



# Lunar Surface Innovation

C O N S O R T I U M

## LSIC Excavation and Construction Focus Group

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

**March 26, 2021**

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# Friendly Reminders

- Slides, chat and recording will be posted in our website in 2-3 days.  
(<http://lsic.jhuapl.edu/Focus-Areas/Excavation-and-Construction.php>)
- Feel free to post your questions/suggestions in 'chat'.
  - We can move the discussion to Confluence.
- Please mute yourself if you are not speaking.

# Agenda

- Focus group updates and annual goal discussion.
- Presentation on lunar infrastructure development by Dr. Peter Carrato, Fellow Emeritus of the Bechtel Corporation.

# New E&C NASA Lead

**Dr. Mark Hilburger – Principal Technologist (Langley Research Center, VA)**

Dr. Mark Hilburger is the Space Technology Mission Directorate (STMD) Principal Technologist for Structures, Materials, and Nanotechnology at NASA. Previous to his STMD PT appointment, he was the Principal Investigator and Manager of the NASA Engineering and Safety Center's Shell Buckling Knockdown Factor Project from 2007 to 2018.

*Welcome!*

# New LSIC E&C APL Team Member

## Jibu Abraham – New member of E&C focus group at JHU/APL

Jibu Abraham is a Senior Professional Staff in our Air Missile Defense Sector. Expertise: missile system components, complex flight related hardware and structural analysis.

*Welcome!*

- ASCE Earth and Space Conference, Virtual Conference, April 19-23, 2021.
  - Two relevant symposiums:
    - *Granular Materials in Space Exploration*
    - *Exploration and Utilization of Extra-Terrestrial Bodies*
  - Short Course on *Engineering and Construction on the Moon*.
- 11th joint meeting of the Planetary & Terrestrial Mining Sciences Symposium (PTMSS) & the Space Resources Roundtable , June 7 – 11, 2021.
  - PTMSS seeks to promote a closer relationship between the space and mining sectors.
  - Abstracts due on April 12<sup>th</sup>.
  - <https://www.ptmss.ca>

# VSAT Announcement

- Astrobotic Technology, ATK Space Systems (Northrop Grumman), Honeybee Robotics, Lockheed Martin, and Space Systems Loral (Maxar Technologies) recently selected to complete 10 kW vertical solar array designs and conduct analysis through the **Vertical Solar Array Technology (VSAT)** project!
- The full press release can be found here (<https://www.nasa.gov/feature/nasa-industry-to-mature-vertical-solar-array-technologies-for-lunar-surface>).

# *News from other focus groups*



# Extreme Environments Focus Group

## *LSIC-EE “Supersized” Working Meeting on April 13<sup>th</sup>, 2:30-4:30 ET*

- 2:30 - Introduction, Scope, and Products (5 min)
- 2:35 - Review of Environment Drivers (5 min lightning talks)
- 3:00 - Transition to Breakout Zooms (5 min)
- 3:05 - Breakout Sessions (55 min)
  - Polar Specific Environments
  - Non-Polar Specific Environments
- 4:00 - Transition to Plenary Zoom (5 min)
- 4:05 - Brief Recaps / Burning Questions (10 min)
- 4:15 - Next Steps and Discussion (15 min)

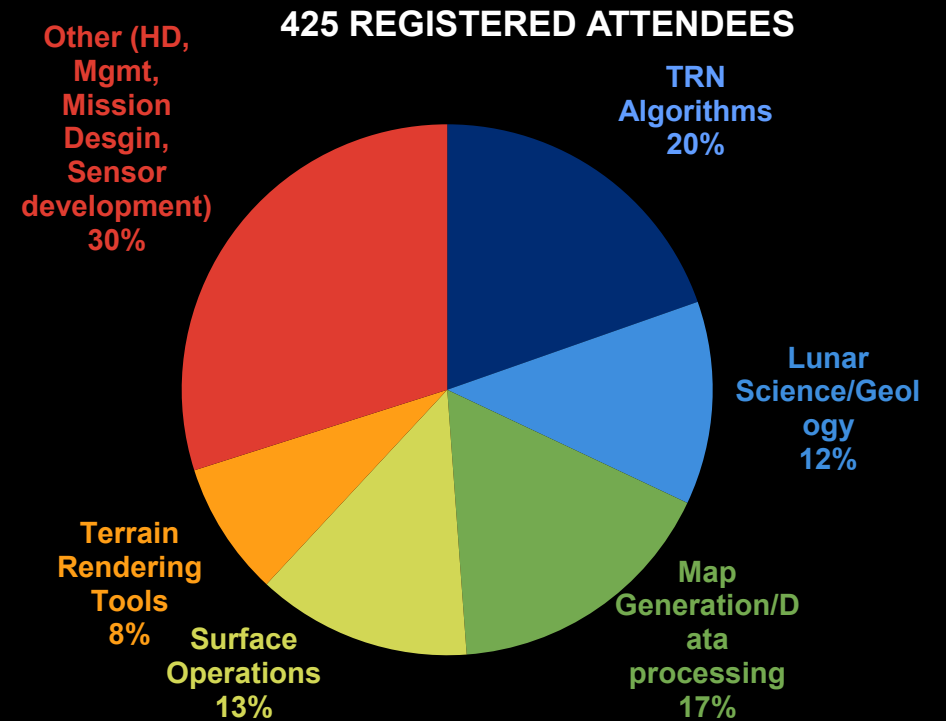
## Follow-up Activities Kickoff After the LSIC Spring Meeting

