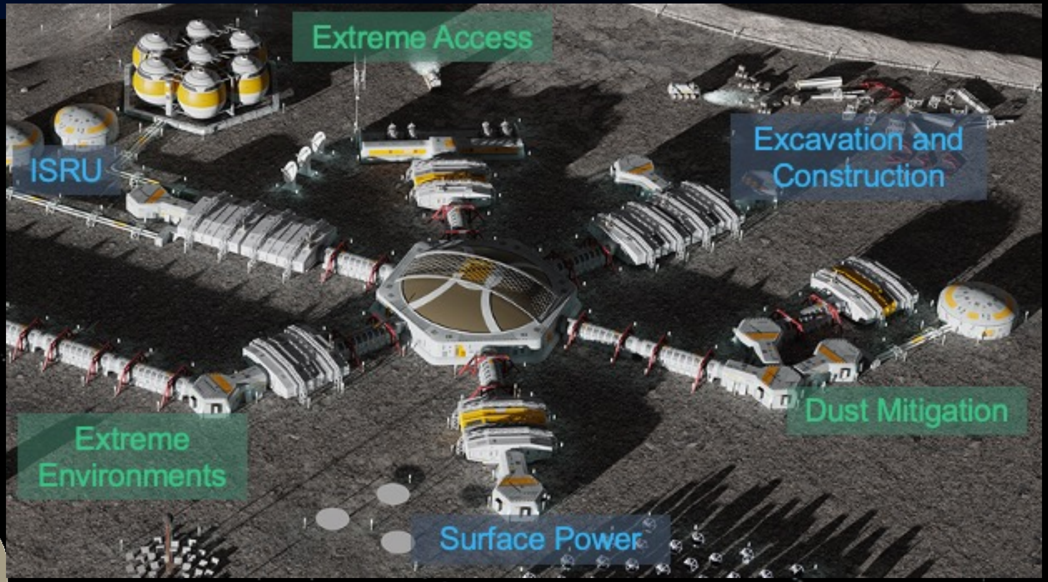
Lunar Surface Innovation Consortium ISRU Focus Group Updates

Space Resources Roundtable
June 6-9, 2023, Golden, CO

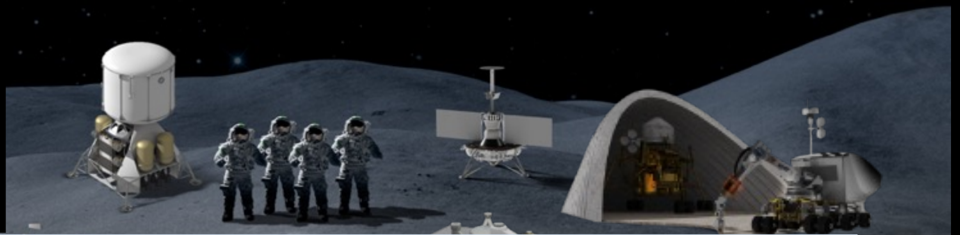
Jodi Berdis, Karl Hibbitts, Michael Nord, Dave Smith, Richard Miller

Lunar Surface Innovation Initiative (LSII) | Lunar Surface Innovation Consortium (LSIC)

NASA's LSII works across industry, academia, and government through in-house efforts and public-private partnerships to develop transformative capabilities for lunar surface exploration



- LSII is a NASA Space Technology Mission Directorate activity
- Johns Hopkins Applied Physics Lab (APL) is the LSII integrator for NASA, including establishing the Lunar Surface Innovation Consortium (LSIC)
  - Foster growth of a diverse community and networking among members.
  - Provide a central resource for gathering information, analytical integration of lunar surface technology demonstration interfaces, and sharing of results.



The Lunar Surface Innovation Consortium (LSIC) provides a conduit for the community to discuss technical challenges and form partnerships.

LSIC | In Situ Resource Utilization (ISRU) Focus Group

Identifying and enabling the development of lunar surface ISRU technologies, specifically the extraction, storage, and utilization of O_2, H_2O, other volatile resources, as well as metals, and identifying the technologies most in need of support.

