Lunar Surface Innovation CONSORTIUM

LSIC Newsletter Volume 2 Issue 3 - March 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.

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Director's Update

We have just passed the one-year anniversary of the LSIC Kick-Off Meeting in which we introduced our effort to build this consortium to the community. Over the last year, LSIC has facilitated communications between hundreds of members through monthly meetings of each of the Surface Power, In Situ Resource Utilization, Dust Mitigation, Extreme Environments, Excavation and Construction, and Extreme Access focus groups, three one-day workshops on focused topics, and a larger two-day Fall Meeting. We are grateful to all of you for the time and energy you have contributed to helping us delve into the technical challenges of establishing a sustained presence on the Moon. We have had participants from over 260 different institutions involved, with members representing roughly 150 of those joining us regularly for focus group meetings and technical workshops. We look forward to many more exciting discussions as the focus groups set their annual goals and we continue to look for new ways to help develop and promote the community.

This year, we will be holding our spring meeting on May 11-12. These days will include updates from NASA, networking opportunities, and contributed technical content from the community. The Abstract portal will open soon, as we are still finalizing some of the details. However, you can expect that like the Fall Meeting, abstracts will be limited to 1 page, and will be due near the end of March or beginning of April. We are currently considering a third day on May 13th that would focus on funding related issues, including more information on proposal opportunities, tips for writing good proposals, and open networking time for members to discuss teaming.

We are also now moving forward with Institutional Memberships. LSIC will remain, as it has been, an open forum for individuals to participate in. For instance, you will not be required to have an institutional membership to access confluence. However, institutions that are formal members will be listed on new website (if they would like to be) and will need to designate a point of contact who we can reach out to for a better understanding of how we can meet the needs of their specific institutions. For instance, as we build the mentoring portal, we would like to have institutional representatives at

universities who can help us understand the needs of their students and how to reach them. Over the next few months, we will be reaching out to those who indicated they were interested in institutional membership. We will focus first on those who have been heavily involved in monthly focus group meetings and workshops, so please be patient.

Thank you all, again, for everything you have contributed over the last year. Here's to another great year as we help take humanity back to the Moon!

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

Focus Area Monthly Telecon Schedule

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

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

Funding Opportunities

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

See more funding opportunities on the LSIC website here:
http://lsic.jhuapl.edu/Resources/Funding-Opportunities.php

Feature Article: **Preparing For The Workshop On Lunar Mapping For Precision Landing**

In preparation for this week's LSIC Workshop on Lunar Mapping for Precision Landing, we sat down with the event organizers Angela Stickle and Carolina Restrepo to get their perspectives on the subject material, the goals of the event, and what they're looking forward to the most. While registration for the workshop is closed, presentations and videos approved for release will be posted on the event website as soon as possible (http://lsic.jhuapl.edu/Events/Agenda/index.php?id=120).

Carolina Restrepo is an aerospace engineer at NASA's Goddard Space Flight Center and currently the project manager for a project called Lunar Navigation Maps that will focus on building lunar maps that are more suited for Terrain Relative Navigation.

Angela Stickle is a Planetary Scientist at Johns Hopkins University's Applied Physics Laboratory, and also serves as the Extreme Access facilitator for the Lunar Surface Innovation Consortium (LSIC).

What is Terrain Relative Navigation (TRN)?

Carolina: Basically TRN helps you navigate with respect to things that you see. Just like you walk around a campus, and you know where you are based on what you see around you. For example, you see a building and search your brain for where you've seen this building before, what is it, and make a comparison between what you knew from before and what you see now. One you have a match you know where you are. TRN is exactly that. One example of TRN is a spacecraft that has onboard cameras, and on your way down it's taking images of the Moon's surface. Onboard is also a map that was uploaded before you fly. When you get there, you take pictures. For example, let's say the spacecraft takes a picture of a crater and it compares that picture to the onboard map and finds the same crater. It can then calculate where it is with respect to that map. So by comparing images to that map, you would know your latitude and longitude and how you are pointed. Another form of TRN is that you don't have an onboard reference map so instead, you identify surface features in the camera images and track them. You know which way you're moving because you know which way the features are moving from image to image. This type of TRN helps you figure out which direction you're going in and how fast, but doesn't tell you where you are in the Moon, it only tells you where you are relative to what you saw.

