Lunar Surface Innovation CONSORTIUM

JOHNS HOPKINS APPLIED PHYSICS LABORATORY

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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.

DIRECTOR'S CORNER

Director's Update

"We Go Together." The Artemis tagline has been on my mind a lot the last few days, so for a change, I am going to take this Director's Corner as an opportunity to share what Artemis and returning to the Moon and establishing a foothold for exploration means to me.

My education is in geology and planetary science, so I have loved and geeked out on all that the Moon can teach us about how planets form and evolve, as well as what our "neighborhood" has experienced over the past ~4.5 billion years. While I was unfortunately too young to have experienced the excitement of Apollo as it happened, I have had the privilege of getting to work with lunar samples and to see how fundamental they are in unlocking the secrets of our solar system (and beyond). Shortly after I started graduate school, the goal of returning to the Moon was announced, and the Constellation program took off. It's been a rollercoaster ride for human lunar exploration since then. But now with the Artemis I launch so close, it feels real in a way I have never experienced before.

While I am incredibly excited to see humans walking on the Moon again, what really energizes me about the Artemis program is the spirit of collaboration. To truly be sustainable over the long term, this needs to be a human endeavor. Where people from throughout the United States and world can see themselves reflected in the astronauts taking the first steps, and they themselves may find their own opportunities to contribute personally to the effort. This is our chance to prove that humanity, not just a single country, agency, or company, can take on an incredibly difficult challenge and work together to make it a reality. I have been so impressed to see how our participants, many of which do directly compete with one another, have also been open to sharing information and collaborating together. Thank you all so much for all of the energy and excitement you have brought to our meetings over the past two years. It is an honor to be on this journey with all of you.

Rachel Klima

Director, Lunar Surface Innovation Consortium

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Focus Areas

Monthly Telecon Schedule

Dust Mitigation (DM)
Third Thursdays at 12PM Eastern

Extreme Access (EA)
Second Thursdays at 3PM Eastern

In Situ Resource Utilization (ISRU)
Third Wednesdays at 3PM Eastern

Excavation & Construction (E&C)
Fourth Wednesdays at 2PM Eastern

Extreme Environments (EE)
Second Tuesdays at 3PM Eastern

Surface Power (SP)
Fourth Thursdays at 11AM Eastern

LSIC General Updates

As a reminder, If you don't have access to LSIC's Confluence wiki, please email Andrea Harman at ams573@alumni.psu.edu to get signed up.

Fall Meeting: Call for Abstracts

Meeting Information

The Lunar Surface Innovation Consortium (LSIC) fall meeting will be held on Nov 2nd-3rd, 2022, at the University of Texas at El Paso and online. The event will feature interrelationships between the six focus areas identified by the Consortium, with a specific focus on how they relate to excavation and construction. Registration will be opening in early September.

Information about the event, including registration and abstract portal, will be posted to the event page here: https://lsic.jhuapl.edu/Events/Agenda/index.php?id=350

Call for Abstracts

We invite abstracts describing technical capabilities within the six LSIC focus areas, as well as those that identify lunar surface technology needs and assess the readiness of relative systems and components. Other topics of interest include defining the parameters and constraints of the architecture required to support a sustained presence on the lunar surface, as well as economic and policy considerations.

The six LSIC technical focus areas are:

- Dust Mitigation
- Excavation & Construction
- Extreme Access
- Extreme Environments
- In Situ Resource Utilization
- Surface Power

The abstract submission portal will open no later than mid August, and all abstracts are due by 11:59PM EDT on September 13th. Abstracts should be submitted in pdf format, and are limited to 1 page, including any figures and tables, at no smaller than 10-point font (and 1-inch margins). Please use the abstract template that will be provided on the meeting webpage. Contributed abstracts will be presented as posters, with a subset of those selected by the technical organizing committee also highlighted in lightning talks.

Data Buy Survey

NASA is interested in your opinion on the topic of "Data Buys" as a mechanism for acquiring new data that advance our ability to establish a sustained presence on the lunar surface. Please find a link to the survey below where you can share your thoughts. It is structured around two types of data:

1. Data that is acquired as part of a lunar landing, e.g. descent imagery
2. New data sets (acquired either from orbit or on the surface) that require a dedicated

instrument to be flown

Whilst the survey is meant to help get your feedback quickly, we want to hear any thoughts you have on this topic. We welcome general comments on the topic of data buys, both from potential customers and providers. Neither responses to this survey nor other information emailed to us on this topic will not be shared outside of NASA.