- Prioritize Specific Lunar Environments (and down select to a few to focus on initially)
- Identify Capabilities and Gaps related to Observation (Knowledge) & Simulation (Prediction), Technology Capabilities, and Experimental Testing & Technology Maturation (including Facilities)

- Workshop on Lunar Mapping for Precision Landing
  - Talks and presentations available at event page
  - Compiling list of resources, including where lunar data can be accessed and POCs
  - Curating a TRN-specific literature list
  - New EA Confluence pages for discussion
- Subgroups:
  - Lunar sheds/wadis
  - PNT (based on March telecon)
- Who's Who in EA on Confluence
- April telecon will focus on communications, with 2 technology spotlights
- Telecons: Second Thursday of each month, 3 pm ET

<https://jhuapl.zoomgov.com/j/1613074157?pwd=RkpWWklwMGV3a0RnL1FKcHB5TE1BZz09>

Contact: [Facilitator\\_ExtremeAccess@jhuapl.edu](mailto:Facilitator_ExtremeAccess@jhuapl.edu)





# LSIC | Dust Mitigation Workshop

**Lunar Dust is a major concern and dust tolerant/dust mitigation solutions are critical for enabling sustained surface operations.**

Over 340 attendees from over 200 institutions attended workshop on February 4, 2020 with the following representation: 20% Academia, 28% Government, 43% Industry, and 9% Nonprofit

## **High priority challenges and needs Identified:**

- Establishing set of tolerances allowing systems to operate “dirty”
- Acquisition of ground truth dust properties and plume/ejecta data from precursor missions to validate modeling tools and designs
- Develop and standardize simulants and testing conditions to better capture real dust problems instead of approximations
- Pathways and mechanism for integrating dust tolerant/mitigation technologies into lunar systems and architecture
- Technology demonstrations on CLPS landers to test in real-world conditions

## **Technology gaps identified:**

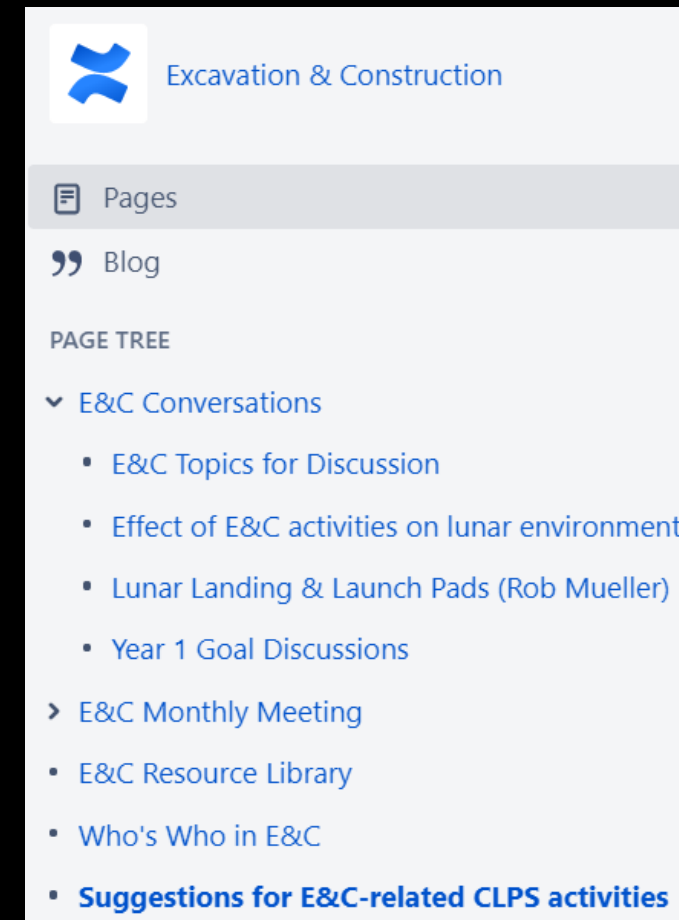
- Landing, launch, and surface transport dust ejecta/plume mitigation
- Passive/Active dust removal tools
- Dust tolerant space suits/fabrics
- Habitats and Vacuum/Filtration
- Dust tolerant mechanisms
- Dust tolerant joints, wheel bearings, and connectors
- Dust tolerant optical power systems
- Dust detection sensors
- Surface modification solutions



# E&C Focus Group Mission

**Overarching Goal:** Help NASA set the stage for a big RFP for 2030 lunar base development.

- Provide recommendations for upcoming E&C-specific CLPS activities.
- Enhance and smoothen interaction between industry and NASA.
  - Help develop RFI and RFP that are easily understood by all.
  - Recommendations for funding through various avenues such as SBRI, STRG, ---.
- Help NASA in technical areas.



