Lunar Surface Innovation CONSORTIUM

JOHNS HOPKINS APPLIED PHYSICS LABORATORY

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LSIC Newsletter

The Lunar Surface Innovation Consortium is administered by the Johns Hopkins Applied Physics Laboratory, and operates in collaboration with the NASA Space Technology Mission Directorate under the Lunar Surface Innovation Initiative. Its purpose is to harness the creativity, energy, and resources of the nation to help NASA keep the United States at the forefront of lunar exploration. To find out more, sign up to participate, or access past additions of this newsletter, please visit lsic.jhuapl.edu.

DIRECTOR'S UPDATE

Director's Update

Hello LSIC Community! This month, I'd like to take a few moments to talk about the LSIC subgroups. When we originally outlined our plans for LSIC, we anticipated that we would have specific topics of interest that would benefit from detailed technical discussions. We have been thrilled with the level of participation in our focus groups over the past two years, but it is also clear that the larger groups often don't lend themselves well to as many voices participating in discussions. Particularly for our "extreme" groups, the broad scope of the focus area means that there are many diverse topics that need to be addressed, and that may interest slightly different participants.

Many of the focus groups have now spun off subgroups, which are often led by community members and that meet separately to investigate special topics. Subgroups provide the flexibility to dig more into the technical weeds or specific problems, and may be stood up or down based on need. If you participate regularly with a specific focus group, you are like already aware of its subgroups, but we encourage you to have a look at the LSIC website to see whether there are others associated with different focus areas that might interest you. This cross-pollination of subject matter experts is crucial as we all move forward towards developing technology for establishing infrastructure for the lunar surface.

Rachel Klima
Director, Lunar Surface Innovation Consortium
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Focus Areas

Monthly Telecon Schedule

Dust Mitigation
Third Thursdays at 12PM Eastern

Excavation & Construction
Fourth Wednesdays at 2PM Eastern

Extreme Access
Second Thursdays at 3PM Eastern

Extreme Environments
Second Tuesdays at 3PM Eastern

In Situ Resource Utilization
Third Wednesdays at 3PM Eastern

Surface Power
Fourth Thursdays at 11AM Eastern

LSIC General Updates

Regolith to Rebar Workshop: 23 February 2022 (Registration Deadline 15 February)

This one-day virtual workshop will bring together lunar In-Situ Resource Utilization (ISRU) developers to represent the supply side and Excavation & Construction (E&C) focus group participants to represent the demand side, in an early attempt to link the in-situ production, the processing and the use/consumption of metals and metal-like by-products that result from O2 production technologies on the lunar surface. The workshop will consist of approximately 10-minute long talks from the two perspectives, followed by panel discussions. This workshop is intended to lay the foundation for the development of an ecosystem in this nascent field of lunar ISRU metals and to strengthen public-private partnership. Our overarching goal is to develop a common and realistic mutual understanding of what is possible for metal ISRU in the near-term (next 5-10 years). Some issues to be addressed include:

- Discuss infrastructural needs for the use of metals. What kinds, how much, and in what shape and form?
- Discuss the usefulness of the 'low hanging fruit' resulting from current O2 extraction processes. What these products will be, how useful would they be, and if modest post-processing can be effective?
- Discuss feasibility of metal-specific manufacturing processes on the lunar surface.
- Develop concepts for how to integrate the demand and supply sides, including identifying possible roles for NASA.
- Identify gaps and challenges in metal construction on the lunar surface.
- Discuss economic feasibility of metallic yields and any desired associated additional processing, including areas ripe for improvement.

Registration and the full agenda are available online at https://lsic.jhuapl.edu/Events/Agenda/index.php?id=177. Sign up today to join us for this exciting event!

Modular Open Systems Approach LSIC Working Group

LSIC has established a working group to focus on collecting community feedback on implementing a Modular Open Systems Approach (MOSA) for lunar exploration. The goals of this working group are to determine which systems could benefit from a MOSA, identify critical interfaces, and identify what types of requirements need to be set to ensure interoperability. Each focus group has a MOSA working group point of contact who will inform their focus group on upcoming MOSA activities. This includes the MOSA activities within their focus group and in other focus groups. In fact, we highly encourage the reader to participate in MOSA activities outside your typically attended focus group to ensure that these discussions capture a system-wide perspective. The findings of the working group will be published in a report and available to the community.