Survey link: https://forms.gle/tuhzwAUaQLDivQ2D7

For questions, comments, or to have further detailed discussions, please contact Brenda Clyde (APL LSII Project Manager) via email at brenda.clyde@jhuapl.edu.

Launch of Pilot LSIC Mentor Program

After lots of planning, LSIC is excited to offer signup surveys for Mentors and Mentees looking to enrich their professional lives! The goal of the Mentoring Program is to provide a path for individuals (from academia, industry, nonprofits, and government) to partner between those looking to grow professionally and those looking to help build their own experience by giving others access to their insight. Our hope is to foster networking, provide business and career growth opportunities, and build the 'next generation' of professionals who will make an impact on lunar surface development.

If you are interested in giving or receiving mentorship, please fill out the appropriate survey below. We will give three weeks for everyone to express their interest, and then will spend one week pairing mentors and mentees. You will receive a notification of who you have been paired with by early October. Your input surveys, along with supporting material that will be made available to you by LSIC, will help guide your conversations and build a productive relationship. Please note that this is a pilot program with limited space - we'll do our best to accommodate as many participants as possible, but be aware that we may not be able to take all applicants.

We appreciate your interest and look forward to continuing to build this program based on feedback from this initial round of mentors and mentees. Feedback will be requested throughout the program to help us continue to create a forum where professionals can share experience and grow together

Mentor Signup Survey: https://docs.google.com/forms/d/e/1FAIpQLSdfqzEur42a28w1NgPRAudtyQnjoOnIzgmIKpuGRNHYpf8TCA/viewform?usp=sf_link

Mentee Signup Survey: https://docs.google.com/forms/d/e/1FAIpQLScnIInDsaYQoK9Kkn0tUz_QOe8VNMds_hP3CgkhfjnYNy7TuA/viewform?usp=sf_link

CLPS Survive the Night Workshop (06-08 December 2022)

NASA's Science Mission Directorate (SMD) and the Space Technology Mission Directorate (STMD) are pleased to announce a workshop to facilitate collaboration between lander and rover providers and technology developers to share technologies that can enable survival through the lunar night. The Commercial Lunar Payload Services Survive the Night Technology Workshop is scheduled for December 6–8, 2022, at NASA's Glenn Research Center in Cleveland, Ohio, with an opportunity for virtual participation. General event information is available here: https://www.hou.usra.edu/meetings/clps2022/

Call for Abstracts

Abstract submission deadline: September 22, 2022, 5:00 p.m. U.S. Central Daylight Time (GMT -5)

https://www.hou.usra.edu/meetings/clps2022/abstracts/

Important: To be added to the mailing list to receive additional information about this conference, submit an indication of interest here: https://www.hou.usra.edu/meeting_portal/iofi/?mtg=clps2022

Focus Group Updates

Dust Mitigation

The Dust Mitigation (DM) Focus Group held its monthly focus group meeting on August 18th. The focus group meeting centered on the topic of "Testing in Dusty Environments" and featured a technology presentation by AJ Gemer, Co-Founder and Chief Technology Officer of Lunar Outpost on "Particle Detection, Quantification, and Testing in Simulated Lunar Environments at Lunar Outpost." In addition, Dr. Ben Bussey, APL Lead for LSII, presented on LSIC's Data Buy Survey. NASA is interested in your opinion on the topic of "Data Buys" as a mechanism for acquiring new data that advance our ability to establish a sustained presence on the lunar surface. The survey is structured around two data types: 1) Data that is acquired as part of a lunar landing, e.g., descent imagery; 2) New data sets (acquired either from orbit or on the surface) that require a dedicated instrument to be flown. We welcome general comments on the topic of data buys, both from potential customers and providers. Survey link: https://forms.gle/tuhzwAUaQLDivQ2D7

The presentations were followed by a discussion on challenges and needs for testing in dusty environments. You can view the recording, slides, and notes from August's FG meeting and previous meetings at our LSIC Dust Mitigation Focus Group page on the LSIC website: https://lsic.jhuapl.edu/Focus-Areas/index.php?fg=Dust-Mitigation.

Our next focus group meeting will be held on Thursday, September 15th at 12:00 pm Eastern Time. The topic for the meeting will focus on "Dust Testing Facilities." The meeting will include featured technology presentations along with a discussion session.

Excavation & Construction

In August, the Excavation and Construction Focus Group hosted a meeting focused on the launch of its four subgroups: Autonomy & Site Planning, Additive Manufacturing & Raw Materials, Site Prep, Horizontal & Vertical Construction, and Outfitting & Maintenance.

