



In support of the [Artemis](#) program, NASA is looking for innovative and cost-effective technologies and systems that will enable the manufacture of lunar infrastructure from **ISRU-derived metals** found on the moon.

# NASA's BIG Idea Challenge

**2023 Theme - Lunar Forge: Producing Metal Products on the Moon**

The Breakthrough, Innovative, and Game-Changing (BIG) Idea Challenge is managed by the National Institute of Aerospace (NIA) on behalf of the National Aeronautics and Space Administration (NASA)

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# 2023 BIG IDEA CHALLENGE

## LUNAR FORGE: PRODUCING METAL PRODUCTS ON THE MOON

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# 2023 BIG IDEA CHALLENGE

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### Overview

The **B**reakthrough, **I**nnovative, and **G**ame-changing (BIG) Idea Challenge is an initiative supporting NASA's Space Technology Mission Directorate's (STMD's) Game Changing Development Program's (GCD) efforts to rapidly mature innovative and high-impact capabilities and technologies for infusion in a broad array of future NASA missions.

The BIG Idea Challenge also offers real-world experience for university students in the development of the systems needed to support NASA's exploration goals. For this reason, the National Space Grant College and Fellowship Project supports the challenge by leveraging funds to help develop the next line of a STEM-trained workforce with skills and experience aligned directly with STMD technology focus areas and capability needs.

Participation in the BIG Idea Challenge is limited to teams of undergraduate and graduate students at **accredited U.S.-based colleges and universities officially affiliated with their state's Space Grant Consortium**. However, non-Space Grant affiliated colleges and universities may partner with a Space Grant-affiliated academic institution. **Minority Serving Institutions are encouraged to apply**. The BIG Idea Challenge allows students to incorporate their coursework into real aerospace design concepts and work together in a team environment. Multi-university and interdisciplinary teams are encouraged.

The 2023 BIG Idea Challenge provides undergraduate and graduate students the opportunity 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.*

This competition is intended to be an open innovation challenge with minimal constraints so that proposing teams can genuinely create and develop out-of-the-box solutions.

Based on the review of detailed proposals, 5-8 university teams (the primary institution for each team must be a Space Grant-affiliated school) will be selected to build and demonstrate their proposed system concept. Teams will be responsible for developing key performance parameters based on what capability is required to meet their specific use case as a part of the end-to-end metal product production process. Teams are also responsible for preparing test environments and performing verification testing to show their concepts are credible. Teams are encouraged to be creative and design their own accurate and realistically simulated verification scenarios. This is key, because if any proposed concepts are

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deemed viable, NASA may be interested in including all or part of one of these concepts in a future NASA technology demonstration mission.

Each team will submit a detailed and realistic budget in their proposals, not to exceed \$180K. A wide range of award sizes is expected (in the range of \$50K to \$180K), depending on the scope of the work proposed. We anticipate funding several larger-scope awards (\$125 - \$180K) and several smaller-scope awards (\$50K - \$124K). **Proposers are encouraged to request what is actually needed to conduct the proposed work, because value to NASA will be considered in the selections.**

## Context for the 2023 BIG Idea Challenge Theme

When NASA returns to the Moon with the [Artemis](#) program, we plan to put in place sustainable infrastructure that will allow us to increase our exploration capabilities and pave the way for a sustainable human presence. Crews will stay on the surface and in lunar orbit for longer periods of time. Using in-situ resources (ISRU) is critical for supporting human activities on the moon due to the high cost of transporting materials from the Earth. Currently, a top priority for ISRU system development has been the extraction of oxygen, and other volatiles, since they are the easiest to extract and can be used as propellants and for life-support systems. The next priority is the extraction of metals which have many potential uses critical to the operation of a lunar base. These include pressure vessels, pipes, power cables, and supporting structures.

NASA's [Lunar Surface Innovation Initiative](#) is working to develop and demonstrate technologies to use the Moon's resources to produce water, fuel, and other supplies as well as capabilities to excavate and construct structures on the Moon. We need practical and affordable ways to use resources along the way, rather than carrying everything we think will be needed. Future astronauts will require the ability to collect space-based resources and transform them into the products needed for a sustained presence.

NASA is making long-term investments to advance ISRU technology in multiple areas such as oxygen extraction from regolith as well as regolith-based in-space manufacturing and construction. With the addition of ISRU-derived metals for pressure vessels, power cables, landing pads, rails for transportation, and pipes for the distribution of liquids and gases, most of the high mass products needed can be made locally. Advancements in additive manufacturing, or 3D printing, may make it possible to use metal feedstocks harvested on the Moon to fabricate a wide variety of complex products without complex casting, forging, milling, and machining. Feedstocks may be in the form of metal powders, wire, or billet for extrusions. The vacuum environment may have advantages for manufacturing methods such as electron beam freeform fabrication or the production of metals such as titanium. Incorporating other ISRU-derived materials into metal matrix composites could allow robust structures such as vaults and landing pads to be developed using additive manufacturing techniques.

