2023 Breakthrough, Innovative, and Game-changing (BIG) Idea Challenge

Q&A Session

October 20, 2022

(Please mute your mics)

http://bigidea.nianet.org/

The BIG Idea Challenge is sponsored by NASA's Space Technology Mission Directorate (Game Changing Development Program) and Office of STEM Engagement (Space Grant), and managed by the National Institute of Aerospace.

Agenda

(Please mute your mics)

- Welcome and Introductions
- Context for the 2032 Challenge
- Questions Received in Advance
  - Technical
  - Programmatic
- Additional Questions (time permitting)
- Programmatic Remarks
- Wrap Up

BIG IDEA CHALLENGE

NIA BIG Idea Challenge Program Team

Shelley Spears, PMP

NIA Director of Education and Outreach

Stacy Dees, PMP

Program Manager

Robin Ford, CMP

Events Manager and Sr. Program Coordinator

Janice Kurbjun Miller

Communications Manager and Sr. Program Coordinator

2023 Judges – Lunar Forge Technology

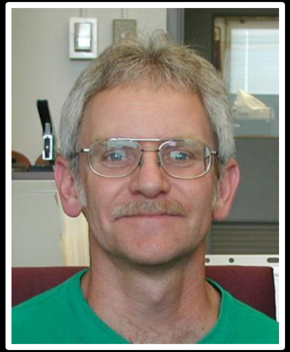
Karen Taminger
NASA LaRC – Co-Chair

Kevin Kempton
NASA LaRC – Co-Chair

Alex Blanchard
NASA MSFC

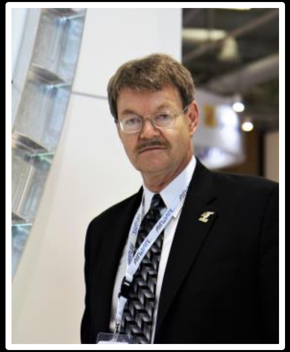
Dr. Cheryl Bowman
NASA GRC

Robert Carter
NASA GRC



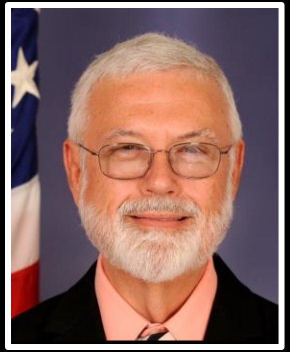
Tim Gabb
NASA GRC

Mick Maher
Maher & Associates



Michael Niedzinski
Constellium

Dr. Kevin Slattery
The Barnes Global Advisors



Dr. Bill Frazier
Pilgrim Consulting

Context for the 2023 BIG Idea Theme

LUNAR FORGE: PRODUCING METAL PRODUCTS ON THE MOON

The 2023 BIG Idea Challenge provides collegiate students **up to $180,000** to design, develop, and demonstrate technologies that will enable the production of lunar infrastructure from ISRU-derived metals found on the Moon.

Key infrastructure products desired are storage vessels for liquids and gases, extrusions, pipes, power cables, and supporting structures (i.e., roads, landing pads, etc.). Teams are invited to submit proposals that focus on any part of the metal product production pipeline* from prospecting to testing.

***Exclusions:** Proposals that focus on drilling, excavation, or transportation will NOT be considered for selection in the 2023 BIG Idea Challenge. The challenge is not looking for concepts that focus on the recycling of landed assets into feedstock or metal products.*

General Technical Remarks (Judges)

- Open innovation competition w/limited constraints
- No additional constraints for location, mass, power consumption, volume, or production minimums/maximums
  - Keep in mind NASA values cost effective solutions (e.g., low mass, small size, low power, simplicity, and high reliability).
  - If you have high resource requirements, they need strong justification
- Teams should not feel pressed to mesh designs with current NASA/Artemis planning.
- YOU are selling the value of your proposed concept to the judges
  - Make sure the idea you want to demonstrate fits into a compelling use case. Make it compelling so the judges see the potential value and want to give you money. (Think Shark Tank pitches!)

General Technical Remarks (Judges)

- How do you scope your project?
  - Make it something that can be achieved with the resources you have by the end of the challenge. In the guidelines we ask you to develop schedules with milestones, lay out goals and objectives, provide a budget, etc. These are all project management activities that, if you make them realistic, can help you scope your development effort.