Save-the-Date for LSIC's Spring Meeting 04-05 May 2022 (Online and In-Person at APL in Laurel, MD)

The LSIC 2022 Spring Meeting will concentrate on understanding NASA's plans and technology investments relevant to building a sustained presence on the lunar surface. The meeting will include invited speakers, panels, posters, and breakout discussions. We invite abstracts from the community describing technical capabilities within the six LSIC focus areas, as well as those that identify lunar surface technology needs and assess the readiness of relative systems and components. Other topics of interest include defining the parameters and constraints of the architecture required to support a sustained presence on the lunar surface, as well as economic and policy considerations. Abstracts are limited to 1 page in length, and are due March 4th, 2022, (https://lsic.jhuapl.edu/Events/Agenda/index.php?id=200).

Community Engagement Opportunity: COSPAR Session B0.2 "Space Resources"

Session B0.2 "Space Resources" to be held as part of the 44th COSPAR Scientific Assembly to be held in Athens in July. Further information about the meeting may be found here: https://www.cosparathens2022.org/program/scientific-program/

There is growing interest in the use of the resource base of the Solar System to facilitate space exploration and enable the development of a space economy. Such activities might also supplement the economic resources of our own planet. This meeting will address the extent to which lunar, asteroid, and Martian resources may contribute to these objectives.

Papers are invited on all aspects of the science and engineering of space resource utilization, including the development of synergies among techniques developed to access resources on different Solar System objects, and the scientific investigations that support them.

Please consider submitting an abstract to this session. The deadline for abstracts is 11 February: https://www.cosparathens2022.org/attending/registration-abstract-submission/

Focus Group Updates

Dust Mitigation

The Dust Mitigation (DM) Focus Group kicked off 2022 with a monthly focus group meeting on January 20th, highlighting the topic of Passive Dust Mitigation. We heard an update from Kristen John and Jacquelyne Black of NASA Johnson Space Center on DuSTI - Dust Solution Testing Initiative, a one year project on "Dust Mitigation Characterization of Coatings and Pliable Cleaners" as well as a presentation by Dr. Stephen Furst, Founder and CEO of Smart Material Solutions, Inc., on the latest results of their SBIR-funded project "Passive Nano and Micro Textured Dust Mitigation Surfaces in Space-Grade Materials Made with a Highly Scalable Fabrication Process". The discussion continued to unpack topics such as knowledge gaps, priority technologies, and what kinds of data would support modeling efforts in this domain.

We look forward to connecting with everyone at our next meeting as we follow-on with the topic of Active Dust Mitigation, scheduled for Thursday, February 10th at 12:00pm EST. In the meantime, let's keep the conversation going on Confluence!

Excavation & Construction

The January monthly meeting featured talks from Dr. Corky Clinton and Dr. Mark Hilburger from Marshall and Langley NASA centers, respectively. Corky gave an overview of the Moon to Mars Planetary Autonomous Construction Technology (MMPACT) project of which he is the PI. He also presented the preliminary plans for demonstration and qualification mission concepts to the lunar surface. Mark, who is the NASA E&C lead, gave an update on NASA Capability Needs and Technology Gaps to highlight top priority needs. We also conducted a survey in this meeting to solicit feedback from the members on how the focus group is doing and how we can improve. The E&C team also brainstormed ideas to improve networking in the monthly meetings and workshops. We plan to make our meetings more interactive and discussion-heavy in the coming months. Sub-team formation efforts went on high gear in January with potential sub-team leads identified and a document for code of conduct and roles & responsibilities drafted. In February, the biggest item on our plate will be the joint ISRU – E&C metal workshop, Regolith to Rebar, to be held on the 23rd. For more information and registration, which is required, please visit https://lsic.jhuapl.edu/Events/Agenda/index.php?id=177.

Extreme Access

The Extreme Access focus group had two presentations on Robot Operating System (ROS) in January, one from Amalaye Oyake and Will Chambers on Blue Origin's Space ROS initiative, as well as a presentation from Steve Hart of TracLabs on their 2020 NASA-funded STTR with the Johns Hopkins Applied Physics Lab on Integrating ROS 2 with the Core Flight System. At the monthly telecon, the group also discussed a recent RFI from NASA on ROS. Sarah Withee presented at the Institute of Navigation International Technical meeting on position, navigation, and timing activities LSIC worked on in 2021. The PNT subgroup began discussion of navigation issues in permanently shadowed regions, and the comms subgroup had a representative from Nokia present on their work to bring 4G LTE to the Moon. The mobility subgroup had a presentation from Terry Fong on VIPER along with a summary of the last three months of work the community has done in identifying types of missions, functions, and payloads for future mobile platforms. The TRN subgroup held its first meeting January 25 to discuss hazard detection and avoidance (HDA) and low altitude operations when reference maps become too coarse to be able to use. Their featured speaker was Johns Hopkins University - Applied Physics Lab's Carolyn Sawyer, the Lidar Terrain Sensing (LTS) lead for the upcoming Dragonfly mission to Titan. Next month's telecon will feature a presentation by Alexandria Terry (National Geospatial Intelligence Agency) about the Lunar Reference System for Navigation Safety.