Angela: That was a great description. The reason we care about TRN for the Moon is that we have a lot of data from the Moon from orbiters and past missions. We have a lot of images, and we know where we want to go for science and human exploration. We need to know where we are when we're landing to ensure that we land where we want to be. So we can make maps from the data that we have and use TRN to make sure that we land our robots and humans in the correct spots. There's also active hazard avoidance, which is when you take a picture, but the algorithm evaluates that picture and says, 'I'm headed towards a rock, and should move to not hit that rock,' and then does it autonomously. When you're landing you look for big craters or boulders. If you see the videos from Apollo 11, Neil Armstrong is joy sticking around to avoid craters, and now the computer does that instead of an astronaut. Or if you have a rover and there's a big rock, the rover has to know - you have to have a good idea of where those rocks are. So folks are interested in hazard avoidance too in terrain relative navigation. We'll talk about the data

useful for that on day 3.

Carolina: I know people also care about hazard detection. On day three we plan to talk about modeling and rendering small surface features.

What are the goals for the meeting?

Angela: We want to bring together a large swath of the community, including NASA representatives, industry interested in lunar landing and ways to do that safely, as well as folks from the science side with experience with data that has been collected about the Moon, and with algorithm development. We want to get all the stakeholders in one room to talk about what data is available, what data we need, and what people have questions about. We want to understand the state of the art in terms of landing on the Moon. In particular for the LSIC Extreme Access focus group, we're trying to get an understanding of what technologies are important, along with what types of data analysis tools and sensors need to be developed to allow us to access all parts of the Moon safely.

Carolina: Really the purpose is to connect people who don't normally connect who need to work together for lunar TRN to be successful. For example, navigation engineers don't usually work with lunar geologists or data scientists who build the maps, though these topics are very intricately related for lunar TRN. We want engineers to really have a better understanding of where map data comes from and what errors it comes with, so they know how to use it (and how NOT to use it!). We want the scientists and those working on making those models and maps of the Moon exposed to end users so they understand how they'll be used for navigation. Using them for navigation is different than using them for science. We want people to understand the challenges unique to lunar TRN, and specifically unique to reaching the South Pole sites, that are not present in other TRN problems like Mars 2020 or Osiris-Rex, which didn't face the same kinds of issues. We're trying to bring people together who don't normally work with each other to find the solutions we're still missing for upcoming lander missions. We don't want to lecture people, we want to get the community's help in steering NASA and LSIC to catalog the existing tools and methods that work, and leverage those conversations to explore what we're missing as a whole. We want to collect information on where we are as a community, and where we need to go.

Angela: Another goal is to put the people who know the most about the data, how it's used and validated, in the room with people who need to use the data. They can answer questions about how the specific maps were made. For example, if people are interested in a specific landing site, like if one of the smaller CLPS landers wants to go to the South Pole near Artemis base camp, they'll need data, and will want to understand how they go about finding and verifying that data. We're aiming to have the folks in the room that know the answers to those questions.

What are you most excited about sharing?

Carolina: Really I'm more interested in finding out things that I don't know, like how you make Digital Elevation Maps (DEMs). I'm excited to understand how to process all the orbital imagery needed to build maps of the Moon, as well as what some of the inherent errors that come with those maps are.

Angela: I'm excited to show off the lunar data. I spend a lot of my time looking at data and images of the Moon. We have an amazing amount of data from recent missions like the Lunar Reconnaissance Orbiter (LRO) and the JAXA Kaguya mission. Sometimes I think if you don't 'grow up' scientifically using the data

MAF_20210211_EUS_PanelLift01 (11 Feb. '21): *Lift of three EUS test panels in VWC at Michoud Assembly Facility on Thursday, February 11, 2021. Technicians are manufacturing and testing the first in a series of initial weld confidence articles for the Exploration Upper Stage (EUS) for future flights of NASA's Space Launch System (SLS) rocket at the agency's Michoud Assembly Facility in New Orleans.*

like I did, it can be overwhelming and difficult to know what the breadth and depth of the data is. I'm excited to be able to show off all the lunar data we have, along with both the maps that exist and others we can make. I want people to have a better sense of what's available for their missions.

Carolina: And to tell people where to get it too, that's an issue as well.

What are you looking forward to hearing from attendees of the workshop?

Angela: I'm excited to hear what people think are the biggest tent poles and challenges. I think identifying whether they need more data, or better maps, or validation sets or something, that's our first step in making a really successful and capable suite and robust tool set across the community. I'm excited to hear what people think the issues are, and see what we can do to help the community work through them.

Carolina: I'm just looking forward to finding out and helping people understand better what the needs are right now, and move towards removing obstacles to developing TRN systems. I also hope that we can understand the needs of academia so we can make things easier for developing algorithms given the right maps.