Meeting participants got a chance to hear about the "Why" – what subgroups mean for the E&C community – as well as meeting logistics, relevant Confluence resources, and introductions to each of the Subgroup Leads and APL Co-Leads. We then jumped into Zoom breakout rooms for interactive sessions where the community met and collaboratively started defining the vision and activity goals for each of these subgroups. The four subgroups and their corresponding Subgroup Leads are:

- Roberto de Moraes (Director of Tunnels at AECOM): Site Prep, Horizontal & Vertical Construction
- Dr. Alhassan Yasin (ML/AI Engineer at APL & Computer Science Faculty at Johns Hopkins University): Autonomy & Site Planning
- Dr. Nilanjan Mitra (Professor at HEMI, Johns Hopkins Extreme Materials Institute): Additive Manufacturing & Raw Materials
- Miguel Coto Villanueva (Project Engineer at Herrero Builders): Outfitting & Maintenance

In our first few pilot months, E&C Subgroup meetings take place for 30 minutes following each monthly Focus Group meeting. Each subgroup also has its own dedicated page on Confluence, linked here: https://lsic-wiki.jhuapl.edu/x/KoEiAQ. There, you can find the notes from subgroup meetings – it is also a space for asking questions, continuing conversations, and sharing helpful materials. We look forward to having everyone participate as our E&C Subgroups grow!

Finally, please note the following open NASA challenges relevant to E&C:

- NASA 2023 Big Idea Challenge: https://bigidea.nianet.org/wp-content/uploads/2023-BIG-Idea-Challenge-Proposal-Guidelines.pdf (proposal deadline: January 24, 2023)
- Break the Ice Challenge, Phase 2: https://breaktheicechallenge.com/ (registration deadline: September 30, 2022)

Extreme Access

With the Extreme Environments focus group, we hosted the "Designing for the Extremes" workshop last month. Thanks to all who attended! We had panels discussing environment concerns for ISRU in and near a PSR and what they would mean for designing hardware, and on access technology and needs to perform ISRU near Shackleton crater. The breakout sessions included discussions of needed tests and technology development steps going forward. Look for a report out from the workshop in the next couple months. The PNT subgroup hosted a meeting to discuss the latest draft of the LunaNet Interoperability Standards, and submitted feedback to NASA in mid-August. The EA team has been working hard to line up topics for the upcoming telecons, and we have a nice line-up of Technology Spotlights through the rest of the calendar year. The full list is on Confluence; in September Robert "Bob" Brumley from Commstar Space Communications will speak about Lunar relay communications system. The subgroups are also continuing their discussions with time to dive deeper in specific topics, so please join those if you are interested! Our next telecon is September 8, and we look forward to chatting with you then.

Extreme Environments

Extreme Environments and Extreme Access held the joint workshop "Designing for the Extremes" covering the RLSO2 (Robotic Lunar Surface Operations 2) study and the environment effects related to designing hardware to access these extreme locations. This was well received by the community and key takeaways will be documented. There is/was wide interest on these "things to know" style discussions so EE hopes we can provide more of this information in meetings to come. Coming up in September, we will have Dr. Lubos Brieda highlight an ongoing project to numerically investigate attachment and transport of charged lunar regolith simulant grains interacting with spacesuit sample. We are still working on a new space weather and plasma subgroup lead. If you are interested, please let the team know! Additionally, we are standing up an External Hazards subgroup later this year which will be ran by Dr. Milena Graziano (JHU/APL). As always, if community members have ideas for what they would like to see or discuss, please reach out to any member of EE leadership.

ISRU

The ISRU focus group held its August monthly meeting relatively early on the 10th, with presentations focused on the need for an international lunar resource evaluation campaign by Dr. Clive Neal, Notre Dame. Jeff Plate of WGM and CEO of Interstellar Mining on volatile mapping, and

Dr. Ben Bussey, LSII lead, on the intriguing possibility of 'data buys' by NASA. Dr. Kirby Runyon, also of LSII, previewed a "Moon 101" presentation on the fundamental properties of the Moon that can impact the design and implementation of lunar surface technology with September seeing additional development of the Moon101 package. The breakout groups took a different approach as an open forum discussion on what the community would like to see developed for long term presence on the Moon. September will keep this more open, broad format the breakout group. The TDA portion of the ISRU focus group also participated in a year technical review and briefing of STMD funded ISRU and related technologies and NASA laboratory facilities.