The screenshot shows a website navigation menu for "Excavation & Construction". It includes a blue icon of two crossed tools, a "Pages" section with a document icon, a "Blog" section with a quote icon, and a "PAGE TREE" section. The "PAGE TREE" section is expanded to show a list of items: "E&C Conversations" (with a dropdown arrow), "E&C Topics for Discussion", "Effect of E&C activities on lunar environment", "Lunar Landing & Launch Pads (Rob Mueller)", "Year 1 Goal Discussions", "E&C Monthly Meeting" (with a right-pointing arrow), "E&C Resource Library", "Who's Who in E&C", and "Suggestions for E&C-related CLPS activities" (highlighted in blue).

## (1) Lunar Servicing, Assembly and Manufacturing (LSAM)

*Identify and recommend LSAM capabilities needed for habitat and landing pad construction.*

- What kind of spare parts should be manufactured on the Moon?
- What kind of in-situ fabrication and repair technologies are feasible?
- Translate findings/learnings from orbital manufacturing?
- Create an Industry-academia-government ecosystem.
- Effect on lunar environment
- CLPS activities

## (2) Optimal Lunar Habitats

*Critical analysis of over-ground and under-ground habitats.*

- Optimal habitat architecture for a lunar base
- Different types of pressurized/un-pressurized habitat designs
- AM-based and non-AM-based-structures (AM: Additive Manufacturing)
- Effect on lunar environment
- CLPS activities

Please participate in the poll (link in the chat box) to indicate your preference for the annual goal topic:

- 1. Lunar Servicing, Assembly and Manufacturing (LSAM)**
- 2. Optimal Lunar Habitats**

# Today's Talk

## Major Industrial Facilities on Earth that are Analogs for Potential Lunar Installations

*Dr. Peter Carrato, Fellow Emeritus of the Bechtel Corporation*

Pete is actively engaged in the application of technology in engineering and construction industry. He was the head judge for the four-year long NASA Mars Habitat Centennial Challenge. The team that delivered this competition was awarded the NASA Silver Achievement Medal. Dr. Carrato is currently engaged with the Centennial Challenge Program at NASA Marshall Space Flight Center in delivering the Break the Ice Lunar Challenge.





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# Possible 21-22 Annual Goal Topics

## Lunar Servicing, Assembly and Manufacturing (LSAM)

*Identify and recommend LSAM capabilities needed for habitat and landing pad construction and provide recommendations for CLPS activities.*

- What kind of parts are beneficial to be manufactured on lunar surface as opposed to sending from earth?
- What are some possible demands for metal manufacturing on the moon in the short term ?
- What kind of metal-based spare parts are needed / maybe needed to be made?
- Where can the suppliers / technology developers know about lunar surface construction demands? Identify supply and demand sides.
- How can industry and academia be brought into this eco-system.

*Express your views or suggest any other topic in Confluence*

# Possible 21-22 Annual Goal Topics

## Optimal Lunar Habitats

*Perform a critical analysis of pros and cons of over-ground and under-ground habitat and provide recommendations for CLPS missions.*

- Explore and compare available technologies.
- Analyze the two options from cost, safety and sustainability points of view.
- Effect on lunar environment and how to mitigate.
- Recommend an optimal architecture for habitats; maybe a combination of two.
- How can industry and academia be brought into this eco-system?

*Express your views or suggest any other topic in Confluence*

<b>Habitat construction in lunar conditions. (Inflatable habitat, underground habitat, radiation shielding, multi-functional materials/structures)</b>	<b>70.5%</b>
Manufacturing processes for lunar construction. (Additive manufacturing, sintering, regolith fiber pulling)	63.6%
Excavation technology for hard regolith/icy material. (Drilling, mining, lightweight construction equipment)	61.4%
Autonomous vehicles and robots for E&C on lunar surface.	59.1%
Lunar surface structure development. (Landing pads, berms, roads)	54.5%
Increased autonomy of operations.	34.1%
Virtual lunar terrain simulation.	29.5%
Beyond additive technology.	22.7%
Long duration robust , easily maintainable robot design for industrial scale use (not science)	2.3%
Subsurface and interior imaging and composition analysis	2.3%
Compressed, sifted regolith as a building material	2.3%
Spacecraft refueling station development	2.3%

# 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