Teams can demonstrate the production of products using feedstocks that would likely be available from an ISRU metal production pipeline. An example would be the use of iron which is produced as a byproduct of an oxygen extraction system from ilmenite ores which are common on the lunar surface. Perhaps the quality of the feedstock can be increased using innovative processes and methods that take advantage of the lunar environment.

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NASA's ISRU technology development approach involves engaging industry and academia through multiple approaches, including the BIG Idea Challenge. While we have learned a lot from past and ongoing missions about resources at the Moon, there are still knowledge gaps about the location, form, concentration, and distribution of these resources and how best to extract and process them into usable products. Producing metal products from the Moon's minerals and using it for early construction is an area ripe for additional research and testing.

## Design Guidelines and Constraints

### CHALLENGE GUIDELINES

NASA is engaging the university community for ideas to support the Artemis program through the 2023 BIG Idea Challenge, which invites university teams to submit proposals to design, develop, and demonstrate **innovative and cost-effect technologies and systems that will enable the manufacture of lunar infrastructure from ISRU-derived metals found on the moon.** (Reference [NASA's Plan for Sustained Lunar Exploration and Development](#)).

Proposals must include a specific mission use case(s) for the creation of an end product that supports infrastructure development on the Moon, articulate which part(s) of the product production pipeline they will be focusing on, and identify what metal products will be used from specifically targeted lunar regolith minerals. The use case should provide a compelling need for the development of the proposed concept, describing potential commercial business cases when possible. Teams should also identify what systems they assume will be in place to support their proposed concept/system/technology (with justified rationale) as part of the integrated end-to-end metal production pipeline on the Moon. Provide assumptions on what your "system of interest" receives from supporting systems (e.g., ores, feedstock, power) and what it provides to other systems in the production pipeline. Furthermore, systems/sub-systems/components must be feasible for operation in the targeted lunar environment (mechanisms resistant to lunar dust, incorporating thermal management for extreme cold, realistic power considerations, etc.).

**The end products desired are storage vessels for liquids and gases, extrusions, pipes, power cables, and supporting structures (i.e., roads, landing pads, etc.) that will provide infrastructure for a permanent presence on the Moon.** Teams may propose additional key infrastructure products that fit their use case scenario, so long as they are derived from metals produced through ISRU processes.

Metal pressure vessels and extrusions (i.e., pipes and cables) are critical for a sustained presence on the lunar surface, but they have a high mass and high volume and are expensive to transport to the lunar surface. Pressure vessels are required for volatile storage (air, fuel, water), airlocks, and habitation/work areas. Extrusions are needed for power distribution, and to transport volatiles (air, fuel, water).

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Teams are invited to submit proposals that focus on any part(s) of the product lifecycle\* from prospecting to testing, including:

- Prospecting for metal-bearing ores
- Ore extraction from bulk regolith
- Beneficiation/Refining processes
- Smelting and other metal reduction methods
- Feedstock forming and alloying from ISRU-derived metals
- Handling of materials used in metal production
- Additive manufacturing and joining with ISRU-derived feedstock
- Production of metal matrix composites
- Extrusion and drawing methods tailored for use in the lunar environment where a complex infrastructure is not available
- Test and qualification of ISRU-derived metal products such as storage vessels for liquids and gases, extrusions, pipes, power cables, and supporting structures

Proposed solutions can be new/unique methods or the adaptation of Earth-based methods for use in the space environment where mass, power, reliability, and automation are key attributes.

**\*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.*

### REQUIRED CAPABILITIES

- Able to demonstrate a facet of any part of the metal product production pipeline
- Able to operate for long periods in the harsh lunar environment (e.g., pervasive and abrasive lunar dust, vacuum, wide temperature ranges, etc.). See [DSNE](#) for more information on lunar applications.
- Minimal barriers to NASA adoption/commercial infusion (e.g., cost-effective, low mass, small size, low power, simplicity, high reliability, etc.)
- Technologies should reach a minimum system-level Technology Readiness Level (TRL) of 4\*\* at the end of the challenge. For the purposes of this challenge, TRL 4 refers to:
  - Operation on Earth with analog materials and in relevant environments
  - Analysis showing the design can operate in targeted environments (environmental testing on critical subsystems is highly encouraged)
- Must demonstrate a working system/sub-system

### DESIRED CAPABILITIES

- Testing in a relevant environment testing complete (TRL 5)\*\*
- Ability to add value/improve quality after material is received from one part of the product production pipeline

\*\*See [NASA Technology Readiness Level Definitions](#)



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### PROPOSED SOLUTIONS MUST CONSIDER

Through the BIG Idea Challenge, NASA is looking for proposed systems and technologies that are innovative, cost-effective, realistic, and consider the needs of potential stakeholders/funders (i.e., Exploration, Science, Commercial).