Surface Power

In August the surface power group held a telecon which included a debrief of the Low-Temperature Power and Energy Storage Workshop in July, dedicated networking time, and highlights of recent awardees for the Watts on the Moon Challenge and Phase Two awards for the Vertical Solar Array Technology solicitation. The September telecon will feature a presentation and discussion on the International Space Power System Interoperability Standards (ISPSIS) document. This extensive document has high-level international concurrence and will likely strongly influence power standards on the lunar surface.

Working Group – Modular Open Systems Approach (MOSA)

The MOSA WG and Surface Power FG will host a joint telecon on Thursday, September 22 @11 AM. We are pleased to host Nicolas Carbone and David Sadey, both NASA Power Systems Engineers for Gateway L2, to present an International Space Power System Interoperability Standards (ISPSIS) Overview. Please join us for what will surely be a great telecon!

The MOSA WG is excited to announce the release of our public facing website that has recordings from our prior meetings! You can visit the website using this link: https://lsic.jhuapl.edu/Resources/MOSA.php. On that page, you will also find a link to our confluence site. We appreciate your help in building the MOSA confluence resources and encourage folks to continue to post on those pages. If you are interested in joining the MOSA WG or need a Confluence account, please email Andrea Harman at ams573@alumni.psu.edu.

Working Group – Simulants

The APL-LSII Lunar Simulants team has been completing various geotechnical tests on the eight lunar regolith simulants during August working with Dr. Lucas de Melo at Johns Hopkins University. These tests include a range of geotechnical characteristics important to advancing technology that uses or interacts with regolith such as relative density, shear strength, and specific gravity. Once the tests are completed in August, they will be incorporated into our 2022 assessment in late August and September. Also, following the LEAG meeting held at APL (August 23-24th), we hosted our NASA LSII colleagues that attended the LEAG meeting for tours of the laboratory facilities where many of our geochemical and geotechnical tests have been or are being completed. Finally, we have prepared an e-poster and are writing up a manuscript for the 73rd International Astronautical Congress (IAC) that will be held in Paris in September. In September, our team will be working hard to pull together the geotechnical data into a manuscript for the community.

Feature Article

LSIC Surface Power Low-T Power and Energy Workshop Summary

On July 28, 2022, the Surface Power focus group brought the LSIC community together for a virtual workshop to discuss low-temperature power and energy storage in the sub-kW regime. This workshop was a result of community discussions on the desire to work towards system solutions for high-priority lunar activities, such as CLPS payloads which survive the lunar night and rovers which can operate longer and deeper into permanently shadowed regions. The workshop had 129 attendees across industry, government, academia, and more, and covered the following topics:

- Overview of Lunar Thermal Environments with Ben Greenhagen, LSII Exteme Environments lead
- Panel session discussing near-term system solutions
- Pre-recorded lightning talks surveying recent developments
- Presentation from Marshall Smart (JPL) discussing low-temperature lithium-ion batteries
- 3 breakout sessions where participants addressed specific scenarios and solutions at different levels of power requirements

Slides and recordings for each component of the workshop are available on the event page here: https://lsic.jhuapl.edu/Events/Agenda/index.php?id=214

To start the workshop, the Extreme Environments group shared their deep and comprehensive understanding of the lunar thermal environment with Ben Greenhagen's introduction to the challenges presented by lunar thermal environments. His talk considered the environment in two categories: equatorial and polar. At the equator, the Moon sees daytime maximum temperatures of 387-397 K, and nighttime minimums of about 95 K. Since the lunar day/night cycle is about 14.75 Earth days, there are long periods without solar illumination at the equator and mid-latitudes – however, other sources such as Earthshine, Lyman-alpha, and zodiacal light can provide some illumination even at night. The poles, on the other hand, are much more special environments, and include permanently shadowed regions (PSRs) that never receive any illumination and are therefore always cold, ranging down to ~50 K. Terrain also plays a dramatic role in illumination at the poles, and higher-altitude areas receive much more light than is seen at ground level.

Following this context of the lunar environment, a 6-person panel discussing the latest near-term technologies for system solutions included:

- Richard Oeftering, NASA GRC
- Pamela Clark, Morehead State University
- Joshua Ruedin, Nanohmics Inc.
- Chris Morrison, USNC
- Ian Jakupca, NASA GRC
- Mike Provenzano, Astrobotic

The panelists discussed RTG systems, parabolic radiators/reflectors, cryo-electronics, RHUs, thermal switches, and more. A consensus was reached that there is no single solution that will apply across the board; rather, systems will need to incorporate multiple technologies to achieve desired performance. Current state-of-the-art technologies indicate that surviving the night can be done – the challenge now is to achieve operability during the night.

