Lunar Surface Innovation Consortium

LSIC Newsletter Volume 1 Issue 2 - August 2020

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

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

As we move into August and focus groups continue ramping up discussions about critical technical challenges and year one goals, we are working to provide alternative platforms for discussions and networking among the community. We have a new LSIC group on LinkedIn (linkedin.com/groups/13861869/), which we will use to cross-post funding opportunities and other updates. It is a members-only group, but open to anyone who has signed up for LSIC through our website. We encourage members to join and make use of this space if you're looking for teaming opportunities, for instance for proposals to LuSTR, which will be due in September.

One of the objectives of our focus group discussions about critical challenges will be to identify what technologies need to be next in the queue for funding, so I encourage everyone to make your voices heard. Our fall meeting will be much more geared towards technical discussions, so please stay tuned through our focus groups as we will be soliciting input in advance to help prepare for these.

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

Fall Meeting

Please save the date for the LSIC Fall meeting, which will be held virtually on Oct 14-15, 2020.

In the coming months we will be introducing you to LSIC's six focus groups. This month we are sharing information about the In Situ Resource Utilization group and their facilitator, Karl Hibbitts.

Focus Group Feature: In Situ Resource Utilization

The ISRU focus area will advance technologies for the collection, processing, storing, and use of material found or manufactured on other astronomical objects. This will require TRL maturation of various applicable technologies. Examples of topics to be explored are demonstrating systems for collecting and purifying water on the lunar surface, sorting granular lunar regolith by size, and methods for measuring mineral properties / oxygen content before and after processing. Presentations, notes, and recordings of past ISRU monthly meetings are available here: lsic.jhuapl.edu/Focus-Areas/In-Situ-Resource-Utilization.php

Facilitator: Karl Hibbitts (Facilitator_ISRU@jhuapl.edu)
As a planetary scientist, Dr. Karl Hibbitts conducts research to understand the compositions of the surfaces of airless bodies in our Solar System, including how otherwise volatile materials like water can exist on the illuminated Moon. He is deputy-PI of the Europa Clipper MISE infrared mapping spectrometer and was deputy-PI and mid-IR camera lead on the NASA BRRISON and BOPPS stratospheric balloon missions that demonstrated the scientific and cost effectiveness of spectral imaging of solar system objects from NASA balloon platforms in the upper stratosphere. Dr. Hibbitts also leads an active planetary laboratory spectroscopy effort in a facility he developed at APL that couples VUV –LWIR spectral capabilities with a UHV system capable of mimicking the vacuum, temperature, and radiation environments of the Moon and other airless bodies in our solar system.

ISRU Sub-Group Leads: H_2O and O_2

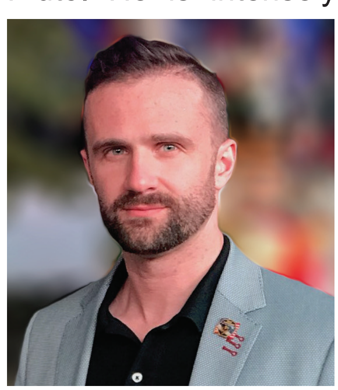
ISRU has two sub-groups that are exploring specific volatiles present on the lunar surface. Our feature article this month, "A Tale of Two Volatiles," shares more detail, and the two leads are introduced here.

O_2 Lead: Michael Nord

Michael Nord is a member of the Principal Staff at JHU/APL. He received a Ph.D. in Physics in 2005 from the University of New Mexico on the topic of low frequency radio imaging of the Galactic Center. His main research interest is radio frequency remote sensing of the Earth and of planetary bodies. He currently leads the oxygen extraction subgroup of the LSII ISRU focus group.

H_2O Lead: Kirby Runyon

Dr. Kirby Runyon is a planetary geologist specializing in the geomorphology and stratigraphy of solid planets, especially the Moon, Mars, and Pluto. He is intensely interested in supporting robust lunar exploration, utilization, and scientific research of and from the Moon. Within LSIC and LSII, Kirby supports ice-focused ISRU technology assessment.