Meetings: 3rd Wednesday of the Month 3:00 – 3:50 pm EST (+ another 25 min)

Mailing List: LSIC_ISRU@listserv.jhuapl.edu

Website: https://lsic.jhuapl.edu/Our-Work/Focus-Areas/index.php?fg=In-Situ-Resource-Utilization

ISRU Wiki: https://lsic-wiki.jhuapl.edu/display/ISRU

Technical Areas		
Water-ice Resource Evaluation and Recovery	Interoperability and Maintenance by Design	Environmental Impact and Scale of ISRU Activities
O_2 and Metal Extraction	Value Network Mapping	Cross-Focus Group Talk

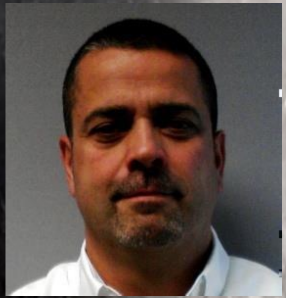
Applied Physics Laboratory


Karl Hibbitts


Jodi Berdis


Michael Nord


Rich Miller


Dave Smith


Jeremy John


Claire Trop

NASA


Jerry Sanders
ISRU Systems Capability Lead


Julie Kleinhenz
Deputy ISRU Systems Capability Lead

THE PATH TO AN ENDURING LUNAR PRESENCE

LSIC Community
Draft White Paper

Power and communication decisions should be made in the same timeframe to enable 1) the "lunar electrical power grid" (M2M LI-1) and 2) "Moon to Earth RF comms" (M2M LI-2).

In the early 2030s, lunar infrastructure could support a science outpost and exploration proving grounds that can also bootstrap commercial activities.

The LSIC community is publishing a white paper to share their perspectives on key enabling actions that will help our nation and the world move together toward our shared use of the lunar surface.

Prior to 2031, determine functionality and equipment needed for "environmental monitoring and situational awareness" (M2M LI-9).

LSIC

Lunar landing events produce hazardous ejecta. An infrastructure decision should be made by 2027 between landing close to emplaced infrastructure and landing farther away to prevent ejecta-induced damage.

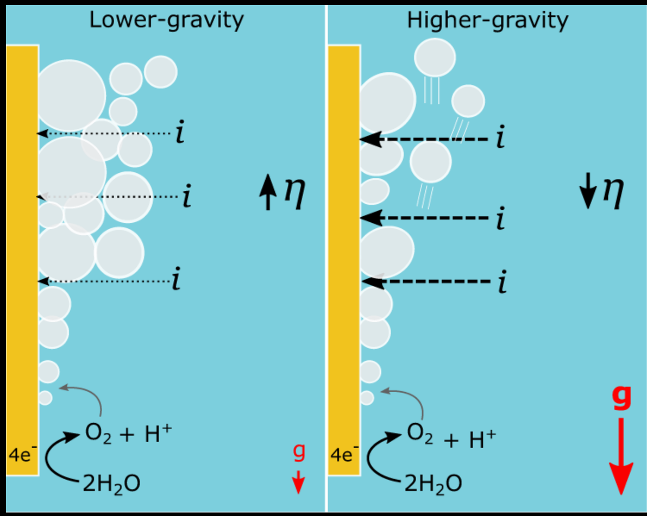
JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

