Lunar Surface Innovation CONSORTIUM

LSIC Newsletter Volume 2 Issue 2 - February 2021

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.

Contents

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

Director's Update

In January we were excited to convene our first full Executive Committee meeting. Some of the key items we discussed were formalizing institutional membership, completing the LSIC Charter, and working to ensure that LSIC fosters communication between different groups within NASA as well as in the greater exploration community, without duplicating the work that other groups are doing. One of the issues that came up at the meeting, and that has come up at a number of LSIC events to date, is the question of standards. While developing or dictating standards is not something that LSIC is tasked to do, we may be in a strong position to provide input regarding what standards and guidelines would be most beneficial for ensuring compatibility in technology developed for flight. The standards themselves should be negotiated by industry members, with a likely leader for that effort being the LEAG Commercial Advisory Board (CAB). We will soon be reaching out to LSIC members through either the focus groups or through a dedicated meeting to provide input on the most critical areas for standardization, which could then be provided to the CAB.

In other news, we are targeting the end of April or early May for a two-day virtual Spring Meeting. An email with the final save the date should be sent out within the next week or so. Like the Fall Meeting, we will spend most of the first day with updates from NASA and LSIC, including more detailed presentations about the work the focus

groups have been doing over the last year and their goals for 2021-2022. On the second day, we will focus on networking and talks from the community.

Rachel Klima
Director, Lunar Surface Innovation Consortium
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Funding Opportunities

Updated Space Technology Mission Directorate (STMD) Solicitations & Opportunities Website
(https://www.nasa.gov/directorates/spacetech/solicitations)
STMD has updated their solicitations and opportunities website to streamline access to the funding opportunities available. It integrates all types of opportunities into "Open" or "Future" categories for easy perusal.

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

Break the Ice Lunar Challenge (https://breaktheicechallenge.com/)
Design a system architecture to excavate icy regolith and deliver acquired resources in extreme lunar conditions. Up to $500,000 in Phase I prizes is available. The Mission Scenario takes place in and around a permanently shadowed region (PSR) near the lunar South Pole. In this scenario, the mission will last 365 Earth days. The Challenge seeks solutions to maximize water delivery and minimize energy use and the mass of equipment required to be transported to the lunar surface.
Registration and System Architecture Submission Deadline: 18 June 2021

SAVE THE DATE!

Lunar Mapping for Precision Landing Workshop 02-04 March 2021

Save the Date for the LSIC Extreme Access Workshop dedicated to Lunar Mapping for Precision Landing. It will be held virtually 02-04 March 2021, and will run for about 3.5 hours per day. Registration and abstract submission will be opening soon, so stay tuned for an email with those details. The event will bring together as a community lunar scientists, data scientists, and navigation engineers that work on TRN systems for lunar landing. Navigation engineers will be provided with a deeper insight into the map data and the map building processes, and lunar scientists will receive an overview of map requirements needed to achieve navigation solutions for lunar TRN. Another objective of the event is to determine how the community can help NASA catalog existing tools, methods and approaches for building DEMs, for accurate rendering of the lunar surface, and for validation and verification of TRN systems. Check for details to be released on the event website by clicking here.

Feature Article: Gearing Up For The Dust Mitigation Workshop

LSIC is holding a Dust Mitigation Workshop on Thursday 04 February, organized by Jorge Núñez (Johns Hopkins Applied Physics Laboratory) and Michael Johansen (NASA). The objectives for the workshop are to update the state of dust mitigation and identify technologies that are already available, define gaps in knowledge and research, and get community perspectives. Output from this workshop will continue establishing dust mitigation protocols and technology to support a sustained presence on the lunar surface for organizations in industry, academia, nonprofits, all the way to NASA. The last day to sign up is today (01 February), so make sure to register if you plan to attend (click here for the event website).

The first half of the workshop will be dedicated to establishing what we know of the lunar dust environment and known knowledge gaps, as well as the current state of NASA's lunar architecture and dust mitigation strategies. The findings from two past events, the "Impact of Lunar Dust on Human Exploration Workshop" and the "Lunar Surface Science Workshop" will also be highlighted (and you're invited to review the event materials using the links above). A panel of NASA experts will speak to the organization's current dust mitigation and impacts on the proposed architecture.

