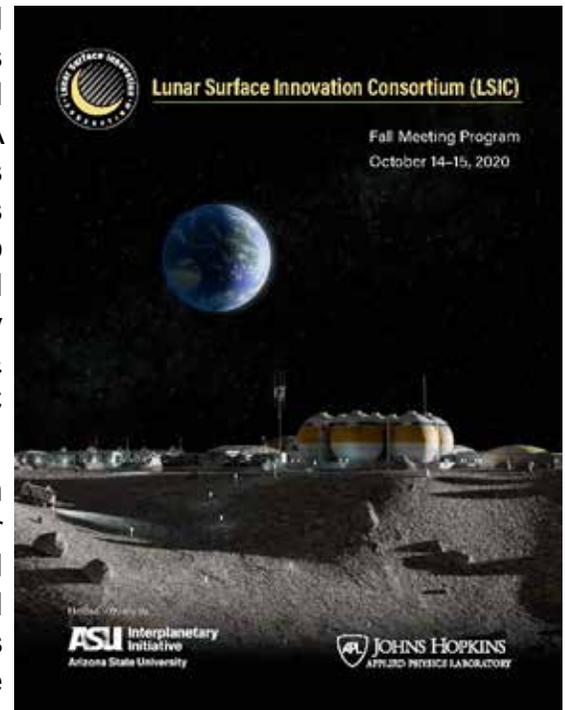
**Big Idea Challenge: 2021 Lunar Dust Challenge** (<http://bigidea.nianet.org/2021-challenge/>)

Through the 2021 BIG Idea Challenge, NASA seeks innovative ideas from the academic community for a wide range of lunar dust mitigation solutions for issues including reducing dust clouds upon landing, dust removal from spacesuits and other surfaces, dust obstruction of optical systems, and reducing in-cabin particulate levels, among others.

**Project Plan Proposal and Video Deadline: 13 December 2020**

The 2020 LSIC Fall Meeting took place on 14-15 October and attracted over 400 attendees for the two days of presentations and discussion centered on power systems for a sustained presence on the lunar surface. The keynote speaker was NASA Administrator Jim Bridenstine, who gave important updates about NASA's Tipping Point solicitation selections as well as the latest developments for the Artemis program. Day one also featured a panel exploring Space Tech Opportunities with broad representation from NASA's various funding programs, and day two had a panel dedicated to Power: System Level Concerns & Current Status. Videos of the event are available on the LSIC website here: <http://lsic.jhuapl.edu/Events/102.php>

The second day involved a series of breakout discussion sessions where participants discussed the power implications for establishing a sustained presence on the Moon, and how to build towards that sustainability. The findings from those sessions will be released in the future, but we asked a selection of participants to answer a few questions and share their impressions from the event in the meantime.



## Perspectives from the 2020 LSIC Fall Meeting

This month's feature article invited three attendees to share their thoughts about the proceedings.

**Wes Fuhrman:** LSIC Surface Power Facilitator, JHU Applied Physics Laboratory

**Arthur "Gene" Goldman:** Director-Huntsville Operations, BWX Technologies, Inc.

**Paolo Venneri:** CEO USNC-Tech, Ultra Safe Nuclear

*What were your main takeaways from the material presented at the LSIC Fall Meeting?*

**WES:** In short, there's lots happening and it's happening fast. While it's only been a very short time since we kicked things off, the community is already becoming large and actively engaged in laying the foundation for our broader goals. Personally, I felt a real sense of co-creation from Administrator Bridenstine's talk, and that left me with the sense that we are part of something with great potential.

**GENE:** There is a lot of work to be accomplished in multiple areas. The meeting gave insight to how expansive the technical issues to be addressed are, as well as identifying many of the key areas.

There is significant interest from the community, including government, industry, academia and non-profit, as well as others. A rapport developing among the community as we begin work to quantify the challenges as well dialogue to address them.

**PAOLO:** There were a couple big takeaways. First, that the community was so large, varied, and developed. The community not only has a wealth of knowledge as to how and what we would be doing on the Moon, but also in addressing the root question of why we are going to the Moon. While this differed among participants, most everyone had an answer to that question including science, developing the lunar surface, and engaging in commercial activities in space. The second was the amount of power the community at large is looking for. While NASA is putting forward 10 kWe demonstrations, it seemed that the majority of the community was pushing for increasingly high power levels, starting at 50-100 kWe in order to meet initial needs. In my past experience, mission designers have rarely been interested in

more than a few hundred watts or at most a few kW. Finding the community filled with people looking for higher power levels made me realize where all the power needs went.