A Tale of Two Volatiles:

Exploring Water and Oxygen as In-Situ Resources for a Sustained Lunar Presence

On the Moon, it can be the lightest of times (continuous sunlight for two weeks) or the darkest of times (in one of the many permanently shadowed regions (PSRs), but either way, careful planning and consideration of in-situ resource utilization (ISRU) will be a vital component sustained human presence to enable them to “live off the land.” That’s why LSIC’s ISRU focus group has created two sub-groups to focus on water (H_2O) and oxygen (O_2), to delve into how they can be accessed and utilized on the lunar surface. Focus group members widely supported the creation of the two sub-groups, and there’s a large overlap (over 90%) in participants planning to serve on both. The approaches, materials involved, and extraction technology for each can be very different, though there are opportunities for parallel processing to make the most of limited power and available equipment.

Uses for H_2O on the lunar surface include drinking water, dust mitigation, plant cultivation, as well as what is expected to be the greatest need: production of oxygen and possibly hydrogen for use as propellant. Water has the additional advantage of being recyclable for other applications other than propellant: “You can keep splitting and combining that water over and over in fuel cells,” said H_2O lead Kirby Runyon, “there are a lot of uses for water on the Moon, and you can keep re-using it again and again.” One area already identified as a topic for a trade study would be analyzing whether it’s more cost effective to bring water from Earth for uses where it can be recycled or to build up the infrastructure to extract it from the lunar surface.

For propellant usage, it is clear that in-situ extraction of water offers great benefits—if the technology challenges can be resolved! Because O_2 makes up about 80% of rocket fuel by mass, obtaining it locally would be a major asset in sustaining long-term operations between the Earth and the Moon, and even Mars. A great case study for a complete system development around gathering and utilizing lunar in-situ resources could be developed by considering all the aspects of oxygen extraction and storage from ice in PSRs. Technology challenges extend beyond extraction of the water and electrolysis to create O_2 and H_2. The technology would have to be continuously supported to enable long-term lunar operations, the O_2 would need to be purified, condensed, and stored. PSRs are an excellent candidate location for storage, with temperatures often below what would be necessary to keep the oxygen in liquid state, but how do you get the large tanks that would make this possible to a PSR in the first place? Questions remain about the form and distribution of ice in PSRs (snow vs. ice), depth (at or below the lunar surface), and other accessibility concerns. As stated by O_2 lead Michael Nord, “It’s like saying ‘there’s oil in Texas.’ That’s good to know, but to use that oil you still have to determine exactly where to drill, at what depth, and how to build that drill.”

O_2 extraction directly from the regolith offers an attractive option for propellant production. A critical difference between water and oxygen is that the latter is already confirmed to be present in all regolith on the lunar surface at an abundance of ~ 40%. While the oxygen on the Moon isn’t ‘free’, but

Continued on page 4...

AS12-46-6832 (19 Nov. 1969) --- A close-up view of a lunar mound as photographed during the Apollo 12 extravehicular activity (EVA) on the lunar surface. Astronaut Richard F. Gordon Jr., command module pilot, remained with the Apollo 12 Command and Service Modules (CSM) in lunar orbit while astronauts Charles Conrad Jr., commander, and Alan L. Bean, lunar module pilot, descended in the Lunar Module (LM) to explore the Moon.

...continued from page 3.

rather present in silicate minerals, while no matter where on the Moon you land, you'll be surrounded by an ore deposit of O_2. Also, the technology to extract O_2 from regolith is the same technology that used on Earth to extract metals from some soils, but in the lunar application , one person's trash is another's gold….the O_2 that is a 'waste product' for terrestrial production is the most valuable product when operated on the Moon. The oxygen sub-group hopes to build a scientific and engineering consensus around an approach that would capture the oxygen and sustainably store it, and possibly refine the metal by-products as well. As for H_2O utilization, this perspective ripples out to a larger system-wide approach that would cover everything from setup (power requirements, chemical reagents needed, handling temperatures, purification etc.) to long-term maintenance and operations.