Extreme Environments

The Extreme Environments (EE) Focus Group started the new year with a presentation from Richard Oeftering from NASA Glenn covering "Power Hibernation: Surviving the Extreme Cold Lunar Environment." In the upcoming months, we plan on presenting summaries of our technology/software gap conversations as well as digging deeper into the relationships between our EE disciplines and diving into "Cross Talk" conversations with the other focus groups. Don't forget to check out all of our subgroup meetings whose cadence is listed on our Confluence site to view featured presentations like we had in our plasma subgroup this month on "Yield Measurements of Highly Insulating Granular Materials: Precursors for Lunar Dust Measurements." Come join us in February to hear about Illumination Modeling. As always, if community members have ideas for what they would like to see or discuss, please reach out to any member of EE leadership.

ISRU

The ISRU Focus Group held its monthly meeting on January 19th followed by breakout subgroup discussions. Dr. Anne Parsons, NASA GSFC, presented on BECA (Bulk Elemental Composition Analyzer), an active source neutron spectrometer. Curtis Purrington, Colorado School of Mines, presented on the Rotary Extraction Drum – a concept for processing icy regolith. Dr. Clive Neal, Notre Dame, announced there will be a pair of LSSW this summer focused on defining and implementing an international lunar polar volatile prospecting campaign. In the breakout sessions, the Interoperability/Modularity Subgroup met for the first time. Additionally, the report generated from the surveys and breakout group discussions on the availability and needs of facilities to support ISRU technology development was submitted to NASA.

Surface Power

In January, owing to the open RFP sponsored by NASA and in collaboration with the DoE and INL, the LSIC Surface Power Focus Group held its monthly telecon themed on Fission Surface Power for the Moon. Anthony Calomino, NASA, gave a presentation with context and details on Fission Surface Power, as well as a Q&A on the topic. Also starting in January, one of our APL Surface Power facilitators, James Mastandrea, took on formalizing an LSIC-wide effort in modularity and interoperability. Next month the Surface Power focus group plans to cover updates on this effort, as well as have subgroup sessions for networking, collecting feedback on active areas relevant for STMD, and shaping our plans over the coming year.

Feature Article

Regolith to Rebar: How In Situ Resource Utilization on the Lunar Surface Directly Supports Excavation & Construction

The lunar surface is not only a target for exploration and establishment of a sustained presence, but also boasts resources that can be gathered and used to support operations and infrastructure development. The currently anticipated Artemis landing area of the South Pole, like elsewhere on the Moon, is covered with regolith – loose, heterogenous rock powder and fragments that overlay a rockier substrate, like dirt on the Earth's surface but without the organic components. The regolith composition at the South Pole is dominated by minerals containing silicon, aluminum, and calcium, which are all bound to oxygen. In the more equatorial-located mare, iron has been detected in relatively large amounts (~20 wt.% FeO or more) whereas FeO content in the Highlands regolith is much lower (<7 wt.%). The mare also boasts a more diverse suite of elements such as silicon, aluminum, magnesium, calcium, and even titanium all of which also exist as various minerals (or glasses) chemically bound to oxygen. It should be noted that the Mare is not currently a planned Artemis target.

These mineral resources can certainly be used in a raw unprocessed form for a variety of purposes. More investigation can be done on how best to do that as well as how to process or purify it in the lunar exosphere for more advanced uses. One of the most often talked about ways of processing the regolith is the extraction of O2, needed for life support but which can also be sourced as the oxidizer for rocket fuel. There are several viable technologies currently being matured for the extraction of O2 from the regolith such as reduction using methane or hydrogen followed by electrolysis, melting the rock and performing electrolysis on the melt, possibly augmented with conductive salts, and even heating the regolith until the volatiles and oxygen vaporize out. Each of these processes also results in left-over material that is depleted in O2, potentially making the concurrent extraction of metals like aluminum and iron a natural byproduct to the extraction of O2. This 'leftover' metallic material from O2 processing can be used for a variety of purposes, some of which are outlined in Table 1. Whether and to what extent these extracted metals can be purified is still an outstanding question, and even the efficiency of extracting the metals from the lunar regolith is continuing to be investigated. Missions to the Moon are currently planned to further investigate these questions.

