Lunar Surface Innovation
CONSORTIUM

LSIC Excavation and Construction Focus Group July Meeting

July 31, 2020

Athonu Chatterjee

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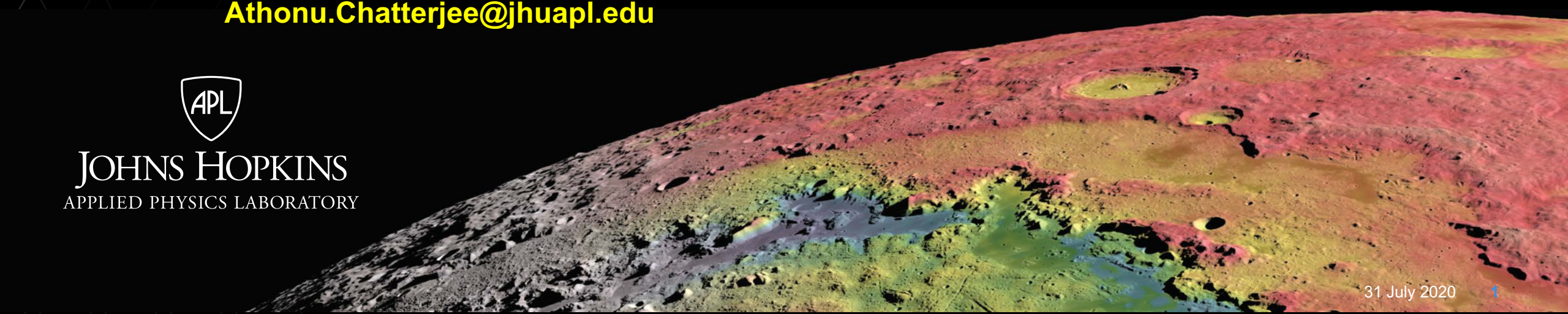
JOHNS HOPKINS
APPLIED PHYSICS LABORATORY



Friendly Reminders

- Please sign in using ‘chat’.
- 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 get back to you later, if not now.
- Please mute yourself if you are not speaking.

Agenda

- Communication updates
- Excavation and Construction focus group update.
- Content from STMD
  - Solicitations and funding update.
  - LuSTR update
- Two NASA presentations:
  1. NASA Centennial Challenges Program – Lunar Excavation, Manufacturing, and Construction Challenge (Monsi Roman and John Vickers, Marshall Space Flight Center).
  2. Overview of In-situ Construction at NASA. (Rob Meuller, Kennedy Space Center).

Communication

- Slack, Mattermost are out for NASA.
- APL Confluence wiki is in progress. It should be up and running before August 10th.

- LinkedIn group with an internal message board
  - Connect to broader LSIC community
  - https://www.linkedin.com/groups/13861869/

- Email always an option
  - Athonu.Chatterjee@jhuapl.edu
  - LSIC_ExcavationConstruction@listserv.jhuapl.edu

Excavation and Construction Focus Group

Supporting STMD in developing technologies that enable affordable, autonomous manufacturing or construction for sustained human presence.

The goal(s) of the LSIC Excavation and Construction focus group is to assess technologies related to lightweight manufacturing, mining, and assembly equipment that can process in-situ lunar surface materials. Relevant manufacturing and assembly processes will be assessed some of which are additive construction, deployable metal structures, sintering, molten regolith fiber pulling, etc.

APL Facilitator: Athonu Chatterjee – Athonu.Chatterjee@jhuapl.edu

NASA Lead: John Vickers – john.h.vickers@nasa.gov
(NASA principal technologist in the area of advanced manufacturing. Associate Director of the Materials and Processes Laboratory at NASA's Marshall Space Flight Center. Manager of the NASA National Center for Advanced Manufacturing)

Website: http://lsic.jhuapl.edu/Focus-Areas/Excavation-and-Construction.php

Mailing List: LSIC_ExcavationConstruction@listserv.jhuapl.edu

Membership: 210 members

Focus Group Composition

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

- **Zoom Meeting:** https://jhuapl.zoomgov.com/j/1605411480?pwd=a3BBR2hNSG41OUhiRyt2V3R2MXNIdz09