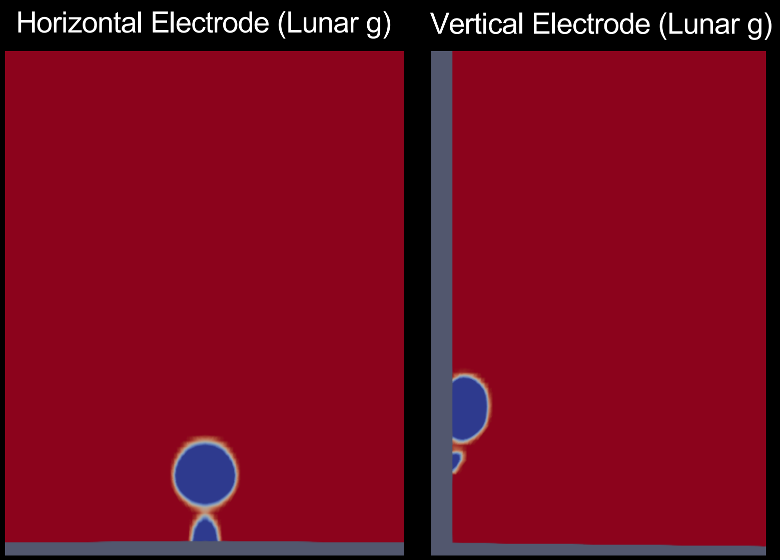
Exploring the Challenges of Molten Regolith Electrolysis and Oxygen Production on the Lunar Surface (Paul Burke)

Presentation on Thursday (Michael Nord)

- Is molten regolith electrolysis a viable form of oxygen extraction on the Lunar surface?
- If bubbles do not detach and rise from the electrode (due to reduced gravity – 1/6 g), electrolysis may be stalled
- APL has developed a electrolysis/bubble detachment CFD model to investigate
- Conclusions (discussed more on June 8 at 1:45pm):
  - In Lunar-g, MRE sees bubble detachment times on the order of dozens of seconds
  - Vertical electrodes results in larger bubbles and longer time to detachment, compared to horizontal electrodes
  - MRE and water electrolysis are nonlinearly dependent upon gravity level
  - MRE is significantly dependent upon electrode surface roughness (electrode degradation could affect this)

(Lomax, et al, 2021)

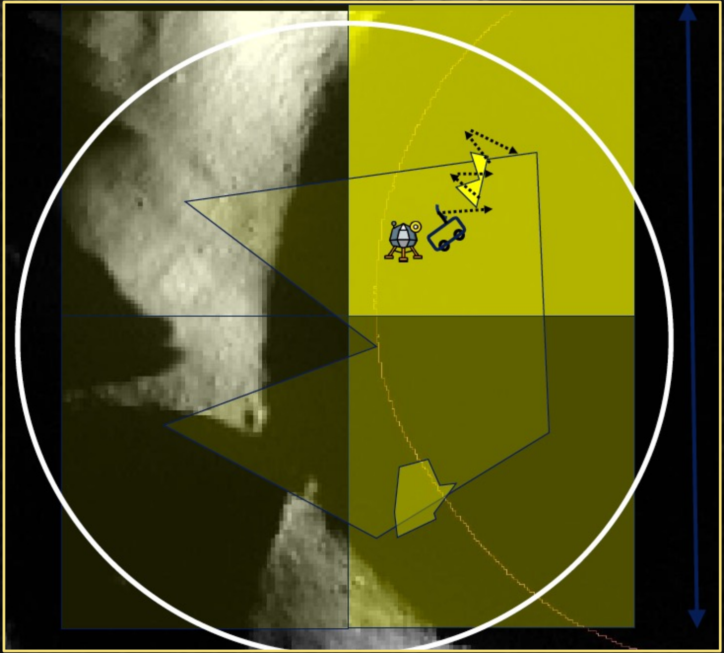




LSII | Water Prospecting: Finding the Water

What do we need to know?

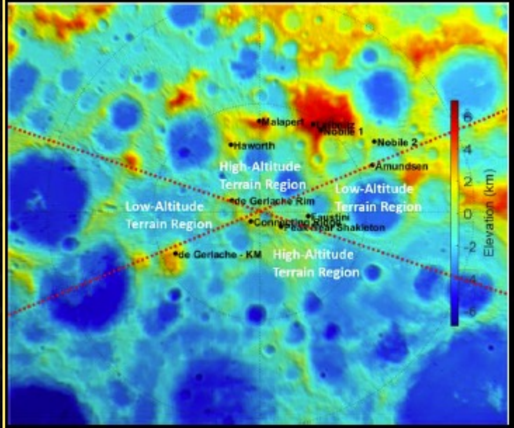
1. Location and abundance in the subsurface
2. Location and abundance on the surface
3. Physical state
4. Composition
5. Modeling