After the panel, workshop participants had the opportunity to view 12 pre-recorded lightning talks (5 minutes or less) surveying the latest advancements in low-temperature power technology:

Richard Ambrosi (University of Leicester)	European Radioisotope Power and Heat Solutions for Lunar Applications
Gary Barnhard (XISP-Inc)	Surviving The Lunar Night: Power and Ancillary Services Beaming as Part of an End-to-End Power System V1-1
John Bucknell (Virtus Solis Technologies, Inc)	Highly Efficient Thermoelectric Storage for Lunar Small-Scale Consumers
David Bugby (JPL, CalTech)	Passive Thermal Management Technologies for Lunar Day/Night Survivability
Nathan Davis (OxEon Energy)	A SOXE-PEM Hybrid Energy Storage System for Continuously Powered Lunar Operations (HESS-CPLO)
Shanti Garman (University of Washington)	Wireless Power Transfer as a Thermal Management Solution for Mobility Energy Storage: CubeRover Lunar Night Survival Study Using Magnetically Coupled Resonators
Christopher Greer (Penn State)	Surviving the Lunar Night Using Metal Oxidation Warming Systems with Electricity Cogeneration
Alex Ignatiev (Metox Technologies)	Using Lunar Superconducting Magnetic Energy Storage (LSMES) for NASA Artemis Program
Randall Kirschman	Electronics for Cryogenic Temperatures – Real and Ready
Richard Oeftering (NASA GRC)	Battery and Electronics Technologies for Lunar Power Hibernation
Nick Rolston (Arizona State University)	Improving Thermomechanical Reliability of Li-Ion Batteries to Withstand Freeze-Thaw Process (Thermal Cycling)
Arjit Sengupta (Vanderbilt University)	Operation of Silicon Carbide Power Devices under Lunar Surface Temperatures

Next, Marshall Smart at JPL presented a summary of the latest state of the art battery technology that has been employed in recent missions such as Juno, GRAIL, InSight, and more, as well as ongoing work that will pave the way for the future. New technologies that have been demonstrated to provide excellent low-temperature characteristics include Quallion BTE cells and 12 Ah cells (operational down to -90° C and continuously operational at -60° C), and 18650-size E-One Moli Li-ion cells (operational down to -60° C and demonstrated over 167 Wh/kg at -40° C with low rates). These advancements will expand power capabilities for future mission and can help inform this priority area within STMD.

In the final workshop session, the participants were divided into 3 groups to address power needs and challenges for specific scenarios at different scales: CLPS-scale, PSR-rover, and mini-rovers. The CLPS-scale group discussed thermal isolation (both from the environment and other parts of the lander itself) and identified weak points in the interfaces. This discussion led to the question: should payloads and the bus be self-sufficient through the night, or should they share thermal resources? The PSR Rover group noted that regulatory approval is likely to be one of the biggest hurdles for implementing new radioisotopes, and called for more information on how to push this area forward. The group covering miniature rovers such as Astrobotic's CubeRover discussed the challenges associated with three options for operational modes: full hibernation during lunar night (or in cold regions), partial operations during the night/cold, or full operation. Wireless charging and compact radioisotope heater units will both be highly impactful tools to support small-scale operations at night or in PSRs.

Overall, the workshop provided our community with several significant takeaways to help the community understand the current challenges and advancements surrounding low-temperature power systems. Currently, delivering anything beyond modest levels of continuous power (10's of W) through the lunar night would be very difficult, but minimal operational modes would be viable at these and lower levels, and achieving even minimal operations is a high-value goal for the near term. For larger-scale power, there is a need to probe the regulatory framework for launching alternative radioisotopes – the technology is well-understood and will be impactful when it is able to clear regulatory hurdles. Finally, we've seen an encouraging shift in goals in recent years and even months: we have established that we can survive the night, and have moved on to tackle the challenge of operating through the night.

Member Spotlight

REVEALS - Georgia Tech SSERVI Node

Thom Orlando, Principal Investigator (PI) of REVEALS (Radiation Effects on Volatiles and Exploration of Asteroids and Lunar Surfaces) SSERVI (NASA Solar System Exploration Virtual Research Institute) node and of the EPICS (Electron and Photon Induced Chemistry on Surfaces) Lab, both at Georgia Institute of Technology (Georgia Tech)