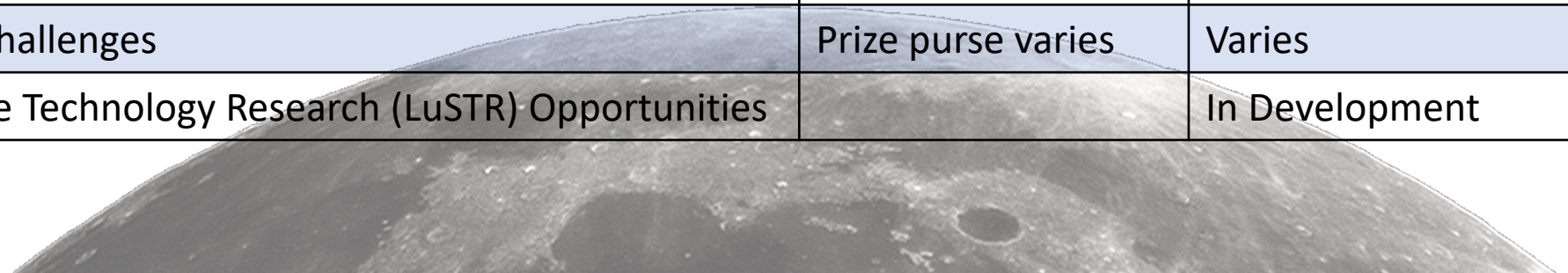
E&C Technical Areas Google Survey Results

Habitat construction in lunar conditions. (Inflatable habitat, underground habitat, radiation shielding, multi-functional materials/structures)	**70.5%**
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%

STMD Recurrent Solicitation Opportunities

Opportunity	Solicitation Totals for New Awards*	Solicitation
Tipping Point (TP)	$250M	Jan-Mar
Space Technology Research Institutes (STRI)	$30M	June-Aug alt. years
SBIR/STTR Phase I, II, Phase II-E, CCRPP, Sequential	$212M	Jan-April (Phase 1)
NASA Innovative Advanced Concepts (NIAC) Phase I, II, III	$4M	Jun-Jul (Phase 1)
Announcement of Collaborative Opportunity (ACO)	$10M	Jan-Mar
Early Career Faculty (ECF)	$6M	Feb-April
Early Stage Innovations (ESI)	$9M	April-June
Smallsat Technology Partnerships (STP)	$3M	Sep-Nov alt. years
Flight Opportunities Tech Flights	$10M	Feb-May
NASA Space Technology Graduate Research Opportunities (NSTGRO)	$19M	Sep-Nov
Centennial Challenges	Prize purse varies	Varies
Lunar Surface Technology Research (LuSTR) Opportunities		In Development

*Based on FY 2020 Operating Plan



STMD Opportunities for Academia and Industry

STMD anticipates awarding ~$600M to academia and industry supporting 2020 solicitations & awards

- **STMD Tipping Point Multiple Awards:** *Jan – Mar 2020* — $250M
- **Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) Phases I, II, II-E, Civilian Commercialization Readiness Pilot Program (CCRPP), Sequential:** *Phase I Solicitation Jan – Apr 2020* — $212M
- **Announcement of Collaborative Opportunity (ACO):** *Jan – Mar 2020* — $10M
- **Flight Opportunities Tech Flights:** *Feb – May 2020* — $10M
- **Early Career Faculty (ECF):** *Feb – Apr 2020* — $6M
- **Early Stage Innovations (ESI):** *Apr – Jun 2020* — $9M
- **NASA Innovative Advanced Concepts (NIAC) Phases I, II, III:** *Phase I Solicitation Jun – Jul 2020* — $4M
- **Space Technology Research Institutes (STRI):** *Jun – Aug 2020* — $30M
- **NASA Space Technology Graduate Research Opportunities (NSTGRO):** *Sep – Nov 2020* — $19M
- **SmallSat Technology Partnerships (STP):** *Sep – Nov 2021* — $3M
- **Centennial Challenges:** *Varied release dates* — $8M
- **NextSTEP Broad Agency Announcements (BAAs):** *Varied release dates* — *Varies*
- **Lunar Surface Technology Research (LuSTR) Opportunities:** *Coming soon!!!* — $30M

