



Lunar Surface Innovation

C O N S O R T I U M

LSIC Excavation and Construction Focus Group

Kick-Off Meeting

June 26, 2020



JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

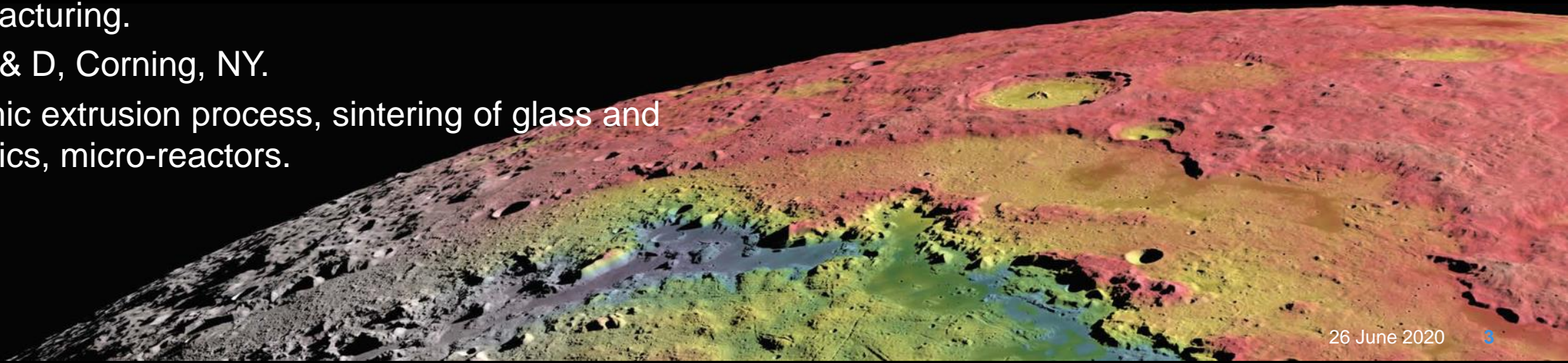
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Senior Professional Staff
Space Exploration Sector
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Agenda

- Introductions.
- LSII and LSIC programs.
- Excavation and Construction (E&C) focus group.
 - Technical areas and driving questions.
- Communication strategy and focus group goals.
- Next steps.
- Discussion.

Introductions: About Me

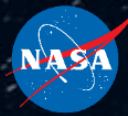
- B.S. in Mechanical Engineering
 - Indian Institute of Technology, Kanpur, India.
- Ph.D. in Mechanical Engineering
 - Stony Brook University, NY.
- Experience:
 - Space Exploration Sector at APL (present)
 - Directed energy, spacecraft design.
 - General Electric (GE) Global Research, Schenectady, NY.
 - Ceramics Matrix Composites (CMC) for aircraft engines, solid-oxide fuel cell (SOFC), turbine blade manufacturing.
 - Corning R & D, Corning, NY.
 - Ceramic extrusion process, sintering of glass and ceramics, micro-reactors.



Introductions: About You

- Please provide an introduction (in the chat) to the group including:
 - What is your name?
 - Where do you work?
 - What specific things you want to get out of this focus group.

Note: These chat introductions will be captured and distributed to the focus group.



Lunar Surface Innovation Initiative (LSII)

Space Technology Mission Directorate (STMD) develops and performs demonstrations that allow the primary technology hurdles to be retired for a given capability at a relevant scale. While there may be additional engineering development required for scale-up, there should be none required for the foundational technologies.

In Situ Resource Utilization

Collection, processing, storing and use of material found or manufactured on other astronomical objects

Surface Power

Enable continuous power throughout lunar day and night

Extreme Access

Access, navigate, and explore surface/subsurface areas

Surface Excavation & Construction

Enable affordable, autonomous manufacturing or construction

Lunar Dust Mitigation

Mitigate lunar dust hazards

Extreme Environments

Enable systems to operate through out the full range of lunar surface conditions



- Accelerate technology readiness for key lunar infrastructure capabilities enabling technology demonstrations for early un-crewed commercial missions, as well as informing development of crewed flight systems.
- Implement through a combination of in-house activities, competitive programs, and public-private partnerships.
- Coordinate with NASA's Science Mission Directorate and Human Exploration and Operations Mission Directorate to identify priorities.