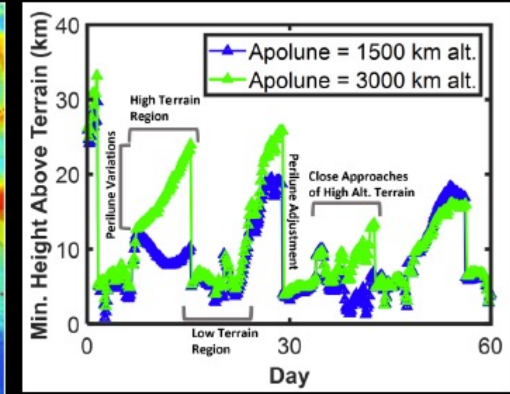


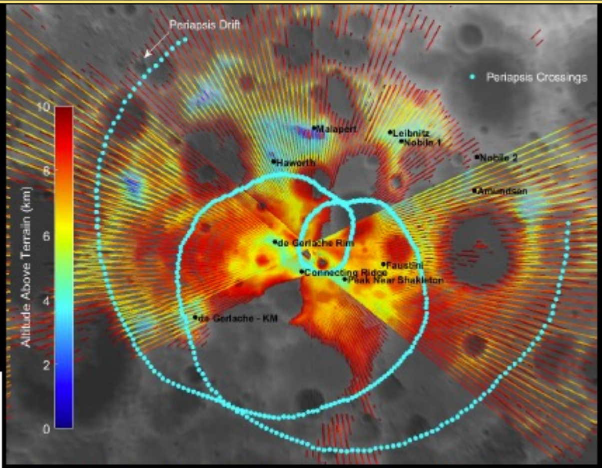
How do we get there?

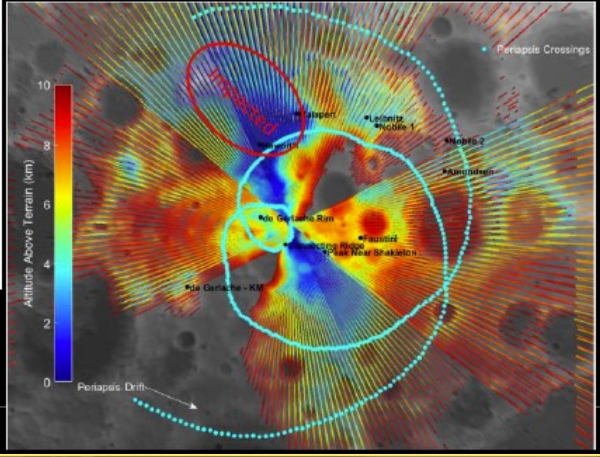
Constraining the areas of interest in PSRs

Active periapsis control has the potential to achieve orbits as good as 5 km and no worse than 10 km above PSR locations of interest.