Thom Orlando admits up front that he isn't a card-carrying planetary scientist – his career began with formal training in chemical physics, and he first spent time working at the Department of Energy on projects exploring the effects of radiation on material stability and carcinogenesis. But that work established a pathway to space when he began to research radiation effects at interfaces during the storage of spent nuclear fuel – the physics of which is related to how solar wind affects the lunar surface and other planetary bodies like Europa. "You can blame Karl Hibbitts for everything about how we got into this," he laughed. Hibbitts was a grad student at the University of Hawai'i with his advisor, Tom McCord, who worked on the Galileo mission. Orlando's work helped advance that team's understanding of radiation processing of ices containing salts thought to be on Europa. After those efforts, Hibbitts and Orlando stayed in touch, even as the former went on to focus on lunar In Situ Resource Utilization at the JHU Applied Physics Laboratory (APL), where he shared his work on the VORTICES (Volatile Regolith Thermal Investigations Consortium for Exploration & Sciences) SSERVI node with Orlando. Hibbitts along with Ben Bussey, who was also at APL and served as Principal Investigator of VORTICES SSERVI node, which inspired Orlando to develop the REVEALS SSERVI node at Georgia Tech.

The REVEALS project is headquartered in the Molecular Science and Engineering Building on the main campus of the Georgia Institute of Technology in Atlanta, Georgia. Additional facilities are located at the partner institutions.

Orlando and the REVEALS team's main objective is to deliver information to NASA for the Artemis program, helping the initiative to succeed especially when humans are landing on the Moon for a long time relative to the Apollo missions. Their work seeks to understand what resources are on the lunar surface, how to get them, and how to use them – as well as how to protect astronauts and mitigate risk, especially health risks related to cancer and dust inhalation. "We really do have the philosophy that exploration and science are mixed," explained Orlando, "so while we do fundamental

work on solar radiation processing, on the exploration side we take that knowledge and work with condensed matter physicists, materials scientists, and systems engineers to develop passive radiation detectors that can be worn on space suits for real-time dosimetry on the lunar surface." And it turns out that if the materials REVEALS has developed work like our modeling tells us, well, they could also make an effective radiation shield – lightweight shielding that could be made on the lunar surface instead of being brought from Earth.

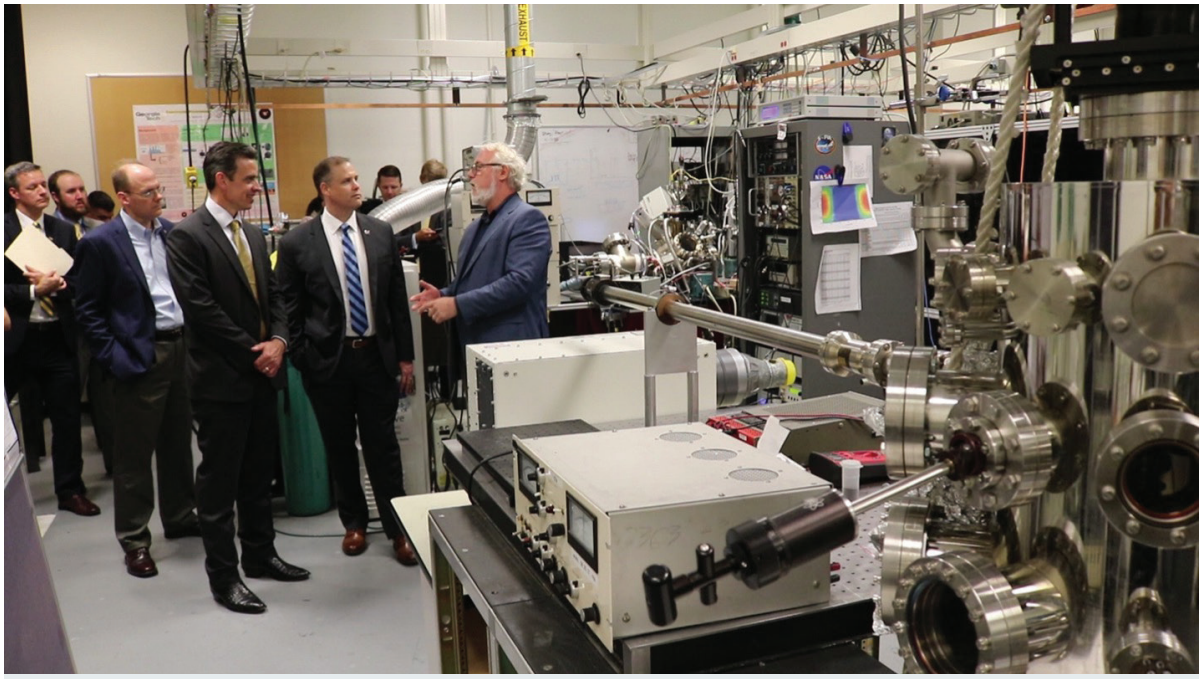
While the REVEALS team is based at Georgia Tech, multiple institutions are involved in its work. The Deputy PIs are Carol Paty (formally from Georgia Tech but now at the University of Oregon) and Esther Beltran (of the Florida Space Institute). Their team includes people from the University of Central Florida, Florida Space Institute, the University of California at Davis, Notre Dame's Radiation Laboratory, the JHU Applied Physics Laboratory, Auburn University, and the University of Georgia, located about an hour away from Georgia Tech's Atlanta campus in Athens, Georgia. International collaborators come from the University Stuttgart, Reprecht-Karls-Universitat Heidelburg, and the European Space Agency. "The un-written rule we follow is that we have to work with lots of colleagues from different universities – we don't have any one task just at Georgia Tech, Florida, Davis or other SSERVI Centers," said Orlando, "It's an integrated effort. It diversifies the team intellectually as well as personnel-wise." And REVEALS considers it vital to their mission to train the next generation of planetary scientists, so multiple graduate students are attached to each project. Approximately half of the students Orlando works with are pursuing dual degrees in engineering and science, which he proudly shares while explaining that Georgia Tech is well set up for such cross-training. Originally his group saw a lot of physics and chemistry graduate students, but what Orlando calls the "SSERVI effect" has seen their fields of study expand to include mechanical engineering, physics, chemistry, and materials science. These students and postdoctoral fellows are set up in leadership roles for their projects and enjoy multiple mentors from different backgrounds as well.

