LSIC ISRU Focus Group Initial Meeting

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Today’s Agenda

• Overview: The purpose and role of LSIC and the ISRU focus groups
  - Why NASA has asked this to be set up.
  - Why it’s relevant to you.
  - The organizational structure of LSIC and other opportunities for you

• The ISRU Focus Group
  - Our objectives and who we are as a Focus group
  - What this means to you
  - How we communicate
  - Goals

• Challenges the ISRU Focus Group will address/discuss/pursue
  - O₂ & H₂O ISRU

• Open Forum
  - Your goals and needs as institutions and participants
1. Harness the creativity, energy and resources of academia, industry 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.
General FG Goals

- Identify technology needs
- Develop talent
- Build community
- Serve as an information clearinghouse
- Establish collaborative relationships among members

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

The LSIC is a US 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.
# All LSIC FG Contact Information

LSIC Director: Rachel Klima  [SES-LSiC-Director@jhuapl.edu](mailto:SES-LSiC-Director@jhuapl.edu)  [http://lsic.jhuapl.edu](http://lsic.jhuapl.edu)

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<td>In-Situ Resource Utilization</td>
<td><a href="mailto:LSIC_ISRU@listserv.jhuapl.edu">LSIC_ISRU@listserv.jhuapl.edu</a></td>
<td>Karl Hibbitts</td>
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<td>Surface Power</td>
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<td>Jorge Núñez</td>
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LSIC ISRU Focus Group

• Connect industry, academia, and NASA in ISRU technology related to the extraction, storage, and utilization of O$_2$ and H$_2$O, and other volatile resources, to help ISRU technology development for supporting NASA’s exploration of Moon’s surface.

• Identify and determine how to address critical challenges to NASA’s ISRU needs

• The focus group is to enable and facilitate all categories of members; it does not, as a group, do the tech development
Consortium activities include two large semiannual meetings and off-cycle virtual meetings for each technology area focus group.

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

Each focus group conducts quarterly meetings to identify and discuss critical needs.

Contextual Role of the Focus Group

- LSIC SPRING MEETING @ APL
- TARGETED SITE VISITS
- TECHNICAL NEEDS ASSESSMENT
- PROPOSAL OPPORTUNITIES: BAAs, RFPs, PPPs
- FOCUS GROUPS

The diagram illustrates the flow and interactions between these components.
The focus group work, technical needs assessment, and local site visits all feed into proposal or other funding opportunities provided by NASA STMD.

Focus group results feed into the technical needs assessment performed by APL, and may lead to personal site visits to provide more in-depth discussions with NASA.
Community Diversity within the LSIC ISRU Focus Group

<table>
<thead>
<tr>
<th>Number</th>
<th>Category</th>
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<tr>
<td>17</td>
<td>Small business</td>
<td>25.00%</td>
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<tr>
<td>6</td>
<td>Medium to large business</td>
<td>8.82%</td>
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<tr>
<td>13</td>
<td>NASA</td>
<td>19.12%</td>
</tr>
<tr>
<td>17</td>
<td>Academia</td>
<td>25.00%</td>
</tr>
<tr>
<td>9</td>
<td>UARCs and other labs</td>
<td>13.24%</td>
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<tr>
<td>1</td>
<td>Foreign</td>
<td>1.47%</td>
</tr>
<tr>
<td>5</td>
<td>Nonprofit</td>
<td>7.35%</td>
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Industry ~ 35%
NASA ~ 20%
Academia ~ 25%
Non-profit ~ 20%
Value to You

- Access to quantitative information of ISRU relevance about lunar surface
- Potential for collaboration with emerging technologies from academia
- Influence into setting of standards together with greater community
- Ability to identify technology gaps and suggest technical priorities
- Frequent communications between sponsor and providers
- Insight into gaps where R&D is needed
- Possible early-career opportunities
- Partnerships for maturation and implementation of new technology
- Means to build reputation for programs
- Insight into upcoming funding opportunities
- Finger on the pulse on the community
- Visibility into technology development
- Conversations with the community as they set standards and interfaces
Focus Group Communications

• Monthly FG zoom meetings
  - Sharing of relevant information via short/lightning presentations
  - Develop focus group goal(s)
  - Voice issues to be brought to NASA
  - NASA updates

• Possible separate breakout zooms for discussions of specifics for O₂, H₂O, and other processes
  - Brainstorming on specific technologies and progressing on focus group goals.