The design package must include a concept of operations (ConOps) that clearly describes the team's mission scenario, metal being used from targeted lunar regolith minerals, portion(s) of the production process being addressed, and metal end product that supports infrastructure development on the Moon. The ConOps should include all design assumptions and address fabrication, transport, deployment, and operations.

### ASSUMPTIONS

Proposing teams should clearly identify their assumptions and provide the justifying rationale to support them. Below are some recommended assumptions for missions, but teams can adjust them if a good rationale to do so is provided.

- The technology readiness should allow for a technology demonstration on the Moon by 2028.
  - This drives the [technology readiness level \(TRL\)](#) of the components used in your concept. A technology development/qualification plan should be discussed for any required component with a TRL less than 4.
- Operational use and simplicity (minimize required crew time for use and maintenance)
  - Teams are encouraged to avoid concepts that are extremely complex as this adversely impacts long term reliability, and any system maintenance on the lunar surface will be expensive and challenging.
- Verification that the key performance parameters required for your part of the metal product production pipeline are met. Examples of performance parameters might be: Refined ore purity from lunar ore simulants, quality factors of the feedstock produced from refined ores, conductivity of power cables produced from analog feedstock, etc.
- Design for the analog environment
  - Temperature/vacuum/limited power/degraded communications/abrasive regolith, etc.
  - Refer to the [SLS-SPEC-159 NASA Cross-Program Design Specification for Natural Environments \(DSNE\) Revision H](#).
- Energy Efficiency
  - Power and energy supplies will likely be limited in early Artemis operations.
- If the ConOps includes a technology demonstration, consider using NASA Commercial Lunar Payload Services (CLPS) for placement on the lunar surface.
- Credible fabrication and material selection
- Scalability of a technology demonstration toward larger operations

### POTENTIAL METAL-BEARING MINERALS

There are several abundant minerals containing potential metals on the lunar surface that make them prime targets of opportunity, including, but not limited to:

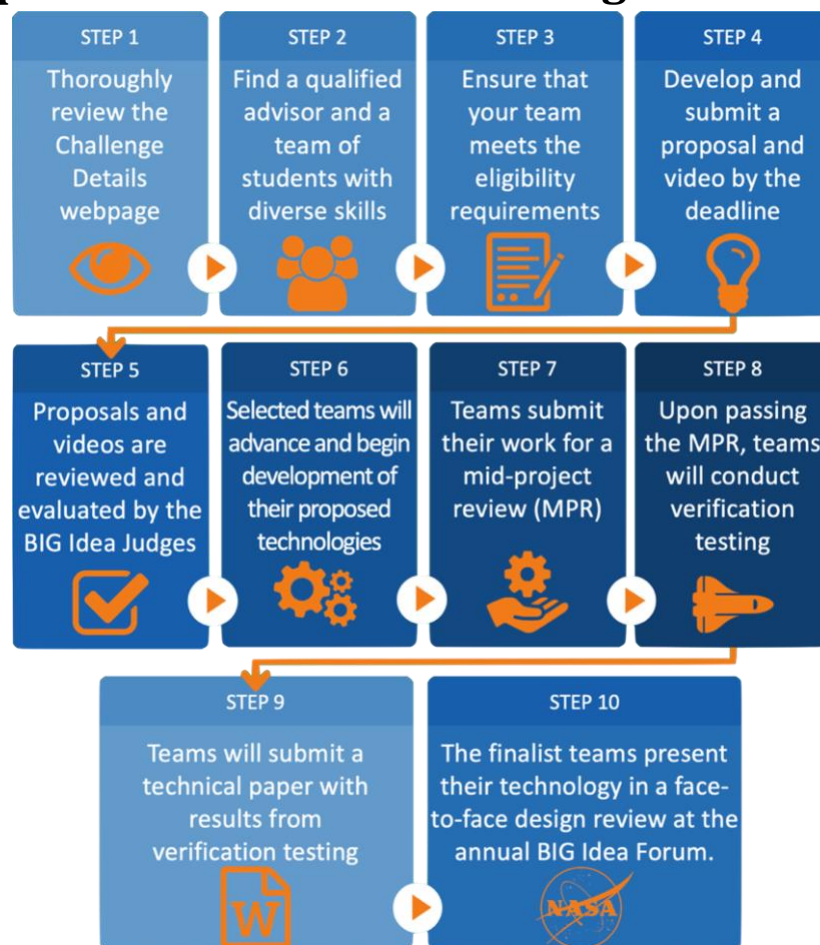
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- **Ilmenite (FeTiO<sub>3</sub>) ore**, a key Lunar resource
  - Fourth most abundant mineral on the lunar surface
  - A likely candidate for oxygen production with the byproducts being iron and titanium dioxide
  - Ilmenite is paramagnetic and can be sorted with magnetic fields
  - Iron can be extracted through a smelting process and converted into feedstock
  - Titanium Dioxide can be reduced to titanium and oxygen
  - Titanium can be formed into wire feedstock for electron beam free form fabrication (EBF<sup>3</sup>) production of large objects such as pressure vessels
    - The lunar near vacuum environment is ideal for EBF<sup>3</sup> production
- **Anorthite (CaAl<sub>2</sub>Si<sub>2</sub>O<sub>8</sub>)** is most commonly proposed as a lunar substitute for Bauxite.
  - Anorthite could be separated from the lunar highland material with mechanical methods.
  - It could then be reduced through various chemical and electrochemical methods to produce aluminum.