REVEALS' specialty is doing fundamental physics and chemistry, working with mission teams to provide ground truth for mission data. Lots of opportunities for this work have been created through the Artemis program. "When I was at the Department of Energy, we built a lot of programs focused on understanding radiation effects of materials and the molecular basis for radiation induced carcinogenesis – in other words, DNA damage. These are some of the most important issues being faced by NASA in the Artemis program," explained Orlando. He shared that there were two main foci of these radiation effects currently: first, risk mitigation of cancer due to radiation, and second, radiation processing and the production of volatiles on the lunar surface. "That's where we focus," Orlando went on, "trying to understand the role of the solar wind and micrometeorite bombardments of the surface in forming and transporting volatiles, moving and burying them." Most of the information the community has on volatiles is gleaned from infrared mapping conducted by previous orbital campaigns, and while that has been valuable, it is only a superficial measurement. The REVEALS team is working to support such orbital observations and scheduled lander missions by researching the effects of micrometeorite strikes, which can make a significant amount of water on impact.

As a SSERVI node, REVEALS also has a vital applied science and technology component where they are developing technologies for the extraction of lunar volatiles. Their approach uses solar energy, related to another effort at Georgia Tech for the Department of Energy dedicated to splitting water for more efficient (and sustainable) hydrogen production. Orlando and his team have developed protocols with mobile pods to extract water, purify it passively, and utilize it for sustained existence on the lunar surface. "There's a corollary of that, that once you extract the water and volatiles, you leave behind building materials," Orlando shared. This work has provided an opportunity to work

with the Georgia Tech Research Institute (GTRI), Georgia Tech's applied research organization. They have funded the program with REVEALS that researches the utilization of solar radiation to release oxygen and extract metals from regolith.

Orlando and REVEALS' activities in LSIC expand beyond basic event attendance and networking – when the NASA Big Ideas Challenge was released for student led teams, REVEALS got involved with a project based around dust mitigation out of their collaboration in LSIC's dedicated focus area. "Dust is a big deal," said Orlando, "It can pose health risks as well as challenges to materials, robots, and extravehicular activities." He sees LSIC as the primary conduit that brings together NASA's Space Technology Mission Directorate (STMD) and Exploration Systems Development Mission Directorate (ESDMD). He also sees the organization as a pathway for partnering, especially with industry, which could help SSERVI nodes move beyond prototype development into actual production and application.



A delegation led by former NASA Administrator Jim Bridenstine visited Thom Orlando's REVEALS research lab July 31, 2019. (Photo by Renay San Miguel)

Looking ahead, Orlando is most excited by opportunities to understand the physics of how water is formed from a fundamental standpoint. This doesn't just happen on the lunar surface – it has applications from the surface of asteroids to solar nebula processes and planet formation. "That's a fundamental issue," he said. "Where did the water come from?" He also believes that technologies being developed for exploration initiatives can be used on Earth. But barriers exist to getting their developed technology up and running on the lunar surface. "It's a very nasty environment," Orlando explained. There's hostility from radiation fields, there's no atmosphere, and polar nights are long and challenging. And they're operating under a tight timeframe. He believes that more support and funding will help achieve the Artemis goal of getting 'boots on the ground' on the Moon within this decade.