The possibility of using existing resources on the lunar surface is incredibly impactful on the path to a sustained presence. In-situ resource utilization, including the raw regolith, O2 and metals derived from it, would mean that material would no longer have to transported from Earth. Eliminating the cost associated with lifting the material from the Earth into space and then setting it down on the Moon would significantly defray the cost and risk of developing a sustained presence on the Moon. Realistic plans for a sustained lunar presence will inevitably include 'living off the land' as much as possible.

Initial efforts for in situ resource utilization would likely be geared towards items that do not demand high purity metals (or alloys) such as blast shields for landing pads, spares for regular maintenance and repair, protective roofs for rovers, materials for heat storage, etc. Habitats could also be manufactured on the lunar surface using in-situ resources, likely using a combination of the basic regolith as well as products derived from it for refinement and improved stability of design. These applications will require thinking outside the box, beyond just using traditional materials like pure metals such as steel and aluminum, as well as determining what can be used that's 'good enough' for

the infrastructure needed to support a sustained presence on the Moon.

As the technology for harvesting and processing of the regolith to extract resources matures, the metals derived from the regolith could be used to form rebar for infrastructure reinforcement, or to 3D print spare parts for the maintenance and repair of equipment on the Moon. Research about space manufacturing is already being conducted on the International Space Station (ISS), and expanding those efforts to the lunar surface will continue to pave the way for future extended expeditions to targets like Mars. The knowledge gained from these efforts could also pave the way for other important advanced applications such as in-situ production of photovoltaic (PV) panels for harnessing solar energy.

Metal	Uses
Silicon	Electronics and photovoltaic panels, Silanes (SiHx) as rocket fuel alternative, Energy carrier / storage
Aluminum	Construction material (pure or alloyed), Solid powder as rocket fuel, Energy carrier / storage
Iron	Construction material (pure or alloyed), Energy carrier / storage
Magnesium	Construction material (alloyed), Solid powder as rocket fuel, Energy carrier / storage
Titanium	Construction material (pure or alloyed), Energy carrier / storage
Manganese	Construction material (alloyed), Energy carrier / storage
Chromium	Construction material (alloyed)
Sodium	Thermal fluid / coolant, Energy carrier / storage
Potassium	Thermal fluid / coolant Energy carrier / storage

Table 1: Metals available for extraction on the lunar surface and their applications.
Source: Shaw et. al., Mineral Processing and Metal Extraction on the Lunar Surface – Challenges and Opportunities, Mineral Processing and Extractive Metallurgy Review, DOI: 10.1080/08827508.2021.1969390

Member Spotlight

A SSERVI Principal Investigator / Program Officer's Experience & Perspective: Dr. Jennifer Heldmann

Jennifer Heldmann, a Research Scientist at the NASA Ames Research Center, is running her second SSERVI team and spoke with us about the organization's goals, activities, and impact. SSERVI stands for "Solar System Exploration Research Virtual Institute," and was started by NASA to address questions fundamental to human and robotic exploration of the Moon, Near Earth Asteroids (NEAs), the Martian moons Phobos and Deimos, as well as the near space environments of those target bodies according to their website. Heldmann has served as both a program officer and a Principal Investigator (PI), giving her a unique perspective on this dynamic organization. When asked about the group's objectives, she shared that SSERVI aims to push the needle forward for both science and exploration. Heldmann quoted the late Michael Wargo, a past Chief Exploration Scientist of NASA's Human Exploration and Operations Mission Directorate (HEOMD), "Science enables exploration, and exploration enables science."

SSERVI began as the NASA Lunar Science Institute (NLSI) in 2008. The original goal was to provide opportunities for teams to propose large scale, important work regarding science and exploration of the Moon. By 2013, the target had begun to shift beyond the Moon to NEAs, Martian moons, as well as their respective near space environments, and SSERVI was born. As a virtual institute, their central office is located on the NASA Ames campus at Moffett Field, CA, and individual research groups are led by PIs at institutions across the U.S. International partners also collaborate with the domestic teams to address key topics of mutual interest. Beyond their geographic reach, SSERVI's work has important impacts agency-wide for NASA. "Another big purpose is to bridge the gap between NASA's Science Mission Directorate (SMD) and HEOMD, who jointly fund SSERVI," explained Heldmann.