- Mission starting point
  - Teams can make reasonable assumptions about the infrastructure in place on the Moon to support your system based on NASA and non-NASA concepts for a lunar base. (See Technical Q #21)
    - Current Artemis planning is to ramp up to a crew of 4 for 30+ day stays on the lunar surface sometime after 2031. This may be a good timeframe to start deploying small scale metal production systems as technology demonstrators.
    - It is hoped that commercial activity will begin driving the development of infrastructure to support a growing Artemis Base Camp. 2035 may be a reasonable time frame for metal production systems to start producing products on the surface.

Technical Questions Received in Advance

Technical Questions Received in Advance

1: What exactly are we making? Machinery to make the metals or the metals themselves? Similarly, are we making the actual power cables or pressure vessels? Or are we trying to manufacture the metals?

Short answer: Just about anything that will help us produce ISRU derived metal products on the moon.

The Challenge guidelines provide many processes and ideas that will be needed to create metal products. For your use case, select a metal product that you think will be needed for an expanding human presence on the moon. Think about what kind of end-to-end process would be needed to make that metal product from ISRU derived materials. Pick one part of that process and demonstrate that it can be done on the moon.

Scope your project into something that can be achieved with the resources you have by the end of the challenge. In the guidelines we ask you to develop schedules with milestones, lay out goals and objectives, provide a budget, etc. These are all project management activities that, if you make them realistic, can help you scope your development effort.

(A more detailed response will be provided in the posted Q&A Transcript)

Technical Questions Received in Advance

2: Are we assuming we already have the needed materials on the Moon? Similar Question: What machinery are we assuming would be available on the Moon for our proposal to be hypothetically constructed? Is this an assumption that we must make?

(Discussed during initial technical remarks)

Yes, we are asking you to make reasonable assumptions based upon NASA and non-NASA concepts for a lunar base. The current NASA Artemis planning is to ramp up to a crew of 4 for 30+ day stays on the lunar surface sometime after 2031. This may be a good timeframe to start deploying small scale metal production systems as technology demonstrators. It is hoped that commercial activity will begin driving the development of infrastructure to support a growing Artemis Base Camp. 2035 may be a reasonable time frame for metal production systems to start producing products on the surface. What metal products will a growing basecamp need? What products will have the best chance of a return on investment? 12 years seems like a long time from now but for space systems development this is not at all unusual.

Technical Questions Received in Advance

3: Are we are required to focus on one part of the metal production lifecycle, or can we propose a project which encapsulates the entire metal infrastructure production lifecycle for a particular product or class of products?

You can lay out concepts for the entire metal production pipeline, but it would be difficult to build and demonstrate the complete system within the constraints of this challenge. A big factor in doing well in the BIG Idea Challenge is to scope your project so that you have a good probability of completing and testing the systems you develop. At the end of the challenge, you should be able to demonstrate that your system of interest has the potential to operate as part of an overall system to produce metal products.

4: Do we have to demonstrate our technology throughout its entire lifecycle (fabrication, operation, disposal in the future)?

No. However, thinking about the entire product lifecycle is critical to developing an effective system concept. Demonstrating operation in expected environments is an important part of this challenge and is a big part of what we do in the Game Changing Development Program office. You cannot easily simulate lunar gravity, but other environmental factors can be tested on Earth. Thinking about the types of tests you will do early on are very important to having a credible and valuable project proposal.

Technical Questions Received in Advance

5: Do we show a single point of the process being doable, with the rest of the process given?

Yes. The overall process is something you should describe at a high level. You should describe how your system fits into the overall production process. Make reasonable assumptions and add justifications to support them.

6: How much of the process do we actually have to design for, for example, just the roads not the sidewalks?

This depends on your end product. Metal ingots could be your end product. Metal plates formed with metal ingots could be the end product for someone else. The end product for yet someone else may be a landing pad that uses metal plates welded together onto a suitable surface. Demonstrate at least one part of the process (e.g., removing impurities from metal to form ingots of higher quality, creating metal plates with additive manufacturing methods, welding plates together on the lunar surface).

Technical Questions Received in Advance

7: Do you want our machines to extrude metal or another type of material?