Attendees will then roll up their sleeves in discussion groups to build a more comprehensive view of dust mitigation as seen from the wider lunar surface community. "We really hope to get into specifics," says Núñez. "We want details about the data you need before you can do your models, or what you need to interface with a specific architecture." Participants have already started the conversation by responding to registration questions about hurdles to be cleared for establishing a sustained presence on the lunar surface as well as specific technical gaps that need to be addressed.

"The idea is to get minds together for inputs on how to handle lunar dust," says Johansen. "Dust knows no boundaries; it affects everything. Solar cells, mechanisms, seals, hatches, textiles, you name it – there are a number of documented issues caused by interacting with these very fine, jagged, electrostatically charged particles." Industry, academia, NASA, and nonprofits will collaborate to define solutions that span every part of a lunar surface mission. Johansen mentions NASA's integrated dust strategy, "If you're a crew member on the surface, you worry about your spacesuit and how much dust you bring into the cabin. If you're designing crewed landers, you worry about plume surface interactions, dust in the cabin, and transferring dust to Gateway. If you're designing Gateway, you have to deal with the dust brought from the surface, as well as study what could be sent to Orion. Dust affects many if not all lunar systems in some way and requires consideration from all architectural elements. We're developing an integrated approach – operational and architectural considerations and a toolbox of technologies to solve the dust problem."

If you would like additional background about lunar dust and dust mitigation technologies, Clive Neal of the University of Notre Dame has put together an extensive list of resources that makes an excellent primer on those topics. The list can be accessed on LSIC's Dust Mitigation space on Confluence (click here to access that page). Note that only LSIC members who have requested access to Confluence will be able to reach this page – if you're interested in getting access, please email Andrea Harman at ams573@alumni.psu.edu.

Some great community feedback has already been received in response to two questions posed on the event registration form as folks are signing up. Please take a moment to consider these submissions as you're preparing to join us on 04 February. This workshop hopes to build on existing knowledge about

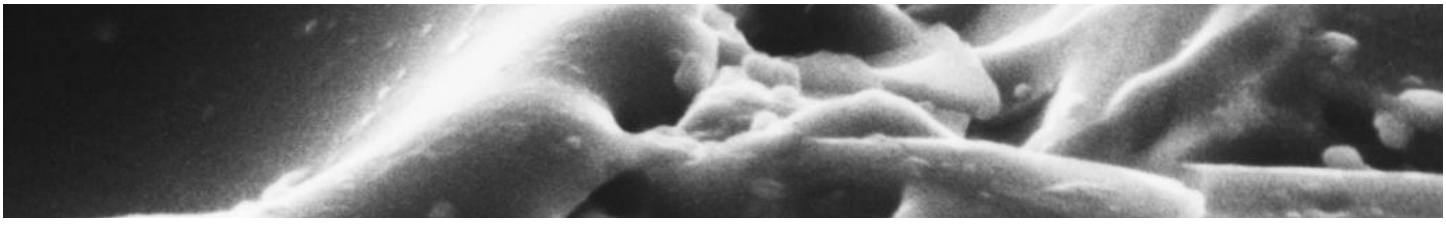
dust mitigation, and the answers we've been receiving help to lay that groundwork.

What do you think are the major hurdles in dust mitigation to overcome in order to establish a sustained presence on the Moon?

- Passively and actively removing dust from all aspects of lunar architecture / infrastructure
- Protecting moving parts and seals on equipment from lunar dust and guarding against friction / clogging
- Minimizing exposure to and infiltration of dust (especially in crew habitations)
- Predicting and modeling space weather and the lunar surface charging environment
- Establishing tolerances allowing systems to operate "dirty"
- Establishing a mechanistic understanding of dust to habitat or instrument interactions
- Assess and characterize electrostatic levitation
- Must develop and standardize simulants and testing conditions to capture real dust problems instead of approximations
- Landing, launch, and surface transport dust ejecta / plume mitigation
- Determine methods to prepare surfaces (grading, construction, coverings) to avoid dust generation
- Explore electrostatic effects on electronics
- Need to develop models for resolving surface attachment, detachment, and transport in detail with consideration of realistic geometries
- Dust disposal strategies
- Acquisition of ground truth plume/ejecta data from missions to validate modeling tools
- Developing lightweight, easy to clean, and controllable filtration materials for suits and habitats

Are there specific technical gaps in dust mitigation, from your perspective, that need to be addressed, and if so, which are the most time-critical?