Another way SSERVI encourages cross-pollination of ideas is through focus groups – any team member can request to start a group dedicated to exploring concepts identified as valuable by the wider community. Heldmann herself leads a group on terrestrial analogues. Records of past focus group meetings are hosted for the public to access on their website, along with outputs from the research teams, past events, and publications. In terms of the broader outputs of SSERVI's efforts, those posted publications are the key product – members are enthusiastically encouraged to publish their results. An annual report is also released that features updates and key findings.

Awards are provided over a five-year timeframe, allowing teams to get intensive research done with the benefit of stable funding and a decent sized team. Within that time span, flexibility is also allotted for research plans, allowing them to change as needed given the fact that sometimes when more is learned, objectives can shift in response to the new information. That tractability extends into encouraging collaboration between teams, within the SSERVI community, and with international partners. The organization's operations also reach up and down the generational talent pipeline, especially seeking to include and support early career researchers whenever possible. "SSERVI has been around long enough to see early career recruits grow into their mid-career status," Heldmann explained, "and for me that's one of the most satisfying things about being a part of all this.

Heldmann's first SSERVI project, FINESSE (Field Investigations to Enable Solar System Science and Exploration) had a twofold goal: first (FINESSE Science), to understand the effects of volcanism and

impacts as dominant planetary processes on the Moon, NEAs, as well as Phobos and Demos, and second (FINESSE Exploration), to understand which exploration concepts of operations (conops) and capabilities enable and enhance scientific return. Her second and current project, RESOURCE (Resource Exploration and Science of OUR Cosmic Environment) focuses primarily on ices and volatiles found on the Moon, how they can be searched for and categorized, exploring the technology needed for extraction and utilization, as well as understanding the bigger picture of how missions can support a sustained presence on the Moon and looking to Mars.

Projects like FINESSE and RESOURCE are funded through SSERVI's central office at NASA Ames. Every two and a half years, a Cooperative Agreement Notice (CAN) is released, and any PI at a U.S. institution can write a proposal for consideration. All submissions are peer reviewed, and NASA then decides which receive five-year awards (making for a staggered award cycle). Monthly executive council meetings are held virtually through the NASA Ames central office, allowing PIs to give updates on what their team is doing, find opportunities for cross collaboration, and maximize their own productivity within the organization. SSERVI also works to ensure inroads are made with the human exploration community so that work being done by their researchers gets infused directly into the planning process of initiatives like Artemis. Heldmann shared that work benefitting Artemis from her own and other SSERVI research groups includes exploring surface conops, what extra-vehicular activities (EVAs) look like for astronauts on the surface, enabling communication with Earth, and much more.

Looking ahead, Heldmann is excited for CLPS and the potential for flying instruments to the lunar surface. She sees the next generation of instrumentation and technology being developed now, and with missions to the Moon planned for the near future, there's a roadmap and real opportunities for putting them to use. A major obstacle she sees ahead is some of the stovepiping that NASA has traditionally experienced, but SSERVI is among those working to bridge those gaps and make sure that science objectives are tightly coupled with human exploration. LSIC is another organization working to the same end, engaging the lunar community across sectors and disciplines. "LSIC is very in touch with the state of the art and where work needs to be done on the lunar front," expressed Heldmann. "We need to stay engaged with that information to inform what our teams do and where funding should be prioritized in the future."

NASA News

Israel to sign Artemis Accords

01/25/2022 \ SPACENEWS

https://spacenews.com/israel-to-sign-artemis-accords-foreign-minister/

STEM Student Experiments Win Flight Opportunity in NASA Tech Contest

01/21/2022 \ NASA Space Tech

https://www.nasa.gov/press-release/stem-student-experiments-win-flight-opportunity-in-nasa-tech-contest

Plus Ultra's lunar comsats to hitch rides on ispace moon landers

01/21/2022 \ SpaceNews

https://spacenews.com/plus-ultras-lunar-comsats-to-hitch-rides-on-ispace-moon-landers/