Note: Funding awards are approximate and subject to change

Open Solicitations as of June 5, 2020

Solicitations were/will be open *in the timeframe specified in italics*

LuSTR

- Lunar Surface Technology Research (LuSTR)
  - Academic (US) lead research with industry support (40%)
  - LuSTR topic areas included two topics in ISRU and four topics in Power
  - Solicitation web link: https://tinyurl.com/NASA-2020LuSTR

- Questions regarding topic areas can be submitted at: hq-LuSTR@mail.nasa.gov

Today's Talks

(1) NASA Centennial Challenges Program – Lunar Excavation, Manufacturing, and Construction Challenge

Speakers:

Monsi Roman, Program Manager, NASA Centennial Challenges Program

John Vickers, Principal Technologist, NASA Space Technology Mission Directorate

(2) Overview of In-situ Construction at NASA

Speaker:

Rob Mueller, NASA, Kennedy Space Center

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STMD LSII Capability Development

ISRU

- ISRU Scaled Pilot Plant Demonstrations
- Demonstrate systems for collecting and purifying water on the lunar surface, capable of scaling to tens of metric tons per month, operating with little to no human involvement.
- Methods for size sorting granular lunar regolith.
- Methods for measuring mineral properties/oxygen content before and after processing

Surface Power

- Surface Fission Power
- Adaptable Lunar Surface arrays
- Energy Storage including Regenerative Fuel Cells
- Power Beaming
- Chemical Heat Integrated Power Source
- Power Distribution Architectures
- Advanced Rover Energy Storage

Dust Mitigation

- Dust tolerant textiles
- Filtration
- Dust Mitigation Structures
- Electromechanical & Magnetics
- Surface Stabilization
- Nanomaterials & Coatings
- Adaptation of Terrestrial Technologies
- Dust Classification & Best Practices Guide

Extreme Environments

- Enable rovers, manipulators, and other systems to operate in the lunar environment including lunar noon (150 ℃), night (down to - 180 ℃), day/night cycles, and permanently shadowed regions (down to -240 ℃).
- Develop & publish Lunar Surface External Environments User's Guide

Extreme Access

- Sustained Surface Activities
- Extended Ops in Permanently Shadowed Regions
- Ingress, Exploration, & Egress of Voids
- Hazard Detection in all lunar environments & conditions
- Autonomous Operations
- Navigation with minimal infrastructure

Excavation & Construction

- Excavation of hard regolith/ice material
- Travel & traverse to mining locations
- Reliability & Maintainability during ops
- Material & Construction of requirements & standards.
- Increased Autonomy

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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 survey and NASA priorities.
- 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 topics:
  - Advanced technologies for excavation of dry and icy regolith.
  - Landing pad development.
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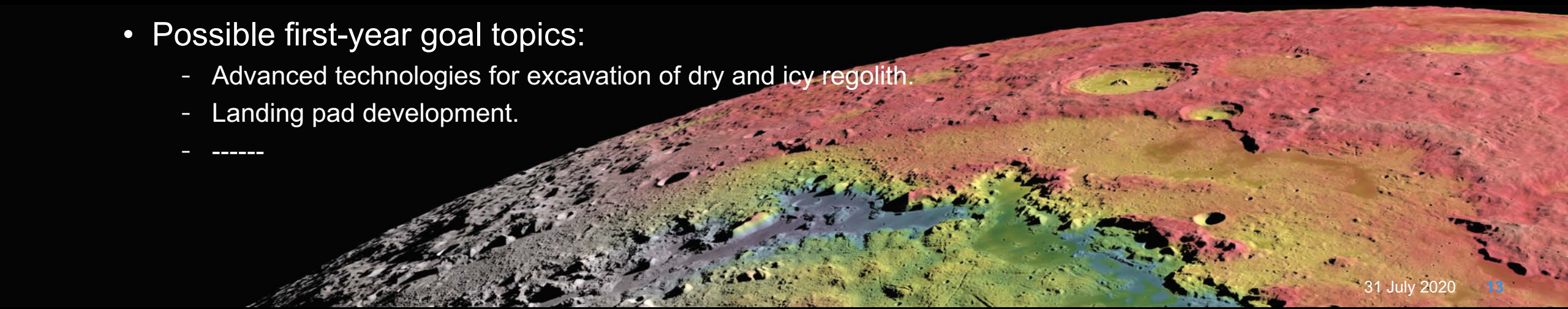

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LSIC Objectives

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

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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.

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