Extrusion is just one potential fabrication method for metal products and may not be needed depending on the product being developed. An example is metal powders used in additive manufacturing.

The end-product should contain metal but may include non-metal material, as is the case for metal matrix composites. Extrusion may produce the final product (e.g., wire) but it may also be a precursor to yet another process that utilizes the extruded material to create end products (as is the case with electron beam free form fabrication).

Realistically for this challenge, extruding anything beyond wire would be difficult for university teams given the systems required and the safety concerns.

8: How much ferrous metal is required to be extracted/processed by teams?

This is totally dependent on your use case. You can target an early demonstration system that produces a small amount in order to show the technology is feasible and can be scaled up for production. Consider the MOXIE experiment on the latest Mars Rover that produces small amounts of oxygen from atmospheric CO_2. We now know this can be used to produce oxygen if the system is scaled up. Teams could also target a large-scale production system as their use case. Realistically, in order to demonstrate something by the BIG Idea Forum a smaller scale demonstration system may be a good choice.

Technical Questions Received in Advance

9: Is it fair to assume a powder metal feedstock as opposed to coils or sheet metal?

Feedstock can be produced or used in any format that aligns with a credible use case. There will be a lot of challenges and opportunities with using metal powder in additive manufacturing in the lunar environment.

The morphology and purity of the feedstock are good things to consider and discuss when choosing the manufacturing processes for this challenge.

10: What is the maximum production of feedstocks in the form of iron powder that has to be achieved per day/month/year?

This is dependent on the use case that is proposed. Are you considering large pressure vessels for habitats or small replacement parts? There are many feedstock options besides iron powder. The ability to produce metal powders in the lunar environment would be valuable for future trade studies on fabrication methods.

Technical Questions Received in Advance

11: Are there any limitations for the equipment installation and construction on the lunar environment?

The lunar surface does not currently have any planetary protection requirements in place. Installation and construction should not endanger crews or existing infrastructure.

Everything brought to the lunar surface must comply with launch vehicle and lander constraints. Large, high mass equipment will significantly drive costs up. Mass is the primary cost driver so teams should consider focusing on manufacturing methods that have the potential to reduce landed mass.

Large power requirements will also drive costs up. Requirements for crew time will drive costs up. Requirements for pressurized workspace will drive costs up. Challengers should consider the cost effectiveness of their overall concept since the goal is to develop technologies that provide metal products to substantially reduce the costs of bringing substitutes from Earth.

Technical Questions Received in Advance

12: Should teams assume that their proposed solutions would theoretically be implemented on the south pole of the moon where the Artemis Base Camp is planned to be located? Similar questions: Is it necessary to consider only the geology of the Artemis mission landing site for metal extraction or can we assume minerals can be gathered from elsewhere?

Targeting one of the locations selected for the Artemis base camp would be a good choice, however teams can target a base camp in other locations. Metal ore concentrations will likely have a low figure of merit when selecting a lunar base location.

Moving ore or even finished products long distances will be hard to do in a cost-effective manner for early outpost development. More than a few kilometers will be a challenge until the transportation infrastructure has matured. Make assumptions but try to be realistic about ore concentrations. We really need more in situ data from high resolution prospecting missions.

Technical Questions Received in Advance

13: Where on the surface of the Moon will the metal fabrication process be implemented? More specifically, what kind of natural environment can we expect where the fabrication is expected to take place?

The natural environment depends on your use case. Some of the product development may occur within a pressurized workspace. This adds to the infrastructure requirements but may be more cost effective than doing it externally. One of the key challenges in implementing large pressurized workspaces on the lunar surface will be dust tolerant airlock seals.

Due to maintenance requirements on equipment, it may be best to locate most of the fabrication systems nearby. Beneficiation systems may be better located near the excavation locations to reduce transportation requirements. It is up to the teams to make these choices in their use cases. Look at Earth analogs for metal production, especially in historical settings where the infrastructure was not well developed.

14: What is the expected content of metallic materials in bulk regolith at the location of the project on the Moon?

There are a lot of whitepapers that estimate ore concentrations for various locations. Teams should make reasonable estimates for the types of metal ore you are targeting.

Technical Questions Received in Advance

15: Is it within the bounds of this challenge to consider the usage of small amounts of other lunar minerals besides ilmenite and anorthite?