*What are you hoping to see result from the meeting? What should the community's next steps be?*

**WES:** My main hope for the meeting itself was to see conversations happening, connections being made. I wanted to know that the community was active and engaged with each other. From my experience, we hit that target: once we hit our stride in the breakout session, ideas were arriving rapid-fire from a wide assortment of people who typically wouldn't sit at the same table. Now, I want to see these relationships continue to develop and to leverage our successes and excitement to bring more voices into the fold. We need to capitalize on this momentum. It'll be our job to convert all this information into action. For the LSIC, I'm especially excited for our next workshops that will bring the different focus areas in closer coordination.

**GENE:** I hope NASA sees the full scope of multiple, inter-related challenges. Though the Administrator said that many of these questions will be addressed by our industry partners, and we will become a customer for solutions, NASA needs to lead the definition of requirements, certainly with input this group can provide. Getting real data on power requirements for intended operations such as obtaining, processing, and storing O<sub>2</sub> and other material from lunar ice or regolith for future uses needs to be identified. This will enable quantification of anticipated cumulative power requirements. Industry and academia interested in resource production should have ideas of how much power they require. NASA is going to have to address how that demand will be met. Will it be an expectation for industrial interests to provide for themselves? What is the best type of power to be used, and what are the advantages, disadvantages and technology challenges? Administrator Bridenstine said that a definition of sustainability might be providing a framework for infrastructure the industry partners will augment. That needs to be decided at some point, preferably soon. Is this a budget exercise where available funding will control what is done, or will it be public-private partnerships? The roadmaps will hopefully be complete and descriptive this spring, and decisions will begin to be implemented for the "plan" for lunar surface operations and the partnerships and entities which will be part of the operation. This is obviously a huge undertaking, limited by our ability to put assets on the surface.

**PAOLO:** I'm hoping to see the discussion from the workshops summarized and presented to NASA and STMD to help inform their upcoming development efforts and upcoming missions. There was truly ground-breaking work in bringing the community at large together that I think needs to be communicated appropriately.

*What do you see as the biggest current power technology gaps related to a sustained presence on the Moon? What approach would be best to close them?*

**WES:** Power during periods of dark. Solar is our reliable standby, but if we want to operate sustainably we will have to learn to live without it. What's interesting to me is that there's a few angles to approach it. There are operational decisions that impact needs: Illumination on the Moon is like real estate — it's all about location, location, location — choosing exactly where to go is the first critical fork. Then, deciding how much we can or want to hibernate or migrate operations during periods of dark. Those decisions set the scale of energy we need to survive. Meeting the remaining demand can be done in multiple ways. While batteries are prohibitively massive at scale, there may be room for novel technologies that take advantage of the lunar environment — storing energy in heated regolith or in the magnetic fields of superconducting solenoids may have a place beside more traditional tech like regenerative fuel cells. Of course, nuclear power in the form of RPS (radioisotope power systems) and FPS (fission power systems) can meet the need of continuous power without illumination, and de-risking FPS enables a

wide assortment of missions where solar is not an option. What's best from all this?! It's like choosing ice cream toppings. There are lots of good combinations, but everyone has their favorite.

**GENE:** The biggest gaps in my opinion are defining the power required for intended operations (life support, resource exploration, extraction, processing, storing, etc.); what type of power should meet that need, such as nuclear vs solar vs fuel cells vs what; power storage and distribution, as well as communication networks. These just scratch the surface, but power is common to any activity, from shelter to resource utilization. A common belief among participants was that it will take MW's, not tens or even hundreds of KW's.

**PAOLO:** There is currently no high-TRL power system capable of supplying the power needs of even the near-term 50-100 kWe demonstrations that the community is wanting to execute on. Moving forward quickly with demonstrating the relevant systems is key for timely deployment. Key to their demonstration, however, is to demonstrate systems that can be scaled to a significant degree. The purpose of these demonstrations should be less to demonstrate the technology but rather the best system to power the development of the Moon.

*What power technologies or capabilities related to sustained operations on the lunar surface are you most excited about? Why?*

**WES:** I'm most excited about seeing how things all come together. From seemingly little things like dust mitigation on solar panels, to big unknowns like getting enough power to operate deep in the PSRs, for me it's all about getting us to come together to find and field solutions. To that end, I'm especially enthusiastic about the technologies and efforts that move us to standard, modular, and scalable power systems. Maybe someday lunar surface power will reach the point that we're at on Earth — we're aware of it, but it doesn't really factor much in our day-to-day decisions. I'll be happy when someone can land on the Moon and simply plug in their pizza oven.