LSIC Objectives

1. Harness the creativity, energy and resources of academia, industry, non-profits and government in order for NASA to keep the United States at the forefront of lunar exploration
2. Identify lunar surface technology developments most in need of sponsor support and communicate those to NASA
3. Provide a central resource for gathering and disseminating information, results, and documentation



Specific Goals

- Identify technology needs
- Serve without bias
- Develop talent
- Build community
- Serve as an information clearinghouse
- Host regular cross-community meetings
- Lead and coordinate focus groups
- Enable site visits from LSIC and LSII leadership
- Establish mentoring relationships among members

Focus Groups are the primary means through which LSIC interacts with the community.

Charter & Structure

- **Technology** – Accelerate the development of key lunar surface infrastructure capabilities
- **Collaboration** – Enable meaningful partnerships across industry, academia, and government that leverage common goals and objectives for establishing lunar surface infrastructure capabilities
- **Communication** – Create information paths and relationships to best match needs with opportunities
- **Future Workforce** – Ensure that the U.S. maintains the workforce needed for sustained space exploration

The LSIC is a nationwide alliance of universities, non-profit research institutions, commercial companies, NASA centers and program offices, and other government agencies with a vested interest in our nation’s campaign to establish a sustained presence on the Moon.



Technology Focus Groups ➤



Value to Industry

- *Access to contextual information for lunar surface*
- Early identification and collaboration with emerging technologies from academia
- Influence into setting of standards together with greater community
- *Ability to identify technology gaps and suggest technical priorities for NASA*
- Mentoring by established companies
- *Recruiting of new talent*
- *Frequent communications with sponsor. Funding information (SBIR, STTR, NIAC, etc.)*

With a value proposition for each constituency, the LSIC will have the support needed to carry it forward, and in turn, to sustainable operations on the surface of the Moon.

Value to Academia

- *Gain insight into gaps where R&D is needed*
- Job/internship placement for students
- *Partnerships with industry for maturation and implementation of new technology*
- Communication with the sponsor
- Means to build reputation for their programs
- *Insight into upcoming university-targeted funding opportunities*

With a value proposition for each constituency, the LSIC will have the support needed to carry it forward, and in turn, to sustainable operations on the surface of the Moon.

Value to Government

- Finger on the pulse on the community
- Visibility into technology development
- Opportunity to suggest early course corrections
- Conversations with the community as they set standards and interfaces
- A readily available resource for rapidly addressing emerging needs
- Effective venue to communicate their needs to the providers

With a value proposition for each constituency, the LSIC will have the support needed to carry it forward, and in turn, to sustainable operations on the surface of the Moon.

- Assist NASA in developing technologies that enable affordable, robust, autonomous manufacturing and construction on the lunar surface to establish a sustained human presence.
- Identify needs and determine how to address critical challenges to E&C.
- Focus group will enable all categories of members.
- Facilitator Role:
 - Manage focus group and ensure clear communication.
 - Organize focus group to maintain alignment with NASA STMD expectations, LSII Leadership, and LSIC Executive Committee.
- There will be opportunities to lead and participate in subgroup tasks

Focus Group Composition

Academia : 37%
Government : 21%
Industry : 41%



RASSOR



3D Printed Habitat Challenge

Consortium activities include two large semiannual meetings and off-cycle virtual meetings for each technology area focus group

**LSIC
SPRING MEETING
@ APL**

Each focus group conducts virtual meetings to identify and discuss critical needs