NASA foresees gap in lunar landings after Artemis 3

01/20/2022 \ SpaceNews

https://spacenews.com/nasa-foresees-gap-in-lunar-landings-after-artemis-3/

Bobby Braun Moving from JPL to APL

01/20/2022 \ Space Policy, Marcia Smith

https://spacepolicyonline.com/news/bobby-braun-moving-from-jpl-to-apl/

Formation of Extravehicular Activity and Human Surface Mobility Program Signals New Era for NASA

01/18/2022 \ NASA Roundup Reads

https://roundupreads.jsc.nasa.gov/pages.ashx/1842/Formation%20of%20Extravehicular%20Activity%20and%20Human%20Surface%20Mobility%20Program%20Signals%20New%20Era%20for%20NASA

NASA 2022 Calendar: 11 Space Missions to Look Forward To

01/16/2022 \ Inverse

https://www.inverse.com/science/nasa-2022-calendar-missions

Artemis I Core Stage Engineering Testing Complete

01/14/2022 \ NASA

https://blogs.nasa.gov/artemis/2022/01/14/artemis-i-core-stage-engineering-testing-complete/

AVL Joins Northrop Grumman Team for NASA's Next-Generation Lunar Terrain Vehicle

01/13/2022 \ AVL

https://youtu.be/Qbr-zIWC_5M

NASA, White House Initiative to Spur Entrepreneurial Spirit of HBCU Scholars

01/12/2022 \ NASA News

https://www.nasa.gov/press-release/nasa-white-house-initiative-to-spur-entrepreneurial-spirit-of-hbcu-scholars

Intuitive Machines Validates Lunar Communication with MSU for First Lunar Landing

01/12/2022 \ Intuitive Machines

https://www.intuitivemachines.com/post/intuitive-machines-validates-lunar-communication-with-msu-for-first-lunar-landing

To The Moon: GM and Lockheed Martin's New Lunar Rover, Rendered

01/11/2022 \ MotorTrend

https://www.motortrend.com/news/gm-design-lockheed-martin-new-lunar-rover-renderings/

Masten Mission 2: Masten Prepares for Next Mission to the Moon in 2024

01/11/2022 \ Masten

https://masten.aero/blog/masten-mission-2-masten-prepares-for-next-mission-to-the-moon/

KSC to study potential new Starship launch pad

01/06/2022 \ SPACENEWS

https://spacenews.com/ksc-to-study-potential-new-starship-launch-pad/

Artemis Moon Rover's Wheels are Ready to Roll

01/06/2022 \ NASA

https://www.nasa.gov/feature/ames/artemis-moon-rover-s-wheels-are-ready-to-roll

NASA funds thermal control solutions for harsh lunar environments

01/03/2022 \ SpaceNews

https://spacenews.com/nasa-funds-thermal-control-solutions-for-harsh-lunar-environments/

In 2022 a Moonrush will begin in earnest

01/01/2022 \ The Economist

https://www.economist.com/science-and-technology/2022/01/01/in-2022-a-moonrush-will-begin-in-earnest

Funding Opportunities

NASA ACO/TP Synopses Now Live

Tipping Point Announcement for Proposals: http://go.usa.gov/xtn6z

Announcement of Collaboration Opportunity: https://go.usa.gov/xtn6J

Topic 1. Cislunar/Lunar Surface Infrastructure & Capabilities

Technologies that support global lunar utilization leading to commercial commodities and services for a robust lunar economy. Such infrastructure could include examples such as long-distance lunar power distribution; survive and operate during lunar night; in-situ Resource Utilization; lunar communications; autonomous construction. These examples for lunar surface infrastructure are not limiting and other potential examples are invited to create a robust lunar economy.

Topic 2. In-Space Infrastructure & Capabilities

Low Earth Orbit (LEO) to Geosynchronous Earth Orbit (GEO) technologies that support additional future services for a growing LEO/GEO economy. Such infrastructure could include examples such as climate research or service; assembly and manufacturing technologies; distributed autonomy; measurement/observation capabilities; entry, descent, and landing; advanced propulsion. These examples for LEO/GEO technologies are not limiting and other potential examples are invited to create a robust LEO/GEO economy.