**GENE:** Nuclear power is the most exciting to me because of its ability to provide long-duration, sustained power. It comes with a host of challenges, from launch to autonomous operation in extreme environments. These will be difficult to address, but every potential power type will have advantages and disadvantages. Nuclear development is a technical challenge now. It may not be the immediate answer, but for credible, sustained operations which provide a viable lunar economy, power is the key. Nuclear, for all its challenges, is ultimately best suited for base load operations, and that is what NASA says they want to create. Creating a lunar economy worthy of the name is going to need MW's of power.

**PAOLO:** I am very excited about the potential for using nuclear fission power on the lunar surface. I think it is a game-changing technology that will enable not only the sustainable development of the Moon, but also the expansion of humanity and its activities throughout the solar system. One of the most exciting things about it is that it's a technology that is within-reach and can have a profound impact on the Earth's environment and climate change as well. The synergy between the benefits of nuclear power for remediating climate change and enabling space exploration and development is groundbreaking.

*What conversations are you not hearing that you think need to be held as the community continues building towards a sustained lunar presence?*

**WES:** Operating within the confines of economic and policy decisions will be crucial to achieving a sustained lunar presence and lunar economy. I think we're on our way — events like the ISRU Supply and Demand workshop go towards building this understanding — but given the degree to which policy and economics control the shape of possibility, I know at least I would benefit from having more awareness of the ways in which we can inform and advocate for our lunar future.

**GENE:** At this point we're operating at a "we dream of" state. As mentioned before, this community has to characterize the operations we believe define sustained presence and economic potential. Then we need to define and quantify the commodities needed to implement. Funding sources, partnerships, contract and incentive arrangements, etc., all need to be estimated and developed. Administrator Bridenstine leaned heavily on industry partner participation; that relationship with government needs to be defined. We need to start with "what are we trying to achieve?" What are the operations for which a sustainable presence can provide an economic benefit to the industry investors as well as the US and international partners? What do each bring to the relationship? This is a massive undertaking with huge potential and incredible costs. The advancement of required technologies in a broad spectrum of disciplines will greatly benefit life on Earth but requires extensive investment now. How do we accomplish that in concert with the other issues the US and the world have? We're going back to create a vibrant lunar economy for the benefit of humanity; exactly what does that mean? LSIC is now an established community to begin defining and building toward that goal.

**PAOLO:** There is a large focus on first steps and long-term steps, but seemingly a lack of resolution on what happens between the two. Developing the connection between the two would help build out any eventual plan and give credibility to the endeavor. That being said, too much resolution in the middle section is difficult to do at this point and may lock us into an unsustainable pathway.



[PIA13160](#): Lunar Swirls at the Mare Ingenii

## November Member Feature: **NASA SBIR / STTR**

Are you a small business or research institution with a technology or innovation that addresses NASA's needs? If you're looking for funding opportunities to get your idea off the ground, and you're looking to build a partnership with NASA, check out the 2021 Phase I solicitation of NASA's Small Business Innovation Research / Small Business Technology Transfer (SBIR/STTR) program! This solicitation, which opens on 09 November and runs through 08 January, is an accelerated release of the annual solicitation for 2021 to give small businesses an opportunity to receive Phase I funding sooner than the typical January release. Phase I awardees will receive up to \$125,000, and with successful completion of Phase I objectives they'll also have the opportunity to compete for subsequent rounds of funding. The research topics for the 2021 Phase I solicitation will be available when the solicitation opens, so be sure to check their website for details! <https://sbir.nasa.gov/>

### **A Little Background**

NASA's SBIR and STTR are two sister programs that, together, fund a pipeline of innovations directly serving NASA's specific technology and innovation needs. The difference between the two programs is that SBIR awards are for small businesses only, whereas STTR awards are given to small businesses that partner with research institutions. The periods of performance for the two programs are different (SBIR Phase I lasts for six months and STTR Phase I lasts for thirteen), but the goals are the same. If you're new to the NASA SBIR/STTR program, the best way to prepare yourself is to review past solicitations. You can find those on their website here: <https://sbir.nasa.gov/solicitations>

**What Phase I Entails**

Phase I (the proposal period that is about to open) is about establishing the scientific, technical, and commercial merit of an idea, as well as its feasibility. Because Phase II and III awards are open only to businesses who have successfully completed a Phase I contract, proposing during the Phase I period is essential for opening the door to additional funding opportunities. To find out if your small business qualifies, please review the NASA SBIR/STTR program’s FAQ page: <https://sbir.nasa.gov/content/frequently-asked-questions>