**FOCUS
GROUPS**

**PROPOSAL
OPPORTUNITIES:
BAAs, RFPs, PPPs**

**TARGETED
SITE VISITS**

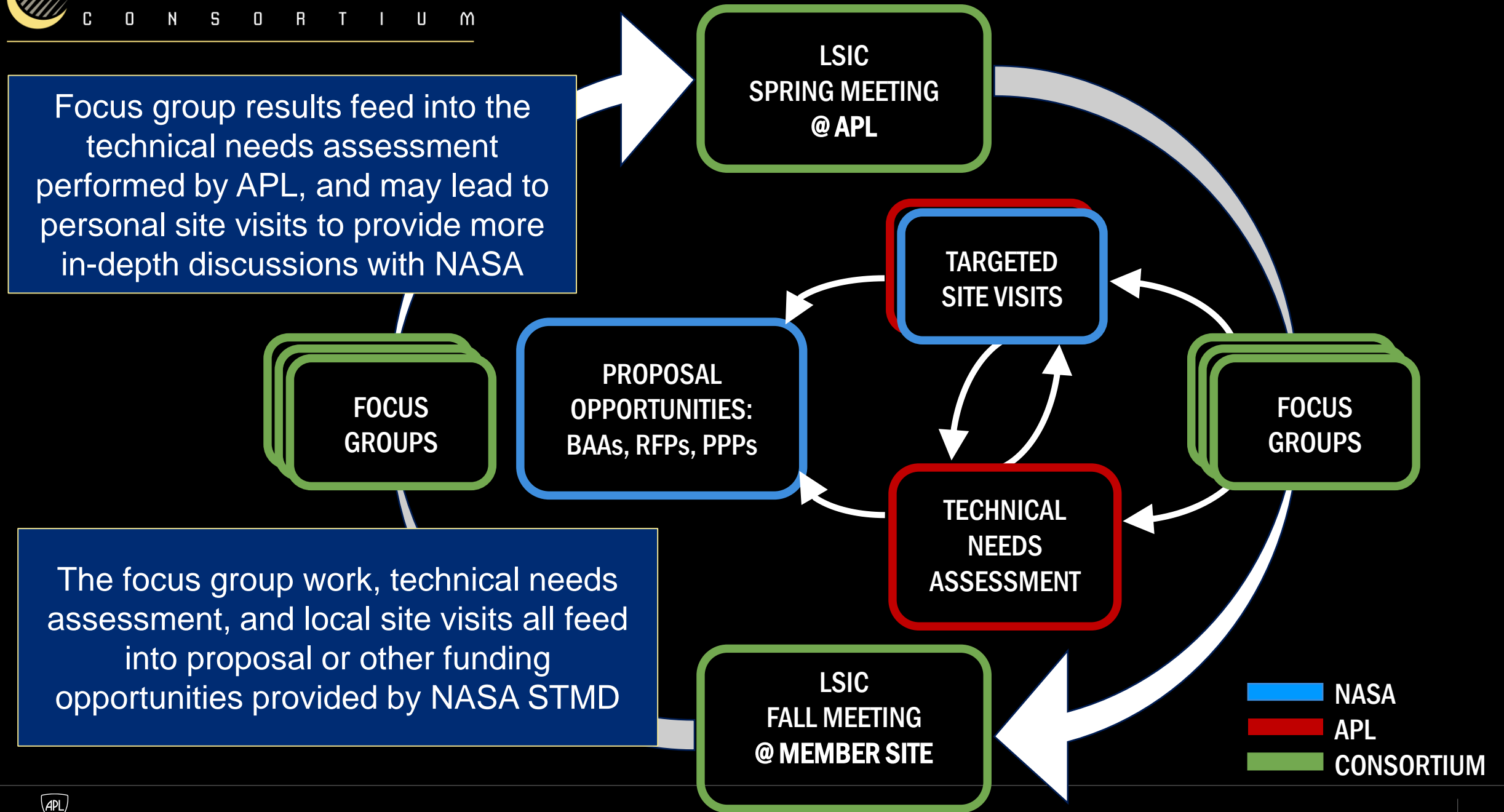
**FOCUS
GROUPS**

**TECHNICAL
NEEDS
ASSESSMENT**

The Fall meeting will feature a specific technology, in addition to status reports from each focus group