These ores can be purchased from different vendors at different levels of fidelity so teams can test beneficiation and metal reduction methods.

## How to Compete in the BIG Idea Challenge





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### Eligibility

The BIG Idea Challenge is open to teams of undergraduate and graduate students at **accredited U.S.-based colleges and universities officially affiliated with their state's Space Grant Consortium**. Non-Space Grant affiliated colleges/universities may partner with a Space Grant affiliated academic institution who takes a primary role on the project (i.e., the Space-Grant affiliated university must submit the proposal on behalf of the joint team). **Minority Serving Institutions are encouraged to apply.**

#### TEAM COMPOSITION AND SIZE LIMIT

Team sizes vary widely, but must contain, at a minimum, one faculty advisor from a U.S.-based, Space Grant Affiliated university, and 2 students from that university who work on the project and present at the BIG Idea Forum, each of whom must be U.S. citizens or Lawful Permanent Residents. Teams may include senior capstone students, clubs, multi-university teams, or multi-disciplinary teams.

- Team size is limited to a maximum of 25 student team members.
- Teams will be comprised of a minimum number of 2 U.S. citizen students or Lawful Permanent Residents who can present the teams' work at the culminating BIG Idea Forum if it is held on-site at a NASA Center.
- A faculty advisor is **encouraged** to attend the Forum with each team.
- An individual (either students or faculty advisors) may join more than one team.
- A university may submit more than one proposal (multiple proposals may be funded from the same institution).

#### SPECIAL NOTES REGARDING FOREIGN NATIONALS

Foreign Nationals (FNs) attending the proposing U.S.-based university can participate on a BIG Idea Challenge team, with one notable exclusion. Due to prohibitive restrictions and ever-changing NASA security regulations, **foreign nationals will not be able to attend culminating BIG Idea Forum events that take place on-site at a NASA Center (including tours)**. There will be no exceptions to this policy. FNs can, however, participate in any portions of the culminating BIG Idea Forum that take place off-Center.

#### FOREIGN UNIVERSITIES - INELIGIBLE

Eligibility is limited to universities in the United States. **Foreign universities are not eligible to participate in the BIG Idea Challenge.**

#### PARTNERSHIPS ENCOURAGED

Teams are encouraged to collaborate and work in concert with other government or industry partners. An "industry partner" is defined as a non-government business or organization that can provide support to the team in terms of mentorship, access to labs or other facilities, in-kind donations, and/or even financial sponsorship.

- Partner vs. Vendor: if a team is paying for a service (e.g., to use a vacuum chamber for testing) provided by a specific company, the company is considered a vendor, NOT a partner.

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### Award Funding for Finalist Teams

A wide range of award sizes is expected (in the range of \$50K to \$180K), depending on the scope of the work proposed. We anticipate funding several larger-scope awards (\$125 - \$180K) and several smaller-scope awards (\$50K - \$124K). **Proposers are encouraged to request what is actually needed to conduct the proposed work, because value to NASA will be considered in the selections.**

Special notes concerning budget:

- The expected number of new awards is somewhat uncertain, as it may depend on the distribution of submissions that have received sufficiently high ratings on the proposals.
- NASA may support an award as outlined in the proposal budget or may offer to fund only selected tasks.
- NASA has the authority to suspend or terminate an award in whole or in part, and funding is contingent upon availability.
- BIG Idea Challenge funding **may not be used** to directly support travel or stipends for federal employees acting within the scope of employment (including co-op students with civil servant status).