Additional reading about TRN and hazard detection can be found at these links:

- Landing NASA's Mars 2020 Rover with Terrain Relative Navigation https://mars.nasa.gov/resources/22592/landing-nasas-mars-2020-rover-with-terrain-relative-navigation/
- A Neil Armstrong for Mars: Landing The Mars 2020 Rover https://mars.nasa.gov/news/8456/a-neil-armstrong-for-mars-landing-the-mars-2020-rover/
- Cooperative Blending Of Autonomous Landing Technology (COBALT) https://gameon.nasa.gov/projects/cooperative-blending-of-autonomous-landing-technology-cobalt/
- Safe and Precise Landing – Integrated Capabilities Evolution (SPLICE) https://www.nasa.gov/directorates/spacetech/game_changing_development/projects/SPLICE/about
- Automated Technology Allows Unparalleled Space Exploration From Moon, To Asteroids, And Beyond http://spaceref.com/moon/automated-technology-allows-unparalleled-space-exploration-from-moon-to-asteroids-and-beyond.html
- Terrain Relative Navigation: Landing Between The Hazards https://science.nasa.gov/technology/technology-highlights/terrain-relative-navigation-landing-between-the-hazards

Member Spotlight: **NASA TechPort**

What is TechPort?

TechPort is a web-based information system that showcases NASA technology development across numerous disciplines including propulsion, avionics, power, robotics, sensors, and more. TechPort provides key insights on past, current, and planned developments, transforming this data into information that enables new discoveries, analyses, collaborations, and partnerships. The objective of TechPort is summarized in its motto: find it, build it, share it.

TechPort Benefits

Sharing NASA technology achievements expands the frontiers of knowledge and capabilities in aeronautics, science, and space exploration, and creates opportunities for U.S. industry and academia. By making this information available to the public, NASA fuels entrepreneurship, innovation, and scientific discovery. Through this system, NASA's partners can access information about novel technologies being developed at the Agency, and use that information to identify new opportunities for collaboration and technology advancement.

Screenshot of the TechPort home page, highlighting most viewed, recently completed, and new technologies.

For NASA, TechPort enables the Agency to create a comprehensive technology development strategy, supporting the prioritization of investments and gap analyses while reducing duplication of effort. This ensures the Agency is advancing the state of the art in the most effective and efficient manner possible.
TechPort contains a wealth of information about each technology development, including a detailed description of the technology, the anticipated benefits it provides, the locations where this work is being performed, and the organizations working on each project. Points of contact are provided to encourage communication and partnership development, as well as to provide additional information upon request. Many TechPort entries also provide a rich library of images, published research papers, journal articles, and success stories. Recently, TechPort also began tracking "target destinations" for each technology, including the Moon, Mars, the Sun, and other destinations inside and outside the Solar System.

An Example of What You Might Find in TechPort

Currently, TechPort contains information on over 12,000 technology development projects. NASA has over 40 programs conducting applied research and experimental development projects. These projects span the entire technology maturity scale from basic observations and concept development to prototypes, space environment demonstrations, and "flight proven" mission operations.
TechPort provides comprehensive search capabilities, facilitating both broad keyword searches and in-

An example of a TechPort search that displays all of the human health and life support technologies destined for the Moon.

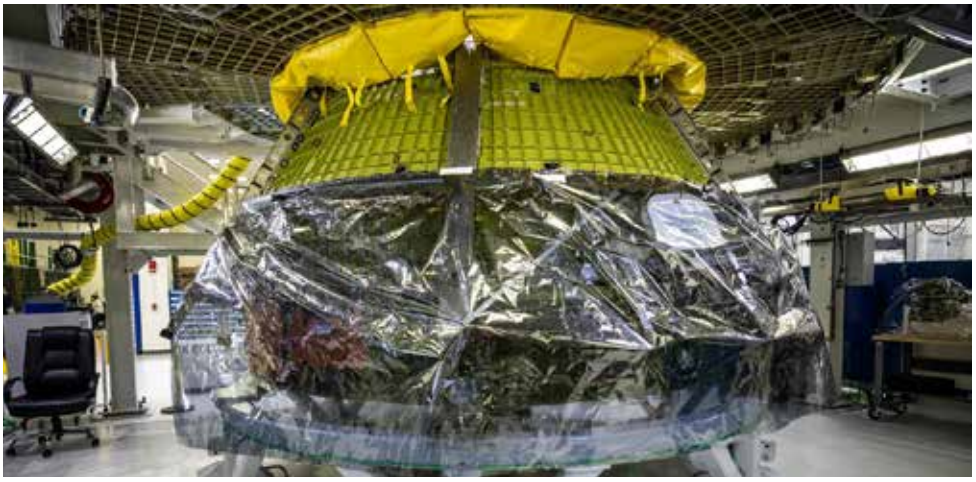
depth, structured searches. For example, users can construct a search that identifies all of the NASA human health and life support technologies destined for the Moon. Each set of search results is accompanied by dynamic rollup reports that provide visualizations of key aggregate facets for all of the technologies matching those criteria. These reports include summaries of the technology areas supported, overall maturity, work locations, and partners.