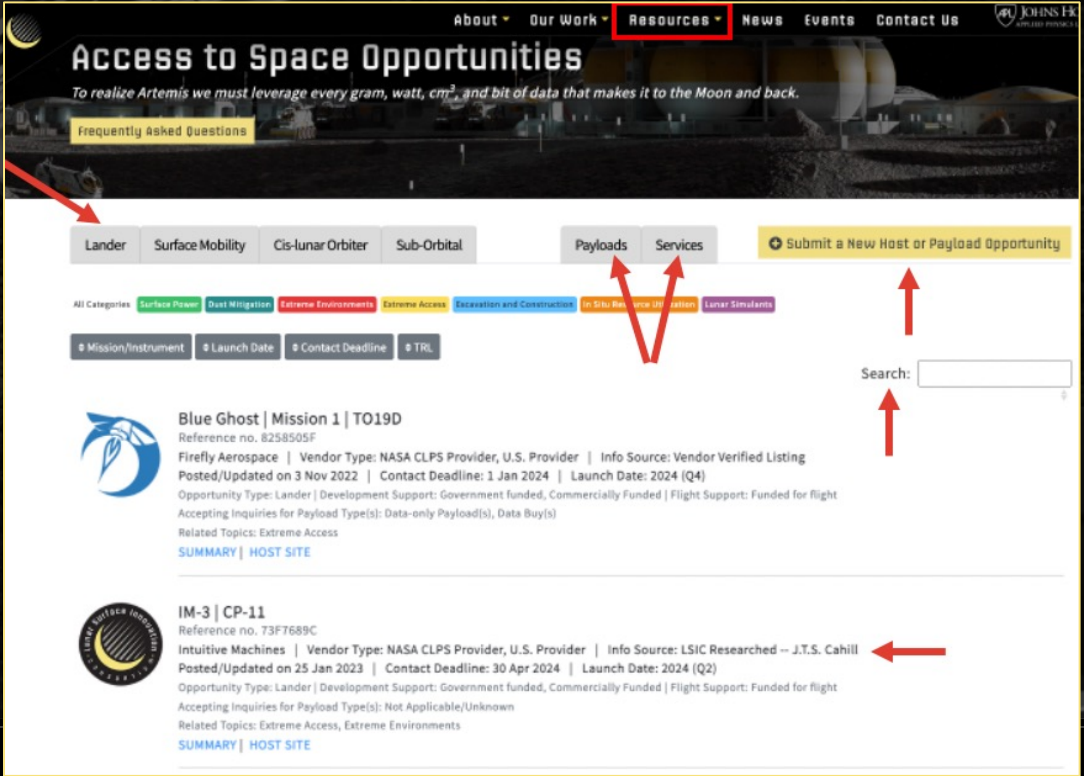
LSII/LSIC | Additional Ongoing Efforts

Value Chain: "Lunar Chamber of Commerce"

- Value chain development and analysis will benefit our return, and extended presence, on the Moon.
- As part of the LSIC/LSII effort, we are currently developing a "value chain tool" that will serve as a Lunar Chamber of Commerce.
- Goal: To maximize efficiency by aiding: communication exchanges; partnership development; resource allocation; cost-effective solutions.
- This tool will enable members of the lunar community to:
    - Promote their technical capabilities, particularly in the realm of in-situ resource utilization.
    - Identify potential users of those resources.

LSIC Access to Space Interface

- The interface is organized by host; host vendors may submit listings looking for riders.
- Payloads and services vendors may make listings looking for rides.
- LSIC will research basic details of unlisted opportunities.



LSIC | Lunar Proving Grounds Definition Workshop
July 12-13, 2023

JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Summary:

- The topic of facilities needed for testing hardware destined for the Moon and the need for Earth-based 'Lunar Proving Grounds' for testing systems has come up across all six Focus Areas of LSIC. While facilities exist for component- and instrument- level technology maturation (e.g., up to system/subsystem demo in relevant environments), and there are potential flight opportunities for component maturation to flight-qualified and even flight-proved systems, the Artemis Program vision for a sustained presence and transition to industry (e.g., the Moon to Mars Objectives and the LSIC "Path to an Enduring Lunar Presence" white paper) suggests an architecture of integrated systems and systems of systems more complex than Apollo or the International Space Station.

This is a discussion-based workshop, no abstracts will be solicited!

Registration is now open!

Objectives:

1. Define the role of a lunar proving ground on the Earth (and potentially on the Moon).
2. Collect/define needs, attributes, and performance capabilities of Lunar Proving Grounds from technology developer's perspective.
3. Identify the programmatics and logistics required to implement the Lunar Proving Ground.

Lunar Surface Innovation Consortium – All are welcome to join!

LSIC welcomes participation from throughout the world, with the goal of connecting those interested in participating in humanity's future in space to one another.