The development of sustained utilization of both H_2O and O_2 will have parallel paths. There will be a need for defining requirements to enable established as well as new technologies to successfully interface. Working glove in glove with other lunar technologies will be of paramount importance for any extraction technology.

Member Feature: EXTEC at Texas A&M University

Texas A&M University's Extraterrestrial Engineering and Construction (EXTEC) Research Initiative leverages interdisciplinary collaborations and accelerates the development and testing of materials and methods for on- and off-Earth civil engineering and construction solutions. Their ongoing work explores, develops, and validates applied infrastructure solutions through robust modeling, simulation, and rigorous experimentation. EXTEC facilitates interdisciplinary research teams across the Texas A&M Space Alliance (TAMSA), within NASA, and across industry and academia. This approach also aims to uncover synergies between STMD, HEOMD, and SMD areas of interest.

A sampling of EXTEC's focus areas and projects are described here, along with laboratories and testing capabilities.

Dust to Structures
D2S is an integrated program to develop in-situ resource utilization (ISRU) - based materials and methods for building horizontal infrastructure (e.g., landing pads, pavers, roads, tiles) on the Moon. Current projects include development of regolith-polymer mix for 3D printing and real granular morphological and mineralogical modeling and testing of simulants and samples.

Lunar Surface Experiments Program
LSEP is a step-wise program to establish the science, engineering, and materials knowledge base required to inform models and methods for building lunar infrastructure. Initial experiments, to be flown on early CLPS missions, will test 3-phase (solid/liquid/gas) fluid dynamics in 1/6 g, novel solar cell power generation and radiative coating performance in the dusty lunar environment.

SpaceCRAFT Virtual Reality "Sandbox"
SpaceCRAFT VR is a high-fidelity, physics-based solar system simulator made for large scale engineering system design, integration and collaboration.

Continued on page 5...

...continued from page 4.

Semi-Autonomous Navigation of Detrital Environments (SAND-E)
Martian science and operations analog studies using rover path-planning through AI-enabled terrain interpretation and unmanned aerial systems.

Laboratories and Testing Capabilities
- Advanced Characterization of Infrastructure Materials Lab
- Advanced Infrastructure Materials and Manufacturing Lab
- Small-to-Large Scale Structural/Vibrational Testing
- Soil and Unbound Materials Lab
- Hypervelocity Chamber for Meteoritic Impact Testing
- Center for Radiation Engineering and Science for Space Exploration
- Aerospace Human Systems Laboratory (AHSL, PoC: bjdunbar@tamu.edu)
- Human-Rated Short-Radius Centrifuge (Acquired from JSC, housed in AHSL)
- AeroSpace Technology Research and Operations (ASTRO) Lab
- Land, Air and Space Research Lab (LASR)
- Aggie Satellite Lab (to build space-ready instruments)

For more information about the EXTEC Research Initiative at Texas A&M, or any of its programs or facilities, please contact Nicole Shumaker (Team Lead, NASA and Industry Liaison) at nshumaker@tamu.edu or visit their website at tx.ag/extec.

This view of Earth rising over the Moon's horizon was taken from the Apollo spacecraft. The lunar terrain pictured is in the area of Smyth's Sea on the nearside. Coordinates of the center of the terrain are 85 degrees east longitude and 3 degrees north latitude.

Current & Upcoming Funding Opportunities

The **Lunar Surface Technology Research (LuSTR) Opportunities** have been released, with notices of intent due by August 12th and proposals due September 9th. Proposals must be led by an accredited U. S. university, but teaming and collaboration with other types of institutions are permitted. Awards are expected to be in the range of $1-2 million. For more information, please review the announcement at: https://nspires.nasaprs.com/external/solicitations/summary.do?solId={0BA38320-8F63-2EAF-D97B-0AB42AF17C35}

The Watts on the Moon Centennial Challenge request for information (RFI) commenting period closed near the end of last month. Further details and rules for the challenge will be distributed on the LSIC_announce listserv as soon as they are available. To view the RFI, please visit: https://beta.sam.gov/opp/49229d99c461439287ead92292c96e23/view?keywords=80MSFC20LST0701&sort=-relevance&index=opp&is_active=true&page=1