#### TWO-PHASED FUNDING STRUCTURE FOR FINALIST TEAMS: INSTALLMENTS FROM TWO SOURCES

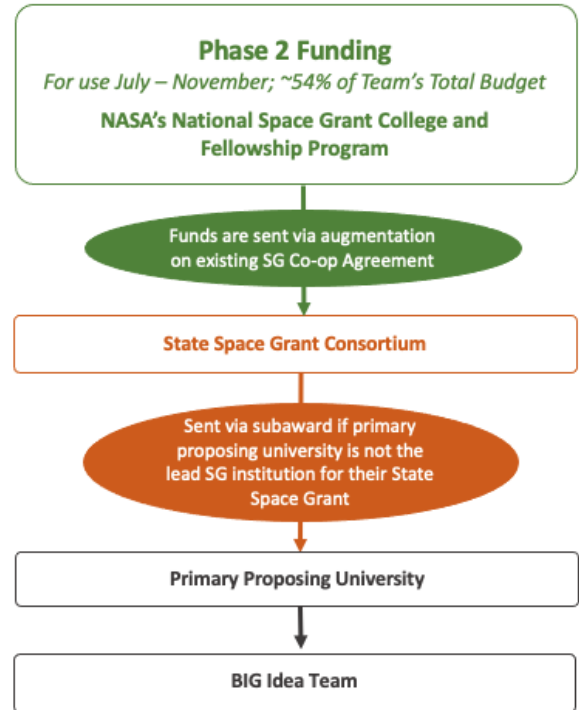
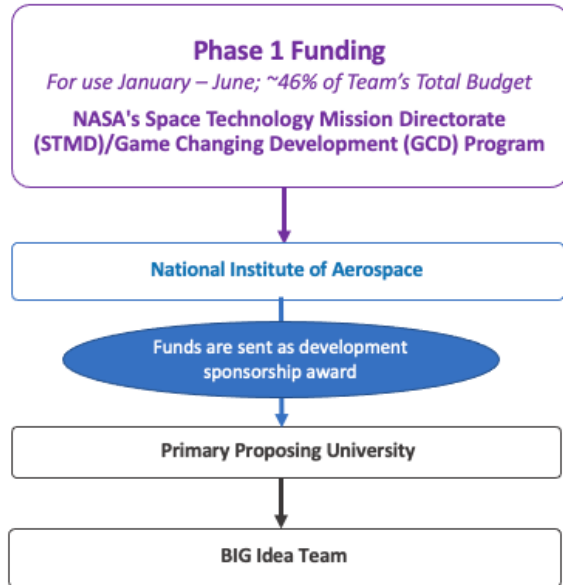
- **STMD Funds for Phase 1:** The 1<sup>st</sup> funding installment will be sent immediately upon selection so that finalist teams may begin development of their proposed concept, and will amount to **46% of the total budget requested**.
  - These funds will be provided directly to the primary proposing university, from the National Institute of Aerospace (on behalf of NASA STMD's GCD Program).
- **Space Grant Funds for Phase 2:** The 2<sup>nd</sup> funding installment (i.e., the remaining portion of the total requested funds) will be provided after teams successfully complete their mid-project review in June.
  - These funds will be provided directly to the state Space Grant Consortium affiliated with the primary proposing institution from NASA's Office of STEM Engagement (National Space Grant Program), via an augmentation to the state Space Grant's base award. The state Space Grant Consortium's lead institution will then direct the funds to the primary proposing university for the BIG Idea Challenge via a subaward.

BIG Idea Challenge funding is to be used for full participation in the competition, including the purchase of hardware/software, creation of analog testing environment, stipends for student research that directly supports the proposed activity, travel to the culminating design review (aka, 2023 BIG Idea Forum), etc. ***Please refer to the [Budget Instructions](#) below for specific guidelines related to the intended use of funds for each installment/phase.***

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### BIG Idea Challenge 2-Phase Funding Structure



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### Dates and Deadlines

All deadlines must be met by 11:59 p.m. ET on the dates specified below, unless otherwise noted.