Absolutely. Teams can utilize any metal bearing material found on the moon that they feel can best be used to produce metal products.

16: Would the production/isolation of silicon from anorthite as a biproduct be of any interest to NASA?

Generation of other useful materials, such as silicon, are worth noting as additional benefits to the processes selected, but don’t let that detract from the focus of this challenge (which is metals-focused).

Any side benefits of the extraction processes use may increase its cost effectiveness. Potential uses of silicon could be in heat resistant surfaces for landing pads and in the long term for large solar cell arrays. These applications would take additional infrastructure to produce products from silicon so the benefit may come later.

Technical Questions Received in Advance

17: Will considering extraction/forming processes for multiple metals give a team an advantage over teams that only considered one metal?

Multiuse technologies typically have advantages over single use technologies. The advantages must be carefully weighed against additional complexity, development risks, and reliability.

18: Will the creation of novel or versatile products be preferred? For instance, if a proposal had mechanisms to make both aluminum metal products and to produce aluminum oxide fuel.

Multiple products from a single system could make it more cost effective. See answer above.

19: What is the expected useful service life for lunar forge devices and components?

Long enough to be cost effective, achieve a return on investment, or if a demo, to verify the technology is ready for full scale production.

Technical Questions Received in Advance

20: How must ideas which only work in the environment on the Moon be demonstrated? (Such as a process that requires the low atmospheric pressure and gravity of the Moon.)

Low atmospheric pressures and extreme thermal environments can be achieved in a thermal vacuum chamber. These facilities are available at many universities and within private industry. Exposure to lunar dust can be tested with lunar simulants. Processes that require Lunar G are more difficult to test except for short durations in aircraft or suborbital flights. Gravity offload systems are applicable for some testing capabilities such as mobility systems but may not be as useful for metal production processes. In many cases system verification must be done through analysis since environmental testing is impractical.

Comparisons may also be made to well-understood physics and/or published works to show if a process can be demonstrated in a lab environment, then those results can be expected to be consistent with operations on the Moon. An explanation of how the results of your experiments may be influenced by the differences between the experiments performed in the lab and the environment on the Moon may help interpret the results you are able to obtain in the lab.

Technical Questions Received in Advance

21: In one of the main points in the guidelines it states, "where complex infrastructure is not available". What is the exact definition of that statement?

At an early base camp, don't expect the kind of infrastructure found on the Earth will be available to support your system (e.g., Spare parts, repair facilities). Maintenance will be limited to general purpose robots and direct human maintenance will need to be very infrequent due to the cost and risks involved with any type of spacewalk.

22: In the required capabilities statement, what is it meant by a working system/sub-system?

The BIG Idea Challenge requires teams to build, test, and demonstrate hardware versus an ideation challenge where everything is based on analysis. Your team must define what your system of interest is and what other external systems it interfaces with. Every step in the process should add value toward making a final product. What you build and demonstrate should add value to something it receives from another part of the process.

23: Is there a resource for design specifications (i.e., pipe diameter, thicknesses etc.) and if not, where is a good reference point for specific information?

Over the years NASA has released many guidelines for space systems. See https://standards.nasa.gov/ for a listing of NASA standards.

Technical Questions Received in Advance

24: Will any preliminary information be provided to teams (ex: previously generated maps of lunar resources, mission data, etc.)?

Some resources are available in the challenge resource section. Maps of lunar minerals can be found using web searches. Example: https://www.usgs.gov/news/national-news-release/usgs-releases-first-ever-comprehensive-geologic-map-moon

25: What are the energy, time, temperature, volume and pressure constraints of operation? *(Discussed during initial technical remarks)*

This depends on the use case. Document your assumptions and perform some research to ensure the environments you design to are reasonable.

This challenge is not intended to be a problem to solve from a textbook. Think of this as a Shark Tank episode where you develop a concept and sell your system so people want to invest in its development.

26. Is there a maximum electrical energy use value for metal extraction/forming processes?

Look at some of the power systems being developed for lunar surface operations (Kilopower, Vertical solar arrays, solar furnace). Scale these systems to what you think would be expected for the time period you are targeting in your use case.

Technical Questions Received in Advance

27: What are the safety requirements for the projects?