- Dust seals and valves (and repeatable cleaning strategies)
- Dust removal tools
- Dust prevention technologies
- Dust purging mechanisms
- Dust resilient mechanics
- Dust repellent and abrasion tolerant coatings
- Dust sensors
- Dust tolerant joints, wheel bearings, and connectors
- Dust transfer prevention technologies
- Automation capabilities for all possible dust mitigation tools
- Mechanisms/linkages that perform latching and kinematic operations without sliding contact
- Insulation for motors and other moving mechanisms
- High performing low temperature materials
- High fidelity testing capabilities



S70-20417 (December 1969) --- Enlarged view shows hypervelocity impact of cosmic dust on broken glass particles, taken during the examination of Apollo 11 lunar material

Member Spotlight: Ohio State Center for Design and Manufacturing Excellence

The Ohio State University's Center for Design and Manufacturing Excellence (CDME) grew out of years of conversations with the College of Engineering and its industrial advisory board. The board, made up of a range of organizations – from national industry leaders, like GE and Honda Manufacturing, to local businesses – challenged Ohio State to develop a program that provided a hands-on industrial experience for students on campus to complement their internships and co-ops.

"Our real mission is experiential undergraduate education," says Ed Herderick, Director of Additive Manufacturing for CDME.

With a stated organizational goal of enhancing America's manufacturing competitiveness, students have the opportunity to work in a manufacturing environment that matches what they'll experience after graduation and in their careers.

"They're writing proposals. They're responsible for deliverables. They're getting their hands on the latest equipment and tools. You can't fake real, and the CDME students are directly contributing to customer projects."

Underpinning the student program, CDME manages one of the most extensive manufacturing user facilities in the United States. The facility is ITAR and EAR compliant while remaining open for use and collaboration. A few of their signature capabilities include six modalities of metal additive manufacturing, an artificial intelligence manufacturing systems lab, and large-scale welding systems.

"Some of our greatest hits involve our work on metal printing," shares Herderick.

CDME completed a project sponsored by the Air Force through America Makes focused on evaluating the use of multiple lasers in the printing process. GE and a Columbus, Ohio-based company called Proto Precision Additive were also partners. The outcome of that work is a new proposed standard for handling multi-laser powder bed infusion.

"That's a good representation of our teaming," says Herderick. "We had a big business in GE, a small business in Proto Precision Additive, and worked on the project with funding from America Makes and the Air Force Research Lab."

The center currently employs 75 undergraduate students. Eighty percent of the students are pursuing degrees in the College of Engineering, with the remaining 20% studying business, biology, physics, and a variety of other disciplines. The students work anywhere from 15-30 hours per week during the semester and are encouraged to take external internships in industry. Over the summer, they often work standard 40-hour work weeks. Supporting the students are 25 full-time staff who all come bearing industry experience. The breadth of work subjects at CDME is vast, with students working on biomedical research and medical devices as well as electrical engineering projects centered on the Internet of Things and cybersecurity.
"One of our pillars is applied research," continues Herderick. "When a professor invents a new welding system, we'll build that equipment."

CDME is no stranger to Space technologies, with several of projects in aerospace and other applicable fields. Ongoing projects include nuclear thermal propulsion as well as lunar surface power generation. That's in addition to designing rocket nozzles using additive manufacturing.

"A lot of it is cross-cutting," says Herderick. "We're trying to figure out how to speed up and lower the cost of metal printing so we can print larger parts. We're bringing online new technologies that will impact Space." The center also has a strong program in nuclear materials and power generation that map to future propulsion and long term energy production in Space. Dr. Herderick holds a joint appointment at the Department of Energy (DOE) Idaho National Laboratory and CDME has many ongoing collaborations with DOE.