**Continue Building Your Technology with Phases II, III, and More!**

After receiving a Phase I award and carrying out the period of performance (by providing a sound basis for the continued development, demonstration, and delivery of the proposed innovation), businesses can submit proposals for additional funding towards prototype development in Phase II (up to \$750,000 over 24 months for both SBIR and STTR). Phase I and II recipients can also pursue Phase III funding, which is non-SBIR funding provided by NASA or another customer towards infusion into a NASA or other government agency mission and/or into the commercial market. There are additional post-Phase II funding opportunities that can help you transition your technology towards infusion or commercialization. You can find more details about Phases I, II, and post-Phase II opportunities on their website here: <https://sbir.nasa.gov/content/nasa-sbirsttr-basics>



**If at First You Don’t Succeed...**

You can always try again! The NASA SBIR/STTR program is competitive, with hundreds of proposals historically received during Phase I solicitations. You can find resources and program contact information on the NASA SBIR/STTR program’s website to help you prepare for future solicitations. (Note that program contacts cannot discuss the solicitation during the solicitation period, but you can get in contact afterwards to help you prepare for the next one.) The NASA SBIR/STTR program can be complex at first glance, so be sure to do research and pursue guidance as needed as you begin your SBIR/STTR journey.

Please look for the official NASA SBIR/STTR Phase I solicitation announcement on the NASA SBIR/STTR website on 09 November 2020: <https://sbir.nasa.gov/>

**NASA News**

**NASA, European Space Agency Formalize Artemis Gateway Partnership**

27 October 2020 – NASA and ESA (European Space Agency) have finalized an agreement to collaborate on the Artemis Gateway. This agreement is an important element in a broad effort by the United States to engage international partners in sustainable lunar exploration and to demonstrate technologies necessary for a future human mission to Mars. The agreement, signed Tuesday, marks NASA’s first formal commitment to launch international crew members to the lunar vicinity as part of NASA’s Artemis missions. [Click here](#) to read more.

### **NASA's SOFIA Discovers Water on Sunlit Surface of Moon**

26 October 2020 – NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) has confirmed, for the first time, water on the sunlit surface of the Moon. This discovery indicates that molecular water may be distributed across the lunar surface at low abundances, and not limited to cold, shadowed places. [Click here](#) to read more.

### **NASA Selects Intuitive Machines to Land Water-Measuring Payload on the Moon**

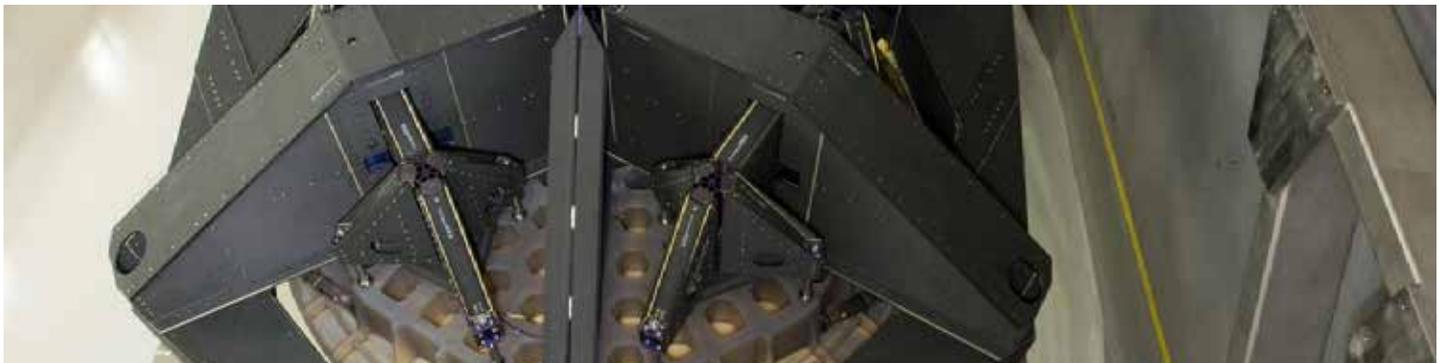
16 October 2020 – NASA has awarded Intuitive Machines of Houston approximately \$47 million to deliver a drill combined with a mass spectrometer to the Moon by December 2022 under the agency's Commercial Lunar Payload Services initiative. The delivery of the Polar Resources Ice Mining Experiment known as PRIME-1 will help NASA search for ice at the Moon's South Pole and, for the first time, harvest ice from below the surface. [Click here](#) to read more.

### **NASA Announces Partners to Advance 'Tipping Point' Technologies for the Moon, Mars**

14 October 2020 – NASA has selected 14 American companies, including several small businesses, as partners to develop a range of technologies that will help forge a path to sustainable Artemis operations on the Moon by the end of the decade. [Click here](#) to read more.

