

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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Focus Area Monthly Telecon Schedule

Dust Mitigation

Third Thursdays at 12PM Eastern

Extreme Access

Second Thursdays at 3PM Eastern

Excavation and Construction

Last Friday 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

Director's Update

With our Fall Meeting less than two weeks away, I wanted to take this opportunity to tell you a bit more about what to expect as far as the content and logistics (registration and agenda available at <http://lsic.jhuapl.edu/Events/102.php?id=102>). We're very excited that Administrator Bridenstine will be kicking it all off with a keynote address. The first day of the meeting (14 Oct.) will be primarily held in plenary sessions, including standard presentations to provide an update on NASA's technical plans as well as a Q&A panel with representatives of several key Space Tech programs to discuss opportunities available to the community. However, in the afternoon, we will transition to a poster session held using a platform called [GatherTown](http://gather.town). One of the biggest things we are all missing during virtual meetings is the opportunity to have spontaneous conversations and network. GatherTown provides each user an avatar, who moves within the virtual environment and can interact with posters, booths, etc. If you are near other folks who are speaking together, you will be able to hear their conversation, and as you move away, they will fade out until you can no longer hear them. We will have the environment set up in advance, including before the meeting begins and during the lunch break on Day 1 so that participants can get accustomed to how it works.

We hope that GatherTown will provide an interesting way for people to view posters and chat about them, but for those who feel overwhelmed even thinking about this, we will also offer other ways to view the posters and interact with the authors, including posting them publicly on the website as well as offering asynchronous discussions between the authors and other members through Confluence. If you have not yet had a chance to

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request an account for Confluence, please email Andrea Harman (ams573@alumni.psu.edu) and she will get you set up.

On day two (15 Oct.), we will begin with a plenary and panel session, and then move into a series of break-out sessions to discuss what 'sustainable' means in the 2028-2030 timeframe in one of three infrastructure scenarios: with limited (~10 kW-scale), moderate (~100 kW-scale with a ~70% duty cycle), or substantial (>1 MW-scale continuous) power availability. In a follow-up session, we will work to identify the key challenges (in all focus areas) that need to be addressed in the 2024-2026 timeframe in order to build towards each of these sustainable futures. Please do remember to register if you would like to attend the meeting, especially if you are interested in participating in the break-out sessions, as it will help us ensure that we have scaled the technology appropriately.

Finally, I want to remind everyone that we are continuously working to build up our external-facing and internal (Confluence) resources. We're adding more community-derived content, including posting surveys, documents, and other announcements, and we encourage all participants to join in so that we can understand the community needs. Thank you all for your involvement thus far, I look forward to "seeing" you at the Fall Meeting!



Rachel Klima

Director, Lunar Surface Innovation Consortium
SES-LSIC-Director@jhuapl.edu



Register Today for the LSIC Fall Meeting

The LSIC Fall Meeting will be held virtually from October 14-15 2020. It will feature a keynote address, working sessions, and technical poster presentations. The event will center on the interrelationships between the six LSIC focus areas, especially in the context of surface power.

Register now at the event page: <http://lsic.jhuapl.edu/Events/102.php?id=102>

Funding Opportunities

NASA Space Technology Graduate Research Opportunities (NSTGRO21) – **Proposals due Nov. 02, 2020** (<https://nspires.nasaprs.com/external/solicitations/summary.do?solId={2BC591E9-FFFA-4B1C-19A2-9283E5018B99}&path=&method=init>)

Lunar Vertical Solar Array Technology Proposals (80HQTR20NOA01-20GCD_C1) – **Proposals due Nov. 16, 2020** (<https://nspires.nasaprs.com/external/solicitations/summary!init.do?solId=%7b68A7EFE3-1B4F-5AA1-A169-119D97C8DB8F%7d&path=open>)

2021 BIG IDEA CHALLENGE Dust Mitigation Technologies for Lunar Applications **Proposals due Dec. 13, 2020** (<http://bigidea.nianet.org/2021-challenge/>)



On 17 September, LSIC's ISRU focus group held a Supply and Demand workshop as a forum for discussing industry's perspectives on resource availability and needs on the lunar surface. The goal was to foster communication amongst organizations and begin building a notional community understanding of the quantities of lunar ISRU products that will be desired and accessible in the near-future cislunar economy. An event report will be issued in the future, and will be available along with the associated videos and presentations on the event webpage: <http://lsic.jhuapl.edu/Events/103.php?id=103>.

This month's feature article was written by NASA's Chief Economist, Alex MacDonald, as a follow-up to the event on 17 September.