**Late deliverables will not be accepted.**

DATE	Description
September 30, 2022	Notice of Intent Deadline
October 20, 2022	Q&A Session for interested teams
January 24, 2023	Proposal and Video Deadline
March 2, 2023	Teams are notified of their selection status
Mid-March, 2023	1st installment of development stipends sent, as appropriate
June 7, 2023	Deadline for Mid-Project Review (MPR) submission
June 27, 2023	Teams are notified of Pass/Fail status
Early July, 2023	2nd installment stipends are sent as appropriate from SG directly to schools
June - August, 2023	Summer work
September – October 2023	Fall work (technology verification demonstrations)
October 2, 2023	Deadline for Forum Registration and Payment
October 14, 2023	Deadline for Forum Hotel Reservations
October 23, 2023	Deadline to submit Technical Paper and Technology Verification Demo
November 12, 2023 4:00 PM Eastern Time	Deadline to submit Presentation Chart Deck and Digital Poster
November 15-17, 2023	2023 BIG Idea Forum (Glenn Research Center, Cleveland, OH)

### Notice of Intent

**Notice of Intent deadline: 11:59 p.m. ET on September 30, 2022**

Interested teams are highly encouraged to submit a Notice of Intent (NOI) to compete by the deadline to ensure an adequate number of reviewers, to receive pertinent challenge updates, and to be invited to participate in helpful events prior to the proposal deadline, including a Questions and Answers session with the judges. NOIs are non-binding.

Please visit the [2023 Challenge Details](#) page on the BIG Idea website to complete the brief online NOI submission form.

The following information will be requested on the NOI Submission Form:

- Primary proposing college/university
- Additional university and/or industry partners (if any)

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- Project title, if known
- Primary part of the metal product pipeline lifecycle proposed
- Name and contact information of the primary faculty advisor and student team leader
- Space Grant Affiliation
- Synopsis of the concept, limited to 3,000 characters (including spaces) providing a high-level overview of the proposed project
  - **Note:** We understand that NOI's are due early in the development process, and teams will still be in the process of fleshing out many of the details of their concepts. We expect that teams' concepts will change and evolve between the NOI and Proposal submissions. Teams have the flexibility to change ideas as they work over the course of the semester, and the idea submitted in the NOI does not need to match the proposal submission.

## Proposal and 2-3 Minute Video Submission

**Proposal submission deadline: 11:59 p.m. ET on January 24, 2023**

### PROPOSAL FORMATTING INSTRUCTIONS

Teams are responsible for the formatting and appearance of their proposal. Figures and tables must be placed in the file and therefore must be in digital format.

- 15 pages minimum; 20 pages maximum (including figures and tables)
  - The Cover Page, Quad Chart, Letters of Support, and Appendices **do not count** toward the minimum or maximum page limits.
  - A Table of Contents is not required.
  - **Appendices are to be used for references only.**
    - **Note:** Judges are not obligated to look at the appendices. Include important details in the body of your paper to ensure they are reviewed. There is no preference in citation formatting, but references must be formatted uniformly and correctly. Just listing a link to the source is not acceptable.
- Proposals should be single spaced and formatted as a single column with normal 1" margins on the top, bottom, left, and right.
- Please use fonts common to Macintosh and PC platforms, i.e., Times, Calibri, Helvetica, or Arial for text; Symbol for mathematical symbols and Greek letters.
- Font size can be either 11 or 12 pt., (including text within charts, tables, graphs, and figures).
- File size cannot exceed 90 MB.

### PROPOSALS MUST INCLUDE

Proposing teams will develop a 15-20 page proposal that describes their concept. The proposal must include the following sections **in order**:

- **Cover Page (Excluded from page limitation)**
  - University name
  - Project title
  - Full names of all team members, with academic level (grad or undergrad) and major
    - Identify any foreign nationals

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- Space Grant Affiliation and Space Grant Director contact information
- Full name(s) and affiliation(s) of all faculty advisor(s)
- **New for 2023:** Faculty advisor signature, attesting to review and approval of the proposal submission on the Cover Page
  - **Note: Submissions without a valid faculty signature will be deemed non-compliant and will not be reviewed.**
- **Quad Chart** (Excluded from page limitation)
  - **Proposers must use the [BIG Idea Proposal Quad Chart Template found on the “Proposal” section of the 2023 Challenge Details webpage.](#)**
  - A Quad Chart is a way for teams to display some standardized information that helps evaluators quickly compare many projects. Teams must insert the provided [Quad Chart Template](#) as an image into their proposal. Quad charts must address:
    - The team’s major project objectives and technical approach to the problem
    - An image/graphic of part or all of the concept
    - A description of the team and management approach of the project
    - A summary of the schedule and cost for the project, broken out by Phase 1 and 2
      - No rounding, please. Use the exact total proposed budget.
- **Summary Statement** (Not to exceed one page)
  - An overall summary of the lunar metal production concept, including a title of the project, a one-paragraph synopsis of the operational scenario the proposed technology is addressing, an overview of the proposed technology solution, a one-paragraph statement on the proposed verification testing, and a statement of the impact the innovative technology concept will have on lunar exploration goals.
- **Problem Statement and Background** (Not to exceed two pages)
  - Mission Scenario/use case where the proposed solution fits into the overall metal production process
    - Include commercial use cases, if applicable.
  - Challenge being addressed and overall approach
- **Project Description** (Not to exceed 10 pages)
  - What technology are you going to develop, and why is it important?
  - How does your proposed technology support the Artemis mission to establish a permanent presence on the lunar surface?
  - Adherence to the Design Constraints, Guidelines, and Assumptions
  - Verification Testing on Earth
    - Proposers must describe HOW their technology could be demonstrated on Earth to provide confidence it can work in the chosen lunar environment. If selected, teams will need to demonstrate a working technology. It is up to each team to determine the best way to accomplish this and provide details on how verification testing will be conducted. Physics-based modeling may support verification, but is not a sufficient replacement for hardware testing.
    - What are the key performance parameters based on the mission scenario being addressed?