• ISRU FG mailing list
  - Use as you would any large email list. Sparingly but unhesitantly.
  - Break off into smaller email groups when possible.
  - Additional lists can be set up. We will begin with O₂ and H₂O lists. Email solicitation will follow.
  - Discuss other possible lists (and continue this conversation over email – ironically enough).

• Wiki
  - The main archival resource for the dissemination of information.
  - Be considerate of others. Think in terms of enabling information.

• Follow Rules of the Road for all communications.
  - To be posted on the website.
Next Steps

• For the remainder of the zoom meeting by voice (please use the raise hand feature to avoid chaos) and by chat please bring up:
  - What you want to get from the FG meetings
  - What you would like the FG to accomplish

• What you can do before the next Focus Group meeting, by email, wiki, etc.
  - Provide input if we want to have separate breakout Zoom meetings on O₂ and H₂O at some regular cadence.
  - Provide input on the Year-1 goal
  - Provide input on next topics (such as update from NASA on ISRU strategy and funding)
  - Send us info on what you would like to see from LSIC ISRU FG. (Stand by for website to come up)

• At the next Focus Group meeting, let’s
  - Decide on the Year-1 Focus Group goal
  - Decide on meeting structures
  - Hear from NASA ISRU SCLT
Focus Group Goal

• The ISRU FG is charged to define a single 1-year goal. We will discuss it at next month’s meeting and hopefully by email or wiki beforehand.

• It needs to be
  - Impactful
  - Address a clear need by NASA (refer to the previously described challenges)
  - Doable within 1 year
  - Uses capabilities of focus group members
  - Can be accomplished by us with existing resources
  - Beneficial broadly-speaking to all stakeholders

Possible draft: NASA needs 10MT/year of O$_2$ produced and stored on the Moon by year 2030 and eventually 15MT/year of H$_2$O in order to support a sustained presence*. We are charged to help assess technology for how to meet that challenge. The first-year goal of the ISRU focus group could be to provide specific recommendations to NASA for maturing the technologies needed to achieve those production goals and for creating a roadmap for developing and fielding that technology.

*Sanders et al., NASA ISRU SCLT, 2020.
Motivation for focusing on O$_2$ and H$_2$O Resources on the Moon

- **NASA’s Current Plan:**
  - Develop and fly demonstrations for both lunar ISRU technologies
  - Develop O$_2$ extraction to meet near term sustainability objectives & H$_2$O for long term needs
  - Utilize orbital missions and early lunar surface missions to understand and characterize polar environments, regolith, and water resources to address risks and technology needs

- **O$_2$ from Regolith in general**
  - Lunar regolith is $>40\%$ O$_2$ by mass
  - Can be incorporated into the architecture from the start with low-moderate risk
  - Potentially provides 75 to 80% of chemical propulsion propellant mass (fuel from Earth)

- **H$_2$O (and other Volatiles) from Polar Regolith**
  - Water is “Game Changing” and enables long-term sustainability, at least at the poles
  - Potentially provides 100% of chemical propulsion propellant mass
  - Limited to the poles, likely the permanent shadows
  - However, the form, concentration, and distribution is not YET known making it currently difficult to incorporate into the ISRU architecture

(modified from Sanders, 2019)
FG will discuss challenges with O\textsubscript{2} ISRU

- Over 20 processes have been identified to extract the oxygen
  - Required components range from TRL 3 to TRL 9
  - Typically, as processing temps increase, O\textsubscript{2} yield increases, and technical and engineering challenges increase

- Work during the Constellation Program focused on three processes
  - Hydrogen reduction: ‘low’ temperature, low yield (1 to 3 wt%), higher TRL
  - Carbothermal reduction: ‘higher’ temperature, medium yield (5 to 15 wt%), medium TRL
  - Molten regolith electrolysis: ‘high’ temperature, high yield (>20 wt%), low TRL

- Challenges include: scaling, durability, power, handling, complexity, and others.

(modified from Linne, 2019)
FG will discuss challenges with polar H$_2$O ISRU and other volatile resources

Challenges include:
Locating the material in the required concentration for determining the appropriate extraction technology as well as contaminants, processing, transport, storage.