ISRU and NASA's Plans for Artemis Base Camp

Alex MacDonald, NASA Chief Economist

NASA has laid out a strategy for returning to the Moon in a way that both lays the foundation for a long-term presence there and prepares for a first human mission to Mars. This strategy is laid out in the recently released Artemis Plan and NASA's Plan for Sustained Lunar Exploration and Development:

- https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf
- https://www.nasa.gov/sites/default/files/atoms/files/a_sustained_lunar_presence_nspc_report4220final.pdf



Core to this strategy is the development of Artemis Base Camp. With lessons learned from previous NASA attempts at lunar development strategy, under the Space Exploration Initiative (1989-1993) and the Vision for Space Exploration (2004-2010), we recognize the inherent technical, budgetary, and political challenges and are focusing on establishing a minimum viable presence (MVP) on the lunar surface that can be sustained budgetarily, under multiple out-year scenarios, with a target of at least one short-stay mission a year. This MVP approach starts with Artemis Base Camp, which to start would be comprised of; a Lunar Terrain Vehicle (LTV), a Habitable Mobility Platform (HMP), and a Foundation Surface Habitat (FSH). The LTV would re-establish the unpressurized rover capability that the later Apollo missions had. The HMP would provide for extended and wider ranging expeditions on the lunar surface in the type of pressurized exploration capability that we expect would be used on a first Mars mission. The FSH would establish the foundation for a permanent presence from which we would build further. These elements – when combined with enhanced habitation capability on the Lunar Gateway – can also allow us to simulate many of the operational requirements for a first human mission to Mars as part of a Mars mission dress rehearsal at the Moon.

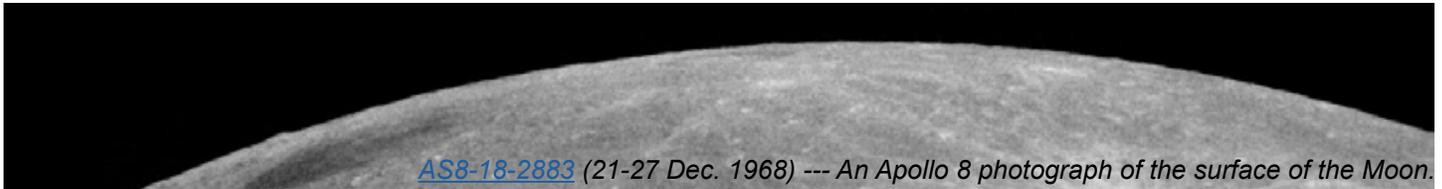
So where does ISRU fit in? ISRU is one of the perennial favorites of our space community, going back to the earliest space theorists of the late 19th century and early 20th century. At the same time, the number of flown ISRU technology demonstrations on the lunar surface to date is zero. As such, the aspiration-to-reality gap is particularly large in the field. By focusing on flight project experiments, we can help close that gap. Having funded a number of ISRU related economic studies over the years, personally I'm not sure we know enough yet to know exactly what type of ISRU application is going to be economically viable first, or when that will happen – but, we do know that ISRU is a critical area of R&D if we are going to be serious about scalable human habitation on other worlds. In recognition of this, NASA is making ISRU one of the core drivers of the science and technology development efforts of Artemis. NASA is planning to fly the SMD VIPER rover mission in late 2023, which will provide valuable

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scientific knowledge regarding lunar volatiles, data which will be of direct use in ISRU planning. NASA is also planning to fly its first lunar ISRU tech demonstration mission – the Polar Resources Ice Mining Experiment (PRIME-1) on a CLPS lander in late 2022 to test out the mass spectrometer and drill that will be used on VIPER to inform and buy down risk for that critical mission. Building from there, STMD’s ISRU efforts, incorporating input and payloads from the LSIC community, will explore both regolith and lunar volatile ISRU pathways with increasingly capable experiments and technology demonstrations, all leading to a viable ISRU pilot production plant that can be incorporated into Artemis Base Camp.

It is an exciting time, and it can be a particularly exciting time for the lunar ISRU community. Under Artemis, the 2020s can be a Golden Age of ISRU technology development if we focus on viable science and tech demo missions and payloads – on viable flight hardware – that can advance the state of practical ISRU technical knowledge, and if we persuasively make the case for the resources to fly them.



October Member Feature: **Supply and Demand Workshop Speakers**

This month, we’d like to thank our members who participated in the Supply and Demand Workshop on 17 September. Some shared additional perspectives with us, and all are listed and linked below for your perusal. You can also view their talks and access their presentations (if available) on the event website here: <http://lsic.jhuapl.edu/admin/agenda/index.php?id=103>.