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- For the testing, will you accomplish a realistic simulated environment? If so, how? What have you considered from the [DSNE](#)?
- For teams planning to work with hazardous materials (e.g., molten metals) or systems (e.g., lasers for additive manufacturing), include some information on safety plans.
- Path-to-flight
  - A brief discussion on the concept's anticipated path-to-flight for a mission to the Moon. Based on significant differences between on-Earth and off-Earth operations, the path-to-flight description must address the critical modifications that would be made to the design for use on the Moon.
- Scalability
  - Can the proposed mobility solution be scaled for larger mission scenarios?
- **Capabilities Statement** (Not to exceed two pages)
  - The relevant past experience, expertise, and capabilities of the team members, faculty advisors, and industry mentors (if applicable)
  - Relevant facilities available to the team (either at the university or another source the team has access to)
- **Detailed timeline** (Not to exceed one page)
  - The timeline should incorporate the full scope of the proposed project through the conclusion of the 2023 BIG Idea Challenge in November, including development and verification testing
- **Detailed budget** (Not to exceed four pages)
  - Proposals must include a single budget spreadsheet that breaks the costs out by Phase 1, Phase 2, and Total Costs. A budget narrative/description must accompany the spreadsheet.
    - **Proposers must use the provided [BIG Idea Challenge Budget Spreadsheet Template](#) found on the “Proposal” section of the [2023 Challenge Details](#) webpage.**
  - Budget should include all relevant costs, not to exceed \$180,000. *Proposers are encouraged to request what is actually needed to conduct the proposed work.*
  - See [Budget Instructions](#) below for specific guidelines on preparing the budget
- Signed “**Letter of Budget Review and Compliance**” from the primary proposing university’s office of sponsored programs (or appropriate alternative authority)
- Signed “**Letter of University Support**” from the primary proposing university’s Dean of Engineering (or appropriate alternative authority)
  - This letter serves to ensure that facilities and equipment at the university will be made available to the faculty advisor and the student team members as needed to successfully design, build, and test and complete their proposed concept. In this letter, the university also commits to facilitate processing stipends and ordering any necessary parts and supplies through university channels in a timely manner (i.e., accounting for any long lead times to ensure that orders can be fulfilled when needed per the project schedule).

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- **Proposers must use the provided [Letter of University Support Template](#) found on the “Proposal” section of the [2023 Challenge Details](#) webpage.**
- Signed “**Letter of Space Grant Consortium Support**” from the state Space Grant Director affiliated with the primary proposing university. This letter must, *at a minimum*, affirm that the Space Grant Director:
  - Has reviewed the proposal and budget for Phase 2.
    - **Note:** Only Phase 2 funds will be sent to the State Space Grant Consortium of the proposer’s state. Phase 1 awards will be sent directly to the primary proposing university.
  - Supports and approves the proposal and the Phase 2 budget in its entirety (calling out special attention to total Indirect Costs (IDCs) requested and approval of any waived fees or IDCs as related to the state Space Grant for Phase 2 funds).
  - Will, if awarded, distribute the Phase 2 funds in a timely manner to keep the team on schedule.
- Letters of Support from any other key partners on the proposal, *clearly indicating what specific type of support they will be providing* (i.e., monetary sponsorship, in-kind services, materials, mentoring, etc.).
  - Proposers may submit a maximum of 10 additional letters of support.
  - If a team is paying for a service (e.g., to use a vacuum chamber for testing) provided by a specific company, the company is considered a vendor, NOT a partner.

### BUDGET INSTRUCTIONS

**Important:** Budgets are required to be displayed as two phases (corresponding to each of the two anticipated funding installments), complete with cost notes/budget justifications.