Additional info:

The National Aeronautics and Space Administration (NASA) continues to embrace partnerships to achieve its strategic goals for expanding capabilities and opportunities in space. STMD has formulated a strategic framework to ensure American global leadership in space technology. The framework consists of four strategic thrusts, representing the capabilities needed for robotic and human exploration of the Moon, Mars, and beyond. These thrusts represent major lines of investment within STMD's portfolio that are expected to have major impacts on space through 2040 and beyond. The strategic thrusts are:

- Go – Enable rapid, safe, and efficient space transportation
- Land – Enable expanded access to diverse surface destinations
- Live – Enable sustainable living and working farther from Earth
- Explore – Enable transformative missions and discoveries

This strategic framework provides context and enables a trace from overarching trends, through high level goals, to topics, and the specific technical challenges that individual projects must address.

A key aspect of NASA's strategy is to stimulate the commercial space industry and commercial capabilities through public-private partnerships to deliver technologies and capabilities needed for future NASA, other government agency, and commercial missions. With the recent increase of U.S. private sector companies interested in space applications, NASA is seeking commercial space technologies that are at a "tipping point" in their development cycle. The anticipated definition to be used for the purpose of this AFP is that a space technology is at a "tipping point" if:

- System/technology is at a Technology Readiness Level (TRL) of approximately 4 or greater at time of initial proposal

- The partner has a robust plan for commercialization
- The activity will substantially advance the TRL of the technology and improve the partner's ability to bring that technology to market

For this AFP, STMD will solicit proposals that are led by a U.S. for-profit entity to advance "tipping point" space technologies. NASA intends to utilize its Other Transactional Authority (OTA) and anticipates making awards utilizing Funded Space Act Agreements (FSAA) with firm fixed milestone payments tied to technical achievement. Please refer to the forthcoming AFP for the full list of eligibility requirements/restrictions. Participants should review the FSAA terms and conditions provided in the AFP prior to determining whether to submit an initial proposal; NASA is not anticipating changes to the FSAA Template. Significant industry investments (both monetary and in-kind) will be required to complement Government funding and ensure successful execution.

This release anticipates soliciting the funded development of tipping point technologies from the following two Topics. This list should be considered preliminary and is subject to change prior to announcement release. For this AFP, STMD seeks proposals that would develop tipping point technologies and integrated system capabilities for demonstration in relevant environments, in-space, or lunar surface. Multiple flight demonstration awards are anticipated with a total funding amount of about $150M-$200M for this announcement, subject to availability of appropriated funds.

This release will utilize a two-step proposal submission and evaluation process. The initial step will be a Mini Proposal (i.e., "Project Pitch"). Only those firms submitting the most competitive Mini Proposals will be invited to submit a Final Proposal.

All proposals must be submitted electronically through NSPIRES by an Authorized Organizational Representative (AOR). Detailed submission instructions will be provided in the AFP. Potential participants and their proposing organizations are urged to familiarize themselves with the submission system, ensure they are registered in NSPIRES, and submit the required proposal materials well in advance of the deadline.

A Virtual Industry Forum is anticipated about two weeks after the AFP release. Further details concerning the Forum will be provided in the AFP. All questions and comments, after the AFP is released, must be submitted in writing to HQ-STMD-TippingPoint@nasaprs.com. Responses to inquiries will be answered by email and may also be included in the Frequently Asked Questions (FAQ) document located on the NSPIRES page associated with the AFP; anonymity of persons/institutions who submit questions will be preserved.

The AFP and any documents related to this announcement will be available by opening the NSPIRES homepage at https://nspires.nasaprs.com/ by selecting "OPEN" and entering "80HQTR22SOA02," and, finally selecting "Utilizing Public-Private Partnerships to Advance Tipping Point Technologies."

It is the offeror's responsibility to monitor the Internet site for the release of the AFP and amendments (if any).

Tech Development

- DOE Fission Surface Power System Design Solicitation
  https://sam.gov/opp/f2610d99cf174e959eede4b170d86e2d/view

  Proposals due: 17 February 2022

- NASA Small Business Innovation Research (SBIR) / Small Business Technology Transfer (STTR) 2022 Phase I Solicitation
  https://sbir.nasa.gov/solicitations

  Proposals due: 09 March 2022

Student Tech Development

- Over the Dusty Moon Challenge (Colorado School of Mines & Lockheed Martin)
  https://www.overthedustymoon.com/

  June 2022: In-person challenge

Request for Information

- New Approaches to Qualifying Electronics in a High Radiation Environment (DARPA Microsystems Technology Office)
  https://sam.gov/opp/c2075bf4d79841b6bd3e666261a97798/view

  Response Date: 04 February 2022

For more funding opportunities, please visit LSIC's website here: http://lsic.jhuapl.edu/Resources/Funding-Opportunities.php