Working with high temperature systems, mechanical systems, and additive manufacturing systems can present many potential hazards. For testing on Earth, teams must develop a safety plan that is approved by their universities. See challenge guidelines.

For lunar operations, there are different safety requirements for crewed and uncrewed operations. This includes factors of safety and many other things such as sharp corners. There are many NASA safety standards available (https://standards.nasa.gov/).

Programmatic Questions Received in Advance

Programmatic Questions Received in Advance

1: Is variability in the finalist teams a significant factor in evaluation? Ex: If there are three proposals that focus on product testing, would the judges be likely to choose just one and let the other finalists represent other components of the pipeline?

Variability is often a factor in selection of the finalist teams, as the judges are interested in supporting a variety of different types of projects. However, each proposal will ultimately be evaluated on its own against the established proposal evaluation criteria.

2: How will dissimilar ideas and processes be judged against one another? (Such as an idea solely based on extraction compared to an idea solely based on reworking refined metals).

Each proposal will be evaluated on its own against the established proposal evaluation criteria.

Programmatic Questions Received in Advance

3: Should teams conduct preliminary research in a lab environment before submitting a proposal, or will most research be scientific-paper-based without actual lab work?
This is up to each team. Preliminary lab work is not a requirement at the time of the proposal. However, if you have the ability to conduct some preliminary research in a lab environment, and you feel will make your proposal stronger as a result – go for it! Your proposal is simply your team selling your idea to the judges…so make it as good as it can be.

4: The max student group size is 25 students. Would otherwise unaffiliated students that help with one task be considered part of this total. (Ex: If a Lab Assistant helps the team in machining a single part, would they be considered one of the students?)
In this example, the Lab Assistant would not be considered an official member of the team, as they are simply providing a simple service to the team. We think of team members as those who are actively contributing the project in a fairly significant way, generally in a regular or on-going manner.

5: Will additional teammates be allowed to join as the research continues, both before the proposal and after finalists are chosen to build their idea?
Yes. We anticipate that team members will fluctuate over the duration of the challenge. Finalists should ensure they give credit to all team members who have contributed to the project in a significant way in their final technical paper.

Programmatic Questions Received in Advance

6: What is the distinction between a Ph.D. student who is considered a mentor and one who is an official part of the 25-person team? What level of contribution towards the project separates one from the other?

If a student is actively pursuing their Ph.D., they are considered an official student team member – even if they are serving mostly as a mentor. Level of contribution is not a factor. Enrollment as a student (at any academic level) is the distinction.

7: Does space in the budget have to be allocated for students to attend the BIG Challenge Forum? To reduce project costs, can it be put upon the individual students to cover the costs of attending?

While teams can always fundraise additional support to bring more students to the Forum, it is required that all teams must include travel costs to the BIG Idea Forum, at least for the minimum number of required attendees (2 student team members). It can be quite expensive to attend the Forum, and we want to ensure that the minimum number of team members can attend and present their work at the Forum. Travel costs to the Forum must assume a four-night stay at the government per diem lodging rate for Cleveland, OH and a registration fee of $550 per person, and include transportation costs as well.

Programmatic Questions Received in Advance

8: What type of content would NASA like to see in the video submission?

That is 100% up to each individual team. The video is meant as another way for you to showcase, demonstrate, or augment what you are proposing to do. It is one tool in your tool box to help you sell your proposal. Sometimes teams find they can better explain their product via animation or verbal explanation, versus relying solely on a written description.

9: Is there a certain dimension ratio that is preferred for the video (i.e., 4:3 or 16:9)?

The preference is 16:9 (widescreen) aspect ratio.

10: Can we use any image NASA has created or only the images provided for the 2023 BIG Idea Challenge?

Yes, you are welcome to use any image NASA has created, as well as any images utilized for the BIG Idea Challenge (past or present). However, please do not use music or images which may violate copyright law.

NASA's image library, images.nasa.gov, consolidates imagery and videos in one searchable location. Users can download content in multiple sizes and resolutions and see the metadata associated with images, including EXIF/camera data on many images.

Programmatic Questions Received in Advance

11: Should the file be of a certain size?