Upcoming Activities and Events

- Lunar Proving Grounds Definition Workshop, July 12-13, 2023
- Surface Power Reliability Workshop, July 26-27, 2023
- Joint E&C / EA Autonomy Workshop, August 21-22, 2023
- 2023 LSIC Fall Meeting – Oct. 10-12, 2023 (hybrid) & Transition to Industry Workshop
  - Hosted by Community College of Allegheny County, Pittsburgh, PA
- 2024 LSIC Spring Meeting – Week of April 22nd, 2024
  - Johns Hopkins Applied Physics Laboratory, Kossiakoff Center, Laurel, MD

Sign up to Participate

- Register at http://lsic.jhuapl.edu/
  - Adds you to LSIC Announcement list – monthly newsletter and major announcements (low traffic)
  - Selecting a Focus Group will add you to that mailing list (moderate traffic)

Other Upcoming Opportunities

- Applications for hosting LSIC Fall Meeting 2025 due by Dec. 31, 2023. Apply at http://lsic.jhuapl.edu/

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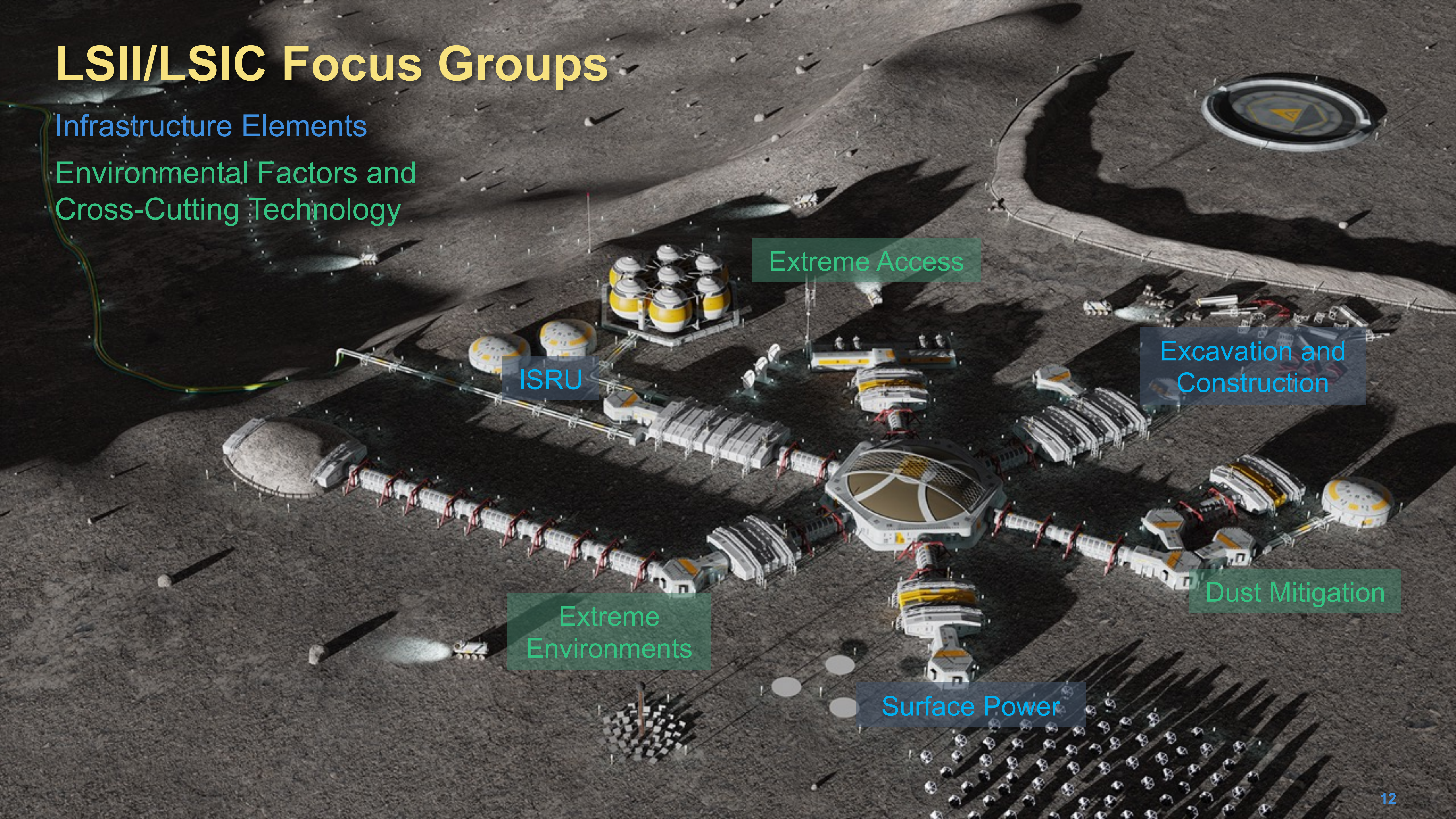
BACK-UP