With a facility and team equipped to produce and mature invention prototypes from early-stage TRL / MRL to full-scale systems for testing, CDME is ready for collaborations with NASA STMD and other stakeholders working towards a sustained lunar presence. Some project concepts to inspire discussion in support of efforts that may already be underway with LSIC members are:

- ISRU evaluation and prototyping for nuclear shielding
  - Demonstration of digging, building, and fabricating shielding for surface power under normal and accident operating conditions.
  - Modeling and trade study design of shielding capability of additives to ISRU.
  - Extension to protection and sensing for higher energy solar radiation.
- Artificially Intelligent Manufacturing Systems
  - Utilizing a combination of robotics, machining, additive, and forging with advanced vision systems and AI.
  - Enable new build and maintenance of complex systems for long term residence.
- Extreme environment materials manufacturing and testing
  - Dissimilar metal welding
  - Metamorphic Manufacturing (aka "robotic blacksmithing")
  - Coatings design, fabrication, NDE, and field testing

Getting started with CDME is simple, according to Herderick. "You just have to pick up the phone and call. It's about finding a shared interest or need in an applied topic. We meet, develop a scope of work, discuss a proposal, aim for funding, and then we go."

They complete quick turn projects in as little as two to four weeks as well as multi-year efforts. Potential partners can look forward to not only cutting-edge technology and research capabilities, but working with the undergraduates who will be shaping the industry's future starting with their undergraduate career work with CDME.

Contact Info for the Center for Design and Manufacturing Excellence (CDME)
https://cdme.osu.edu/

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NASA News

NASA Conducts Test of SLS Rocket Core Stage for Artemis I Moon Mission
16 January 2021 (RELEASE 21-006): NASA conducted a hot fire Saturday of the core stage for the agency's Space Launch System (SLS) rocket that will launch the Artemis I mission to the Moon. The hot fire is the final test of the Green Run series. The test plan called for the rocket's four RS-25 engines to fire for a little more than eight minutes – the same amount of time it will take to send the rocket to space following launch. The team successfully completed the countdown and ignited the engines, but the engines shut down a little more than one minute into the hot fire. Teams are assessing the data to determine what caused the early shutdown, and will determine a path forward. Click here to read more.

NASA, Government of Japan Formalize Gateway Partnership for Artemis Program
12 January 2021 (RELEASE 21-003): NASA and the Government of Japan have finalized an agreement for the lunar Gateway, an orbiting outpost that commercial and international partners will build together. This agreement strengthens the broad effort by the United States to engage international partners in sustainable lunar exploration as part of the Artemis program and to demonstrate the technologies needed for human missions to Mars. Click here to read more.

NASA, FAA Partnership Bolsters American Commercial Space Activities
08 January 2021 (RELEASE 21-002): NASA and the Federal Aviation Administration (FAA) signed a new memorandum of understanding (MOU) reaffirming the agencies' longstanding relationship to foster robust American commercial space transportation capabilities, including commercial crew and cargo activities. The NASA-FAA MOU follows the success of NASA's SpaceX Crew-1 launch – the first crewed mission from American soil to be licensed by the FAA. The new agreement will support the transportation of government and non-government passengers, cargo, and other payloads for orbital and suborbital space missions in a safe and cost-effective manner, as well as streamline spaceflight standards and requirements. Click here to read more.

Community Bulletin Board

MIT Space Exploration Initiative to run new graduate-level course (open-access) on "Operating in the Lunar Environment"
Submitted by Ariel Ekblaw, MIT Space Exploration Institute
Co-taught by LSIC's Ariel Ekblaw (Director of the SEI), and MIT AeroAstro Professor and ret. NASA Astronaut Jeffrey Hoffman, this course is a detailed exploration of the design and engineering challenges posed by operating in the lunar environment. Students will gain hands-on experience, working in teams, to design a payload to address strategic objectives associated with NASA's Artemis program, aiming to enable near-term sustainable settlements on the lunar surface. An extensive guest lecture program will present varying mission goals and operating environments, from lunar-class launch, to orbiters, landers, rovers, and habitats and will include prominent engineers, scientists, industry players and policymakers with direct experience in lunar mission design and development. We are looking for a) corporate sponsorship for this class, and b) nominations from the LSIC community for guest lectureships or panels (self-nominations are welcome). Course materials will be made open-access at tothemoon.pubpub.org and we warmly invite this community to follow along. You can reach the teaching team at: sei-lunar@media.mit.edu