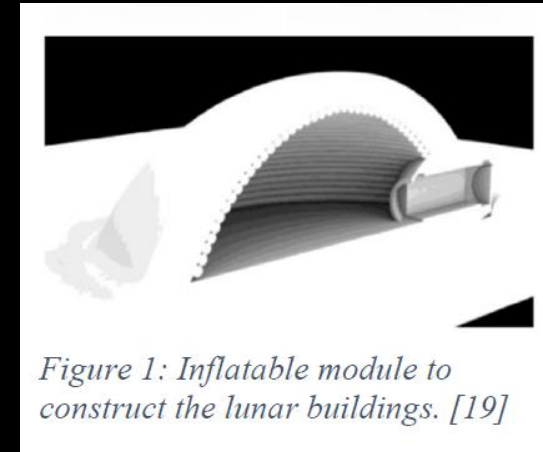
**LSIC
FALL MEETING
@ MEMBER SITE**

NASA
APL
CONSORTIUM



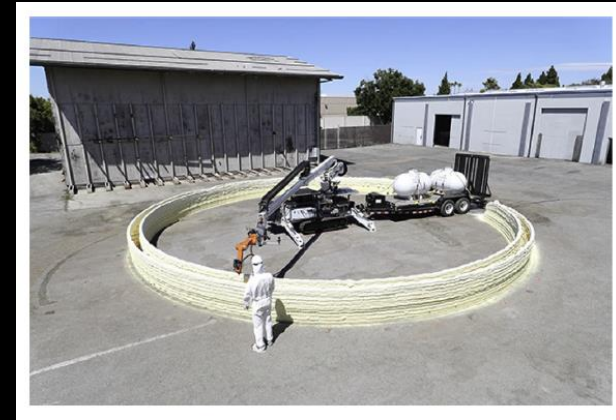
E&C Technology Areas (Based on feedback from the group)

1. Autonomous vehicle and robots for E&C.
 - a. Long-distance travel and maneuverability in lunar landscape.
 - b. Special robot technology for lunar applications.
2. Excavation technology for hard regolith/icy material.
 - a. Special drilling technologies.
 - b. Mining using directed energy.
 - c. Lightweight construction equipment: lunar crane, excavator design, etc.
 - d. Site characterization.
3. Habitat construction in lunar conditions using in-situ resources and specialized manufacturing and assembly equipment.
 - a. Inflatable habitat.
 - b. Welding, joining and fabrication methods for lunar surfaces.
 - c. Setting foundations in potentially loose, highly porous upper regolith.
 - d. Radiation shielding.



E&C Technology Areas (Based on feedback from the group)

4. Lightweight manufacturing processes:
 - a. Additive manufacturing/construction
 - b. Deployable metal structures
 - c. Sintering
 - d. Molten regolith fiber pulling
 5. Lunar surface structure (landing pads, berms, roads, etc.) development.
 6. Increased autonomy of operations.
 7. Virtual lunar terrain simulation.
 8. Beyond additive technology.
 9. Risk Mitigation and identification, financial planning.
- *A Google survey will be sent after the meeting to gauge the relative level of interest in these areas.*
 - *Also, feel free to suggest more to me by email.*



Digital Construction Platform at MIT

Driving Questions

- Where or under what conditions will E&C be easiest or most difficult on the lunar surface (All will be difficult, but perhaps there is a spectrum to consider)? Which aligns with NASA's objectives?
- Where might additive manufacturing (AM) provide the most promise? Where should it not even be considered? *Are their alternatives to AM?*
- What terrestrial mining technologies presently being used are most appropriate for lunar surface and how should they be modified for lunar applications?
- To what degree does E&C need to be automated on the lunar surface? Does all of it?
- How does low gravity help lunar mining and manufacturing? How does it cause problems? How do you remedy these problems?
 - *Please share your driving questions in the chat or email me.*
 - *This will help us frame year 1 goals and objectives and beyond.*

Communication Strategy

- Monthly FG teleconferences (**last Friday of every month, 3 PM**)
 - NASA updates
 - Contain short presentation from participant
 - Develop/advance focus group goal(s)
 - Open forum for brainstorming/discussions
 - Lightning round updates from various participants
 - Opportunity to voice issues to be brought to NASA
 - Give NASA POC (once identified) a slot for NASA updates
- Excavation and Construction FG mailing list: LSIC_ExcavationConstruction@listserv.jhuapl.edu
 - Messages sent to entire Focus Group
 - Use like other large email lists
 - Could create separate groups on specific topics
- Wiki (in development)
 - Main archival resource for dissemination of information
- LSIC monthly newsletter
 - First one coming out in July
 - Please volunteer to contribute
- Other communication tools? (such as Slack)

Focus Group Goal

- The E&C FG is tasked to define a 1 year goal.
- Will collaboratively decide on a 1-year goal for us to work on as a group based on technology areas and driving questions (previous slides) arrived at by consensus.
 - *Please respond to the google survey.*
 - *For discussion at next month's telecon.*
- Goal needs to be
 - Actionable
 - Impactful
 - Address clear need of NASA
 - Can be accomplished with existing resources
 - Inspired by current issues
 - Beneficial broadly to all stakeholders
- Possible first-year goal:

Identify needs & gaps in E&C, provide recommendations to foster development, and create a roadmap for developing and fielding that technology

