The Lunar Surface Innovation Consortium and Extreme Access

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Abstract—The Lunar Surface Innovation Consortium (LSIC) was established in 2020 by NASA's Space Technology Mission Directorate (Space Tech) to bring together universities, non-profit institutions, commercial companies, NASA, and other government agencies to identify the technical capabilities and challenges involved in establishing an enduring presence on the Moon. LSIC is intended to enable team building, pulling from a diverse community that encourages networking, partnering, and collaborations to amplify the results of individual efforts across all technology areas relevant to lunar exploration.

Index Terms—technology assessment, autonomous vehicles, robotic systems

I. Introduction

LSIC [1] is focused on identifying and catalyzing the deployment of components, systems, and technologies for use toward an enduring human and robotic presence on the surface of the Moon. As a part of Space Tech's Lunar Surface Innovation Initiative (LSII) [2], LSIC seeks to foster technology development to help stimulate and support commercial companies that would like to participate in the future lunar economy. LSII and LSIC consider the entire breadth of Technology Readiness Levels (TRLs), from identifying elements and gaps that have not yet been developed, to technologies that exist for terrestrial applications but have not been considered for space or lunar applications, to those that are advanced but require a flight demonstration before they can continue improvements, to heritage systems that can be applied in new ways. LSIC supports the advancement of lunar technologies by hosting meetings and workshops throughout the year, feeding forward findings from these to guide the topics for future discussions, develop community resources, and to provide feedback to NASA on community needs. These discussions provide insight for academic institutions or others who seek to explore early-stage innovation concepts, as well as for commercial space companies to understand where they can make smart investments to position themselves as key suppliers in the future.

II. LSIC Organization and Structure

LSIC is made up of focus groups aligned with LSII's capability areas: In-Situ Resource Utilization (ISRU); Surface Power; Excavation and Construction (E&C); Extreme Environments (EE); Dust Mitigation; and Extreme Access (EA). The first three of these focus on key elements of any permanent infrastructure and the latter three focus on overarching concerns that impact engineering designs for infrastructure (like radiation, thermal, or dust hazards) or cross-cutting technologies that enable access across the Moon. Included in EA are robotics and autonomy topics that are supported through the advancement of communications, navigation, and timing capabilities. Each of the LSIC focus groups meets monthly to share technical presentations, foster networking and partnerships, and identify key issues that need more in-depth research or development. These discussions feed into technical workshop or subgroups geared towards providing findings or recommendations to NASA (e.g., recommendations for flight demonstrations, funding investments, etc.). Two working groups have also been organized: Lunar Simulants and Interoperability.

III. Extreme Access

The EA group is cross-cutting, focusing on technology to enable humans and robotic systems to efficiently access, navigate, and explore previously inaccessible lunar surface and subsurface areas. To accomplish this goal, we consider the needs of robust and sustained lunar surface activities (such as the bulk transport of regolith); ingress, exploration, and

egress of subsurface voids; hazard detection in all lunar environments and conditions; as well as communicating and navigating with minimal infrastructure and autonomous operations. Subgroups within EA meet on a monthly basis. The subgroups include: Communications; Mobility; Position, Navigation, and Timing; and Autonomy.

The technologies in the EA focus area feed into the capability needs of other areas, such as prospecting in extreme terrain for ISRU and the transport of materials across the lunar surface (ISRU and E&C) without human interactions. Toward meeting these goals, the EA focus group led the community input into the LunaNet standards [3, 4] to ensure interoperability in the future lunar communications infrastructure. Furthermore, EA also hosted a multi-day workshop to explore the data availability and needs for precision landing [5], co-hosted a workshop with the EE on designing space system for the extreme lunar domain [6], and co-hosted a multi-day workshop with the E&C focus group to understand the needs and challenges of autonomous systems on the lunar surface [7]. LSIC also hosted a workshop to lead the community discussion on defining a lunar proving ground appropriate for technology maturation and systems integration across all focus areas [8]. Summaries of these workshop are provided to NASA to highlight the needs of lunar technology developers and to suggest paths forward to close the identified gaps.

IV. Conclusion

The high level of engagement from businesses, non-profits, academic institutions, and government agencies in the LSIC meetings suggests that the community is eager to be a part of crafting a peaceful, responsible, and sustainable return to the lunar surface. Full reports from each of the semi-annual meetings, as well as recordings of those discussions, can be accessed publicly through the LSIC website [1]. Semi-annual meetings are held in the spring and fall of each year. Interested members of the community are invited to sign up to participate in monthly focus group meetings, workshops, or other meetings.

Acknowledgment

We are grateful to NASA's Space Technology Mission Directorate for supporting this effort.

References

[1] https://lsic.jhuapl.edu/

[2] https://www.nasa.gov/directorates/spacetech/Lunar_Surface_Innovation_Initiative

[3] D. J. Israel *et al.*, "LunaNet: a Flexible and Extensible Lunar Exploration Communications and Navigation Infrastructure," *2020 IEEE Aerospace Conference*, Big Sky, MT, USA, 2020, pp. 1-14, doi: 10.1109/AERO47225.2020.9172509.

[4] https://www.nasa.gov/feature/goddard/2021/lunanet-empowering-artemis-with-communications-and-navigation-interoperability

[5] https://lsic.jhuapl.edu/Events/Agenda/index.php?id=120

[6] https://lsic.jhuapl.edu/Events/Agenda/index.php?id=232

[7] https://lsic.jhuapl.edu/Events/Agenda/index.php?id=474

[8] https://lsic.jhuapl.edu/Events/Agenda/index.php?id=460