TechPort is also home to the NASA Technology Taxonomy, a hierarchical structure used to categorize technologies by 17 distinct technical disciplines. The taxonomy is a foundational element of NASA's technology management process. NASA mission directorates reference the taxonomy to solicit proposals and to inform decisions on NASA's technology policy, prioritization, and strategic investments. Each TechPort entry identifies the Taxonomy element that best describes that project, as well as references to other cross-cutting elements that may supported by the project.

Where can I find more information?

To access TechPort, go to https://techport.nasa.gov. If you have a specific question, or are interested in certain technologies, you can always contact the TechPort team at hq-techport@mail.nasa.gov. The TechPort team always welcomes user feedback, and would be very interested in learning about how you use the information found in the system.

For data scientists and technology researchers, TechPort also provides a full-featured application programming interface (API) that enables programmatic access to this data for further analytics. More information on the TechPort API can be found on the TechPort help page at https://techport.nasa.gov/help, and in the API specification at https://techport.nasa.gov/api.



KSC-20210205-PH-KLS02_0026 (05 Feb. '21): *A close-up view of Orion's Artemis II crew module inside the Neil Armstrong Operations and Checkout Building high bay at NASA's Kennedy Space Center in Florida, on Feb. 5, 2021. The capsule will house astronauts during its mission around the Moon. Recently, teams removed the spacecraft from its clean room environment, where they have been performing the buildup of the Environmental Control and Propulsion System (ECPS) assemblies prior to their installation into the crew module.*

NASA News

NASA Awards Contract to Launch Initial Elements for Lunar Outpost
09 February 2021 (RELEASE 21-015): NASA has selected Space Exploration Technologies (SpaceX) of Hawthorne, California, to provide launch services for the agency's Power and Propulsion Element (PPE) and Habitation and Logistics Outpost (HALO), the foundational elements of the Gateway. As the first long-term orbiting outpost around the Moon, the Gateway is critical to supporting sustainable astronauts missions under the agency's Artemis program. Click here to read more.

NASA Selects Firefly Aerospace for Artemis Commercial Moon Delivery in 2023
04 February 2021 (RELEASE 21-012): NASA has awarded Firefly Aerospace of Cedar Park, Texas, approximately $93.3 million to deliver a suite of 10 science investigations and technology demonstrations to the Moon in 2023. The delivery, planned for Mare Crisium, a low-lying basin on the Moon's near side, will investigate a variety of lunar surface conditions and resources. Such investigations will help prepare for human missions to the lunar surface. Click here to read more.

NASA Names Leaders to Key Agency Roles
01 February 2021 (RELEASE 21-008): NASA has named appointees for senior agency positions. Bhavya Lal joins the agency as acting chief of staff, Phillip Thompson will serve as White House liaison, Alicia Brown will serve as associate administrator for the Office of Legislative and Intergovernmental Affairs, and Marc Etkind will serve as associate administrator for the agency's Office of Communications. In addition, Jackie McGuinness will join the agency as press secretary and Reagan Hunter will serve as special assistant for the agency's Office of Legislative and Intergovernmental Affairs. Click here to read more.

Community Bulletin Board

Earth & Space Conference: Engineering for Extreme Environments Announcement
Submitted by Paul Van Susante, Michigan Technological University
Registration is now open for the virtual ASCE Earth & Space 2021 Conference: Engineering for Extreme Environments to be held from April 21-23, 2021 (postponed from April 2020 due to COVID).
This conference brings 184 presentations from government, industry and academia (181 papers) spread over 5 symposia in 5 parallel tracks, 3 plenaries and a short course "Engineering and Construction on the Moon" just before the conference.

Monday, April 19 | 1:00 pm - 4:45 pm - Part 1
Tuesday, April 20 | 1:00 pm - 4:00 pm - Part 2
https://www.earthspaceconference.org/program/short-course

General conference website: https://www.earthspaceconference.org/
Program and schedule: https://www.earthspaceconference.org/program/symposium-description

Please join us for the conference focused on ISRU, space mining and construction and the engineering this requires! I look forward to seeing you all there!

Paul van Susante, Technical Chair
Alaina Roberts, General Chair