Additional information about REVEALS and their work can be found here: https://reveals.gatech.edu/

NASA and Community News

NASA Waves Off First Artemis I Launch Attempt

NASA News \\ 29 August 2022

https://www.nasa.gov/press-release/nasa-waves-off-first-artemis-i-launch-attempt

Forget 5G wireless, SpaceX and T-Mobile want to offer Zero-G coverage

ARS Technica \\ 25 August 2022 \\ Eric Berger

https://arstechnica.com/science/2022/08/forget-5g-wireless-spacex-and-t-mobile-want-to-offer-zero-g-coverage/

Three Companies to Help NASA Advance Solar Array Technology for Moon

NASA News \\ 23 August 2022

https://www.nasa.gov/press-release/three-companies-to-help-nasa-advance-solar-array-technology-for-moon

NASA Identifies Candidate Regions for Landing Next Americans on Moon

NASA News \\ 19 August 2022

https://www.nasa.gov/press-release/nasa-identifies-candidate-regions-for-landing-next-americans-on-moon

NASA Awards Accelerate Small Business Tech for Earth and Space

NASA News \\ 18 August 2022

https://www.nasa.gov/spacetech/sbir_sttr/nasa_awards_accelerate_small_business_tech_for_earth_space

Seven Teams Advance in NASA's $5M Watts on the Moon Challenge

NASA News \\ 16 August 2022

https://www.nasa.gov/directorates/spacetech/centennial_challenges/seven-teams-advance-in-nasa-s-5m-watts-on-the-moon-challenge.html

Astrobotic bids for Masten Space Systems assets

SpaceNews \\ 16 August 2022 \\ Jeff Foust

https://spacenews.com/astrobotic-bids-for-masten-space-systems-assets/

NASA Seeks Student Experiments to Soar in Second TechRise Challenge

NASA News \\ 10 August 2022

https://www.nasa.gov/press-release/nasa-seeks-student-experiments-to-soar-in-second-techrise-challenge

Lunar Outpost, Colorado School of Mines developing technology for autonomous lunar excavation and construction

Lunar Outpost \\ 09 August 2022

https://lunaroutpost.com/lunar-outpost-colorado-school-of-mines-developing-technology-for-autonomous-lunar-excavation-and-construction/

NASA Announces New CubeSat Launch Initiative Partnership Opportunities

NASA News \\ 08 August 2022

https://www.nasa.gov/press-release/nasa-announces-new-cubesat-launch-initiative-partnership-opportunities

Northrop Grumman and Firefly to partner on upgraded Antares

Space News \\ 08 August 2022 \\ Jeff Foust

https://spacenews.com/northrop-grumman-and-firefly-to-partner-on-upgraded-antares/

Virgin Galactic Secures Land for New Astronaut Campus and Training Facility

Virgin Galactic \\ 01 August 2022

https://www.virgingalactic.com/news/virgin-galactic-secures-land-for-new-astronaut-campus-and-training-facility/

Funding Opportunities

Tech Development

- NASA SBIR Ignite 2022 Program Solicitation
  https://sbir.nasa.gov/solicit-detail/80089

  Proposals Due: 01 September 2022

- Break the Ice Lunar Challenge - Phase 2
  https://breaktheicechallenge.com/

  Registration Closes: 30 September 2022 - Submission Deadline: 04 November 2022

- Space Technology Research Institutes (STRI) Solicitation
  https://nspires.nasaprs.com/external/solicitations/summary!init.do?solId=%7b000FAF75-9F37-814C-AC23-A21022A96037%7d&path=open

  Preliminary Proposals Due: 03 August 2022 - Invited Full Proposals Due 03 November 2022

- NASA Innovation Corps Pilot
  https://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7b1B42E782-61BB-9834-F20F-44CBEF13C0A6%7d&path=&method=init

  Proposals may be submitted at any time through March 29, 2023, but applications will be reviewed in intervals on the following dates: July 22, 2022; Sept. 16, 2022; Nov. 17, 2022; and Jan 20, 2023

Requests for Information

- STMD EXPLORE and LAND RFI
  STMD has released the third and final Request for Information (RFI), this time for the EXPLORE and LAND thrusts, in our series of STAR RFI's that are intended to help us learn from the space community what they think of our technology development priorities.
  https://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7b1B6EF822-99AE-AECA-6440-6F68C4A3FD31%7d&path=&method=init

  Responses due: 06 October 2022

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