The proposal file size limit is listed in the 2023 BIG Idea Challenge Proposal Guidelines. The PDF proposal file cannot exceed 90 MB, and the video file should be a link to a public YouTube URL, so size is not a factor.

12: Will there be a NASA mentor working/serving as a connection between Universities and NASA? Similarly, is there a NASA contact that teams can reach out to if additional questions regarding the challenge arise?

NASA will not provide a mentor for the university teams. Teams are not allowed to reach out to judges directly. All questions should be submitted to bigidea@nianet.org, and the Program staff will get a response for you. ALL questions and answers will be posted on the FAQs page so that every team has access to the same information…check the FAQs page frequently for updates!

Programmatic Questions Received in Advance

13: What kind of opportunities would be available for feedback once funding has been awarded?

All teams will receive written feedback on their proposals, whether they are awarded or not. Teams selected as finalists will also have a 20–25-minute feedback phone call with the Judging Panel co-chairs immediately after funding is awarded. Then, in late May, finalist teams will submit a mid-project report and will receive written feedback on their progress in June.

14. If we have later questions is there someone we can contact to ask those?

Please email all future questions to the BIG Idea Challenge Program Team at BIGIdea@nianet.org. We will respond to you AND post the answer on the FAQs for everyone to see. Check the FAQs often!

Additional Questions?

Programmatic Remarks (NIA)

Proposal Tips:

- There are no forms or templates for use *other than* what has been identified in the "Proposal Must Include" section of the guidelines. It is up to each team to determine the best method to convey the information they want to share.
- Design maturation of proposal should be at the "convincing level." Include enough information to convince the judges that your proposed concept is ***credible and valuable*** and provide confidence that your team can successfully implement the work proposed.
- Look carefully at the proposal evaluation criteria to see how the judges will be scoring the proposals, and ensure the proposal addresses all of those criteria.
- Budget – 2 phase budget required. Review instructions carefully!
- The proposal process is intensive. Plan ahead and leave time for all the appropriate reviewers (Office of Sponsored Programs, Space Grant, etc.) to review and approve. Ask for letters early.
- Use the Proposal Checklist to ensure all required proposal items are accounted for prior to submitting

Significant $ and ⏲ is available for teams to demonstrate / test concepts.

Next Deadline:

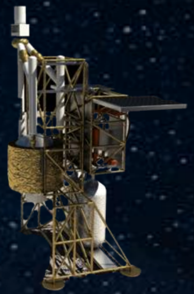
BIG Idea Challenge Announced	Proposals & Videos Due	Finalists Notified	BIG Idea Forum
Aug. 9, 2022	**Jan 24, 2023**	**Mar 2, 2023**	**November 15 – 17, 2023**

2023 Forum will be held in Cleveland, OH

Lunar Surface Innovation Initiative (LSII) – 6 primary capability areas

In Situ Resource Utilization

Collection, processing, storing and use of material found or manufactured on other astronomical objects

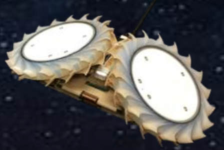


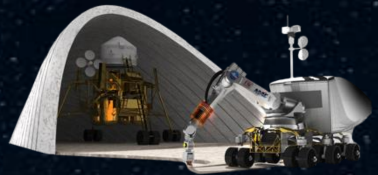
Sustainable Power

Enable continuous power throughout lunar day and night

Extreme Access

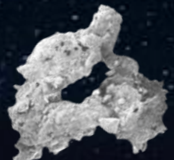
Access, navigate, and explore surface/subsurface areas