Contact information

LSIC Director: Rachel Klima, SES-LSIC-Director@jhuapl.edu

Website: <http://lsic.jhuapl.edu>

Focus Group Area	Listserv address	Facilitator
In-Situ Resource Utilization	LSIC_ISRU@listserv.jhuapl.edu	Karl Hibbitts
Surface Power	LSIC_Power@listserv.jhuapl.edu	Wes Fuhrman
Extreme Environments	LSIC_ExtremeEnvironment@listserv.jhuapl.edu	Ben Greenhagen
Extreme Access	LSIC_ExtremeAccess@listserv.jhuapl.edu	Angela Stickle
Excavation and Construction	LSIC_ExcavationConstruction@listserv.jhuapl.edu	Athonu Chatterjee
Dust Mitigation	LSIC_DustMitigation@listserv.jhuapl.edu	Jorge Núñez

Next Steps

- After this meeting
 - Participate in a Google survey to identify top few technical categories.
 - Another google survey possible to identify the best communication channel (such as Slack).
 - Share (through email) your ideas about the most pressing driving questions in E&C.
 - Please see slide # 17 (driving questions) for some examples.
 - Practical problems you face that need remedies/solutions.
- At the next meeting (July 31st 3 PM)
 - Discussions regarding focus group's first year goals.
 - Update on communication tools.

Please volunteer to present at these meetings



Upcoming Conference



ASTM International Conference on Additive Manufacturing (ASTM ICAM 2020)

Organized by the **ASTM International Additive Manufacturing Center of Excellence**

Learn more about additive manufacturing technologies through a greater understanding of application requirements, process controls, and process-structure-property-performance relationships.

November 16-20, 2020
Rosen Shingle Creek Hotel
Orlando, Florida

A Global Eminent Conference on Additive Manufacturing

Submit an abstract by **May 1, 2020** to:

Application of Additive Manufacturing in Construction on Earth and Beyond

Additive Manufacturing In Construction has made the headlines in many news channels, both AM specific and mainstream, with different governments putting resources into R&D with the objective to improve efficiency through reduced manpower, cost, and lead time. As humanity once again looks to the stars, many see AM as ideally suited for construction on the Moon and Mars. This symposium aims to explore the current state of the art in development of AM techniques for construction across the globe with a focus on what is realistic now and what is a future possibility.

The following specific topics are of interest to this symposium:

- New materials development for additive manufacturing construction
- Developing new test methods, or leveraging existing methods, to demonstrate building code compliance
- Types of AM technologies applicable for deployment in both prefabricated and on-site construction environments
- AM construction beyond Earth

ORGANIZERS

- **Sam Ruben**, Mighty Building, Inc., USA
- **Tan Ming Jen**, Nanyang Technological University, Singapore
- **Alexander Liu**, ASTM International, Singapore

Discussion

- Please use raise hand feature (preferred).
 - You can also comment in chat.
-
- How can this consortium and focus group work for you and your institution?
 - What do you want to get from the FG meetings?
 - What would you like the FG to accomplish?
 - What kinds of FG activities would be most productive for LSIC objectives?



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LSII System Integrator - APL

A key tenet of LSII is to implement a multitude of novel collaborations across industry, academia, and government in order to successfully develop the transformative capabilities for lunar surface exploration.

Origin of the APL Task

- NASA was investigating using a University Affiliated Research Center (UARC) to bring efficiencies to development
- LSII initiated a tasked APL, to assess system integration role for the Lunar Surface Innovation Initiative
- APL established a Lunar Surface Consortium with academia and industry representatives, as well as NASA experts, that span a broad range of capabilities to execute timely studies, tasks, and/or acquisitions