DEMAND



[Daniel Faber \(CEO, Orbit Fab\)](#)

Orbit Fab is building “Gas Stations in Space” to enable a bustling in-orbit economy. In 2019 we became the first private company to resupply the International Space Station with water. The company is selling the first commercial satellite fueling ports and will soon release a compact docking navigation system to simplify access to the propellant supply chain. With tankers initially launched from Earth, we expect to grow demand to billions of dollars for storable propellants which can one day be supplied from lunar or asteroid resources.

[Ronald Jones \(Chairman and Chief Scientist, Firehawk Aerospace\)](#)

Firehawk Aerospace is developing the first rocket propulsion system designed specifically for lunar refueling using lunar natural resources. Our propulsion system does not use hydrogen as a fuel, and we are therefore avoiding the challenge of long-term storage. Our engine technology can be readily designed for specific spacecraft applications, and we are not size limited. We are looking for customers who want to do business on the lunar surface or in cis-lunar space - if you are interested in what we and our partners are doing, please get in touch.



[George Sowers \(Professor, Space Resources, Colorado School of Mines\)](#)

The ice resources near the poles of the Moon are likely to be the first economically viable use of space resources. Providing a space source of LO2/LH2 rocket propellant processed from lunar ice will revolutionize space travel and enable the creation of a robust economy in cislunar space. The LSIC workshop showcased both prospective customers and suppliers of lunar propellant highlighting the extreme interest in this area. Confirming the quantities and characteristics of this ice and developing the technologies for extraction and processing should be priorities for NASA's lunar program.

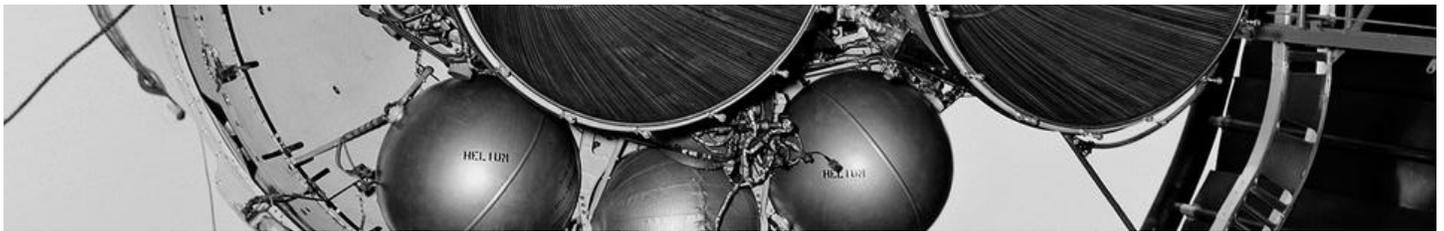


Additional thanks to our other Demand speakers!

[Nick Cummings, SpaceX](#)

[Christine Edwards, Lockheed Martin](#)

[Kathy Laurini, Dynetics](#)



[GRC-1964-C-68846](#) --- A Centaur second-stage rocket is lowered into a vacuum tank.

SUPPLY

[Elliot Carol \(CEO, Lunar Resources\)](#)



LSIC ISRU Supply & Demand Workshop provided a much-needed forum to understand the demand of and the ability to extract lunar-sourced commodities. The workshop demonstrated strong demand for oxygen from the launch service providers and highlighted key resource extraction technologies, such as Molten Regolith Electrolysis being developed by Lunar Resources which can be deployed to the lunar surface by 2025 to meet NASA and the launch service provider needs. In addition, NASA STMD reported future resource extraction missions will soon be prioritized to accelerate resource extraction initiatives. All these factors are culminating to enable for a robust resource extraction ecosystem by the mid-2020s.

[Matt Kuhns \(Chief Engineer, Masten Space Systems\)](#)

We want to create a sustainable CisLunar economy and provide a foundation of resource availability our customers can use to build business, habitats, and fuel depots in space. To achieve that we are working on an approach called Rocket Mining, where a rocket thruster and deep cratering effects are used to rapidly excavate and volatilize frozen water at the lunar poles. This would enable a low cost pathfinder approach to rapidly bring lunar water to market and demonstrate the feasibility of space resource utilization.





[Phil Metzger \(Planetary Scientist, Aqua Factorem\)](#)

Aqua Factorem, or “Water Maker” is a patent-pending method to extract lunar ice from lunar soil at ultra-low energy. It uses a combination of grinding, pneumatic separation, magnetic separation, and electrostatic separation to sort the ice grains from the rock and mineral grains. It takes advantage of the fact that magnetic properties of rock are 6 times stronger in the Moon’s permanently shadowed craters than they are at ambient temperatures, and the fact that ice tribocharges to different voltages than rock does.