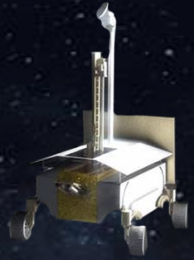
Surface Excavation/Construction

Enable affordable, autonomous manufacturing or construction



Lunar Dust Mitigation

Mitigate lunar dust hazards



Extreme Environments

Enable systems to operate through out the full range of lunar surface conditions

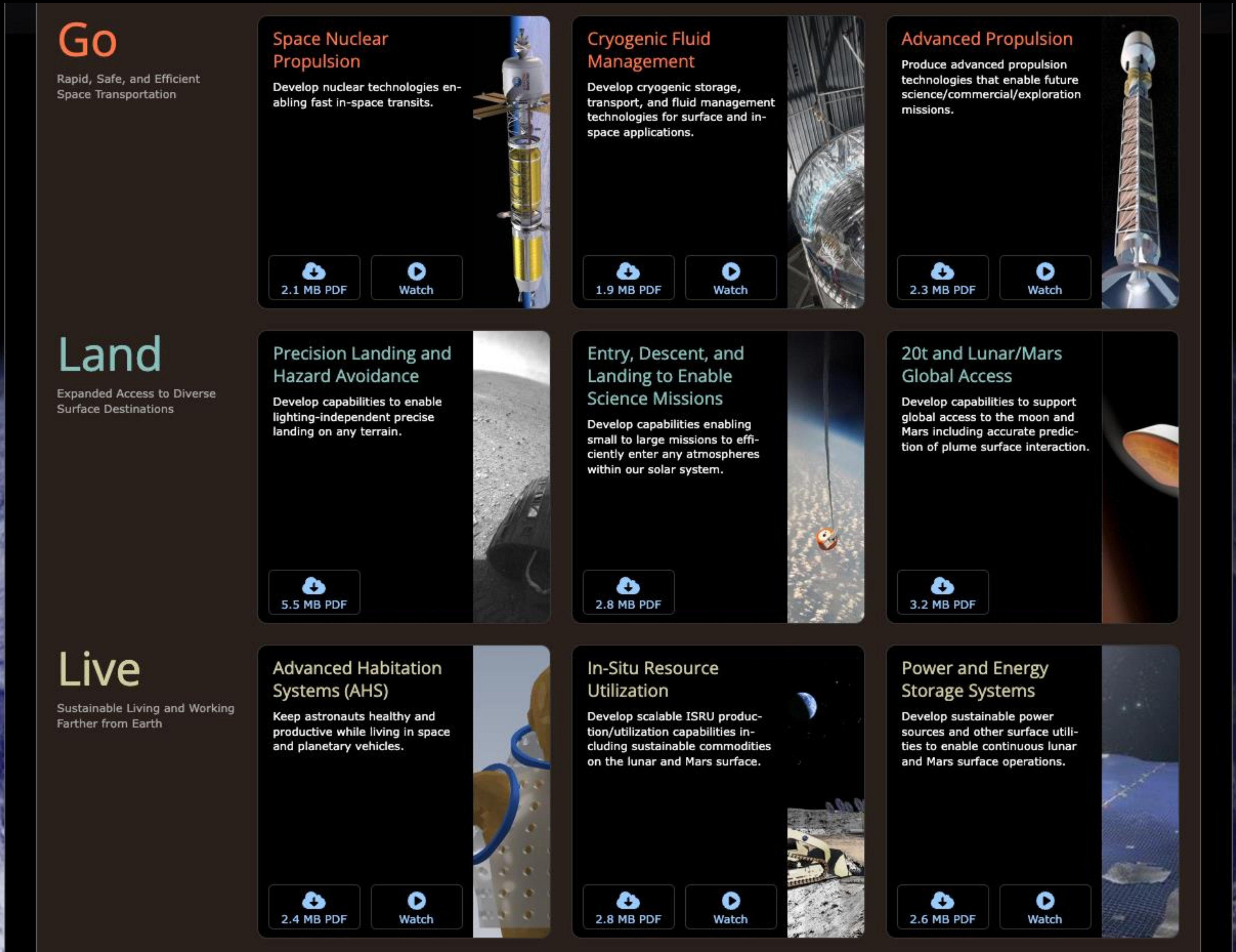
LSII develops the technologies required for establishing lunar infrastructure across these 6 capability areas.

Lunar Surface Innovation Consortium (LSIC):
https://lsic.jhuapl.edu/

Sign up for LSIC here:
https://lsic.jhuapl.edu/News/Sign-Up.php

Visit NASA’s Tech Port: https://techport.nasa.gov/framework

Strategic Framework for charting the horizon of NASA technology development



Future Questions?

Please send all future questions to:
BigIdea@nianet.org

Each question will be responded to directly, as well as posted on the FAQs page for everyone to see.

We encourage you to visit the FAQ’s page frequently for updates:
https://bigidea.nianet.org/2023-challenge/2023-faqs/

View the complete
2023 BIG Idea
Challenge Guidelines PDF