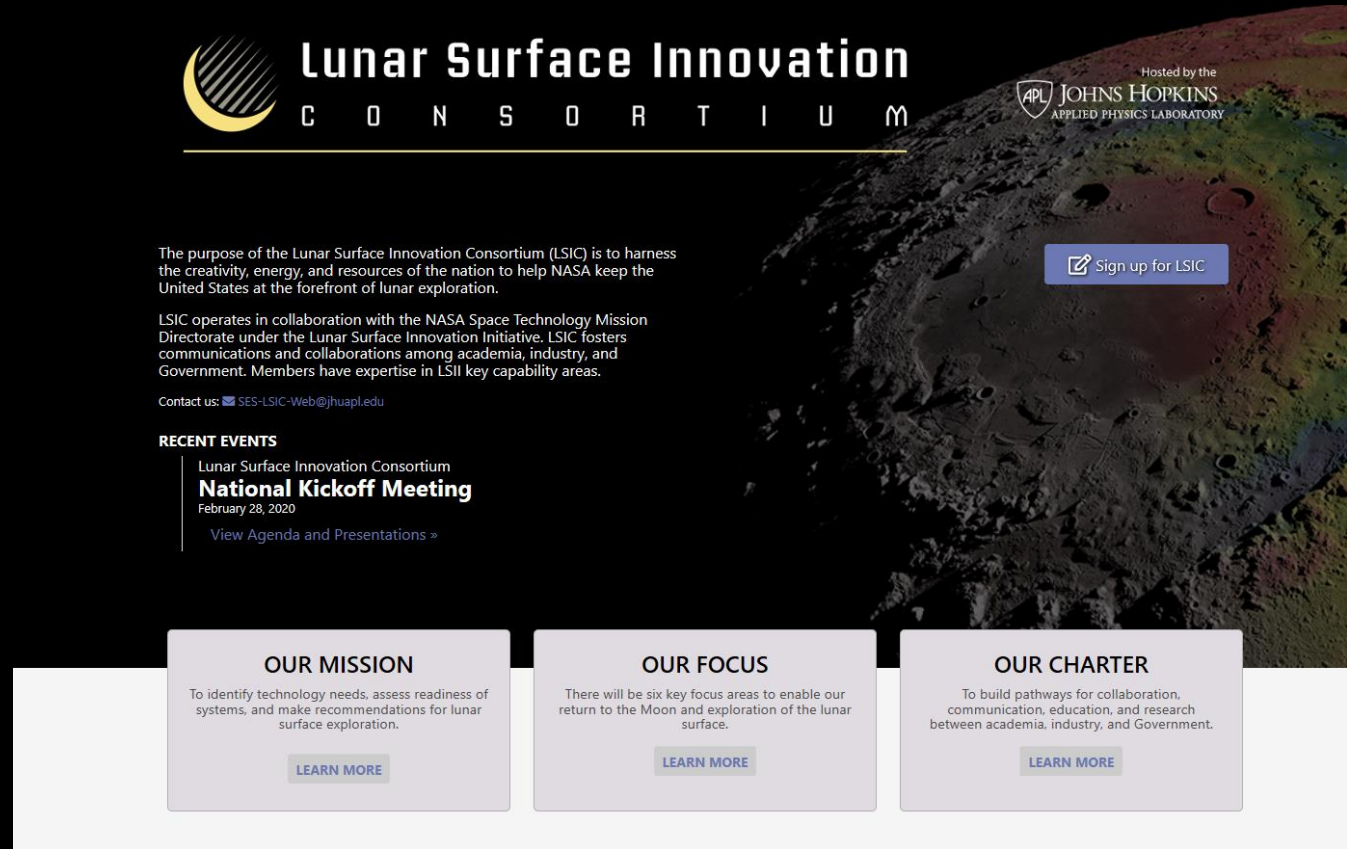
The Consortium will assist NASA in

- Identifying lunar surface technology needs and assessing the readiness of relative systems and components
- Making recommendations for a cohesive, executable strategy for development and deployment of the technologies required for successful lunar surface exploration
- Providing a central resource for gathering information, analytical integration of lunar surface technology demonstration interfaces, and sharing of results



LSIC Website

- <http://lsic.jhuapl.edu>
- Sign up for LSIC
- Ask questions, and please feel free to provide feedback.
- Share additional ideas about how to make this consortium work for your institution.
- Let us know how your institution can contribute to the community.



The screenshot shows the LSIC website homepage. At the top, it features the LSIC logo and the text "Lunar Surface Innovation CONSORTIUM". Below this, there is a navigation bar with a "Sign up for LSIC" button. The main content area includes a paragraph about the purpose of the consortium, a section for "RECENT EVENTS" featuring the "National Kickoff Meeting" from February 28, 2020, and three columns for "OUR MISSION", "OUR FOCUS", and "OUR CHARTER", each with a "LEARN MORE" button. The background of the website is a high-resolution image of the lunar surface.

Please visit <http://lsic.jhuapl.edu/Events/survey.php> to complete a short survey about LSIC and to express interest in membership

APL In Brief



What are we?

Division of Johns Hopkins University

University Affiliated Research Center



Who are we?

Technically skilled and operationally oriented

Objective and independent



Who are our sponsors?

DoD, NASA, IC, DHS, ...



What is our purpose?

Critical contributions to critical challenges

>7,000 staff members, ~\$1.8B in revenues