LSII/LSIC Focus Groups

Infrastructure Elements

Environmental Factors and Cross-Cutting Technology



LSIC | Current ISRU Focus Group Work

Primary Objective

- Enable the identification and maturation of technology needs for ISRU systems in order to help achieve a sustained lunar surface presence by being able to produce up to 10s to 100s metric tons/yr of H_2O and/or O_2, as well as metals.

ISRU Vision – Actions Based on Community Feedback Survey

- Subgroups
  - Initiate subgroup meetings separate from group telecon
  - Add "Economy/Policy & Funding" and "Building Technology Partnerships"
- Monthly Telecons
  - Focus on technical talks, but include some networking
  - Involve DARPA, DoD, USSF, NASA
- Technology Maturation
  - Develop platform for companies to set up meetings with ISRU leadership team and other companies
- Future Meeting Topics
  - Metal extraction & use; Additional ISRU-focused technologies; Lunar environment; NASA Moon to Mars architecture; Testing facilities, Financial and TRL advice

Technical Areas:

- Water-ice Resource Evaluation and Recovery
- O_2 and Metal Extraction
- Value Network Mapping
- Interoperability and Maintenance by Design

Environmental Impact & Scale of ISRU Activities on the Lunar Surface

A sustained presence on the Moon will impact the Moon scientifically and culturally.
- Scale matters. Location matters.

Why worry now about how a sustained presence could impact the Moon?
- Understanding and openly explaining these impacts and listening to others about impacts both physical and perceived (i.e. inclusion) will prevent much misinformation and hopefully eliminate/prevent distrust for more efficient, inclusive and timely progress in developing a sustained lunar presence.

- Advanced information on the impact may allow trades in how a sustained presence is implemented in order to reduce level of impact.

The scale of ISRU activities is dependent on the type of resource being extracted. ISRU has potential to reduce human impact on the Moon.
  - It is propellant inefficient to bring anything from Earth.

Lunar Surface Innovation CONSORTIUM

NASA

JOHNS HOPKINS APPLIED PHYSICS LABORATORY

Lunar Proving Grounds Definition

Roundtable Discussion

Space Resources Roundtable

June 6-9, 2023, Golden, CO

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LSIC | Lunar Proving Grounds Definition Workshop
July 12-13, 2023

Round Table Discussion:

1. **What information would you most want to get out of this workshop, regarding specifically the definition of the needs, attributes, and performance capabilities that will be necessary for a future LPG?**
    1. How will validation and verification of these systems and interactions, including human-robotic operations, be accomplished?
    2. What metrics need to be tested, and thus what capabilities will such a facility or facilities need?
    3. Which functionalities can be tested separately and which need to synergize?
    4. What can be the role of digital engineering?
2. **What deliverables would you most want to see out of this workshop, e.g., that would be most useful in setting up a follow-on LPG Workshop aimed at decision-making amongst present and future facility owners?**
3. **What platform would make it most easy for you to voice your opinion during this workshop?**

APL

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