[Kris Zacny \(VP, Honeybee Robotics\)](#)

Planetary Volatiles Extractor (PVEx) is a robotic mining systems under development at Honeybee Robotics. The system has been successfully tested in vacuum chambers and in lunar simulants doped with various water wt%. PVEx can be scaled down for feeding volatiles to a mass spectrometer and scaled up for water production.



Additional thanks to our other Supply speakers!

[Joel Sercel, Transastra Corporation](#)

[Robert Zubrin, Pioneer Astronautics](#)

NASA News

21 September 2020 -- Artemis Plan to Land First Woman, Next Man on Moon in 2024 Published

Following a series of critical contract awards and hardware milestones, NASA has shared an update on its Artemis program, including the latest Phase 1 plans to land the first woman and the next man on the surface of the Moon in 2024.

In the 18 months since NASA accepted a bold challenge to accelerate its exploration plans by more than four years and establish sustainable exploration by the end of the decade, the agency has continued to gain momentum toward sending humans to the Moon again for the first time since the last Apollo lunar mission in 1972.

- Summary: <https://www.nasa.gov/press-release/nasa-publishes-artemis-plan-to-land-first-woman-next-man-on-moon-in-2024/>
- Full Report: <https://www.nasa.gov/specials/artemis/>

25 September 2020 -- First Economic Impact Report Issued by NASA

NASA commissioned a study of its national economic impact for FY2019 to better understand how its activities impacted the American economy. Working with partners in academia, a detailed comprehensive analysis was conducted to assess the benefits to national and state economies realized by the United States’ investment in NASA and space exploration. This analysis shows the immense impact that NASA and its partners have on the national economy, across all 50 states and the District of Columbia.

- Summary: <https://go.nasa.gov/3cxsYIU>
- Full Report: <https://go.nasa.gov/3i2tycr>

Community Bulletin Board

On October 20-22, 2020 the NASA Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) program is hosting the Innovation & Opportunity Conference! This free event provides small businesses and research institutions with resources, engagement opportunities, and actionable next steps towards transitioning your technology – whether you are just starting your SBIR/STTR journey or ready for a Phase III. Visit sbir.nasa.gov/ioc for more information and to register.



CommStar Customer Demand Questionnaire V 4.0

Please participate in the Customer Demand Questionnaire, created to help CommStar Space Communications, LLC (<https://commstar.space/>) quantify customer demands for Cislunar communications. Their goal is to understand the timing and requirements of the different industries preparing to operate on, below, and around the Moon. Please note that the information you enter, including any contact information, will be kept confidential. <https://docs.google.com/forms/d/e/1FAIpQLSc6o6SgMMBNE1jYjQVr5w4dLLbPrdQdsKI6cOVgbqhhejJXYw/viewform>

LSII Lunar Simulant User Needs Survey

The primary purpose of this survey is to gain understanding of the lunar regolith simulant needs for the NASA Space Technology Mission Directorate's (STMD) Lunar Surface Innovation Initiative (LSII) projects and test facilities. Lunar simulants will be needed for development and testing, as well as verification and certification of hardware systems associated with operations on the lunar surface. Your input will assist the simulant developers in determining when and what types (fidelities) and quantities of simulants will be needed. This survey is also being used to gauge simulant needs of other programs and projects, such as Commercial Lunar Payload Services (CLPS), Orion, Gateway, and Human Landing Systems (HLS). https://docs.google.com/forms/d/e/1FAIpQLSeHoq6_XvUPfY4jV5ZzBGzcYOA06ojWIC-uohynKtu3RWzIVg/viewform

Ensuring Economically Viable Lunar Settlements – Proceedings of AIAA ASCEND

Using “[NASA's Plan for Sustained Lunar Exploration and Development](#)” as a starting point, a panel of experts gathered at the [ASCENDxCo-Lab on Economically Viable Lunar Settlement](#) on 29 July 2020 to discuss a range of considerations that underlie the U.S. government's goal of establishing a settlement on the Moon as a gateway to further exploration of the solar system. Following the panel, AIAA convened a collaborative workshop among the more than 200 attendees, who represented academic institutions, commercial enterprises, government agencies, and professional societies from around the world. These conversations resulted in the publication of the AIAA proceedings report, “Ensuring Economically Viable Lunar Settlements.” Download the report for free here: <https://www.ascend.events/ensuring-economically-viable-lunar-settlements/>