### **NASA, International Partners Advance Cooperation with First Signings of Artemis Accords**

13 October 2020 - International cooperation on and around the Moon as part of the Artemis program is taking a step forward today with the signing of the Artemis Accords between NASA and several partner countries. The Artemis Accords establish a practical set of principles to guide space exploration cooperation among nations participating in the agency's 21st century lunar exploration plans. [Click here](#) to read more.



[ARC-2008-ACD08-0110-261](#): SOFIA (Stratospheric Observatory for Infrared Astronomy) primary mirror coating completed at the Ames Vacuum Chamber in N-211.

## **Community Bulletin Board**

### **Commercial Space Maintenance Survey (CMO AI)**

The commercial space sector is moving quickly. They are designing, manufacturing, and deploying various new space assets on an almost weekly basis. All of these space assets/equipment will require configuration management and maintenance at various points in their lifecycles. The survey is designed to understand if and how commercial space companies and/or governmental agencies are including "maintenance" in their visions, processes, designs and products. The information gained from this survey will be shared on our website, on LinkedIn and with all space agencies, entities and commercial companies and/or their principals with whom we interact.

[https://docs.google.com/forms/d/e/1FAIpQLSdlGsKOCX7uJ9OqGj4o-NkI3\\_giikMyE6ileTRId0wp9s802A/viewform](https://docs.google.com/forms/d/e/1FAIpQLSdlGsKOCX7uJ9OqGj4o-NkI3_giikMyE6ileTRId0wp9s802A/viewform)

### **NASA BPS Fundamental Physics Program Virtual Town Hall**

The Fundamental Physics program of NASA's Biological and Physical Sciences (BPS) Division will be conducting a virtual townhall on December 3, 2020 from 16:00 to 18:00 Central time, to discuss potential mission candidates and research foci that are in preparation for consideration in the upcoming BPS Decadal Survey, which will establish research priorities for the Decade starting in 2023.

Specific topical research areas that will be discussed include:

- Physics of Dust and Plasma Interactions on the Moon
- Dusty/Complex Plasma Research on the ISS

To participate and register for this event please visit: <https://asgsr.org/decadal-survey/>

### **Debut of Lunar Outpost's Next Iteration Mobile Autonomous Prospecting Platform (MAPP)**

Lunar Outpost is excited to announce the debut of the next iteration of our Mobile Autonomous Prospecting Platform (MAPP) rovers and would like you to be one of the first to see it in action!

The United States, and the world as a whole, is entering another pivotal chapter in the history of space exploration. The creation of the United States Space Force, NASA's ARTEMIS and CLPS programs, and a burgeoning private space sector all indicate an invigorated effort towards furthering humanity's presence in space. Enabling this presence is the driving force behind what we do here at Lunar Outpost.

Nearly two years ago we unveiled our first commercial resource prospecting rover prototype: MAPP. This announcement marks another important day in Lunar Outpost history, as we are proud to announce MAPP 2.0, a resource prospector ready to fly to the Moon. At 10 kg, MAPP is compact but effective, able to autonomously prospect the lunar surface for resource-rich areas enabling future extraction and utilization, as well as accommodate up to 5 kg of additional scientific and valuable payloads seeking mobility on the lunar surface. Built on extensive research, strenuous testing, and the information gained from its predecessor, MAPP embodies a high TRL system ready to make a difference in upcoming lunar missions. Equipped with flight-ready hardware, autonomous navigation and mapping algorithms, and the payload space to integrate with Moon-bound scientific instruments, MAPP represents the Next Leap towards humanity's sustained presence in space.

We now invite you to take this leap with us, introducing MAPP: <https://youtu.be/e8fmhYM1FRc>

For more information visit: [www.lunaroutpost.com](http://www.lunaroutpost.com) or follow us @thelunaroutpost

### **ASCEND Session: WRKSHP-14, Sustainable Lunar Presence: Infrastructure to Stay**

This workshop will focus on gathering a group of cross-disciplinary subject matter experts in order to brainstorm and define the necessary infrastructure needed for a sustainable human lunar presence in the context of environmentally appropriate architectural design and civil engineering robotic construction using locally available resources on the lunar surface. Emerging technologies and new materials are opening up new possibilities and economic opportunities. A short term presence can ignore infrastructure, but a long term presence must consider the infrastructure needs in order to provide for all stakeholder needs. The terrestrial construction and mining communities are well versed in running mega-projects for multi-billion dollar Earth based infrastructure such as power plants, city development, mines, transportation networks and more, with commercial motivation and positive cash flow outcomes.

Date: 17 November 2020

Time: 3:00PM to 6:00PM EST

Link: <https://ascend2020.ascend.events/event/member/689647>