- **Phase 1 Budget = ~46% of total funding requested** (February 2023 – June 2023)  
The intent of the 1<sup>st</sup> award installment is to facilitate participation in the 1<sup>st</sup> phase of the 2023 BIG Idea Challenge program, including, but not limited to labor costs, materials, consultants, machine rentals, etc. needed to begin building the proposed technology.
  - The proposing team **must collaborate with the primary proposing university’s Office of Sponsored Programs (or other appropriate authority)** in the creation of the Phase 1 budget.
  - The Phase 1 budget and narrative should include any **relevant Indirect Costs (IDCs) charged by the university**.
  - All waived fees or indirect costs must be specifically mentioned in the **Letter of Budget Review and Compliance**.
- **Phase 2 Budget = 54% of total funding requested** (July 2023 – December 2023)  
The intent of the 2<sup>nd</sup> award installment is to facilitate full-participation in the 2<sup>nd</sup> half of the competition, which can include but is not limited to: stipends for summer/fall research work on the project, costs associated with verification testing (creating simulated analog testing environments or fees for using industry/government testing facilities such as vacuum chambers or cryo chambers), travel and registration fees for the 3.5 day BIG Idea Forum at the NASA Glenn Research Center in Cleveland, OH.

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- The proposing institution must collaborate with both the **university's Office of Sponsored Programs (or other appropriate authority)** AND the **Space Grant Consortium** in the creation of the Phase 2 budget.
- The Phase 2 budget and narrative should include any **relevant Indirect Costs (IDCs) charged by the university**, as well as any **IDCs charged by the Space Grant Consortium associated with the lead institution's creation of the subaward** to fund Phase 2 of the selected BIG Idea proposing team(s).
  - **Reminder:** The Space Grant Director's letter needs to clearly state that he/she has reviewed the proposal and Phase 2 budget, and approves the proposal and budget in its entirety (calling out special attention to approval of any waived fees or indirect costs in the Phase 2 budget as related to the state Space Grant).
- **The budget submission will be considered final, and no additional costs will be funded for failure to include IDC costs for the Space Grant's lead institution.** Proposers are encouraged to carefully specify the amount of IDCs required (for the university in Phase 1; and for the university AND the Space Grant in Phase 2) if the proposing team is awarded.
- Travel Costs
  - **Proposals must include travel to On-Site Forum**, tentatively scheduled to take place in Cleveland, OH at NASA's Glenn Research Center (Assume a **four-night hotel** stay and a **registration fee of \$550** per attendee).
- Overhead/Indirect/G&A Costs (Please see section above titled "Awards for Finalist Teams" for details on how the funding will be distributed)
  - **Note:** Teams should work with their universities to minimize indirect and overhead costs to make their proposals as competitive as possible. ***It is imperative that the primary proposing university and the affiliated state Space Grant Director approve any reduced or waived indirect fees in writing.***

### Examples of relevant and allowable costs include:

- Materials and Supplies
- Facilities Rental (if any)
- Stipends for Summer Student Work/Research
- Testing Costs
- Faculty Salary

### Examples of **unallowable** costs include:

- Scholarships
- Salary, stipend and travel support for federal employees (including civil servant Co-Op students)
- Tuition and Books
- Room and Board
- Food/Beverage (with the exception of per diem meal costs associated with travel)
- Purchase of communication equipment from China

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### VIDEO FORMATTING INSTRUCTIONS

As a part of the proposal submission process, teams will be required to include a 2-3 minute video. The intent is for the video to augment your paper proposal by including animation, graphics, or other creative ways of showcasing unique aspects of your proposed concept. We have included several sample videos from previous teams to serve as examples on the Big Idea Website - visit the “Resources” section on the [2023 Challenge Details](#) page.

- Videos are limited to a maximum length of 3 minutes.
- Videos must be uploaded to YouTube, and the video’s YouTube URL will be required on the online proposal submission form. **Other types of video files will not be eligible for consideration.**
- Videos must be **publicly viewable** via a link. Videos should be “Unlisted” or “Public” on YouTube.
  - Troubleshooting Tip: If your video is stuck in the “processing” stage, check to [make sure your YouTube account is verified](#).
- All team members should appear in the video, if at all possible. In the event a team member is not available for filming, displaying a photo of that team member is fine.
- University name, Space Grant Affiliation, and project title should appear in text at the front of the video.
- Do not use music or images which may violate copyright law. You may use images created by NASA.

### SUBMITTING THE PROPOSAL AND VIDEO

To upload a proposal and video (.pdf file and link), please visit the [2023 Challenge Details](#) page on the BIG Idea website to complete the online Proposal Submission Form. Teams are encouraged to review the [Proposal Evaluation Criteria](#) below to better understand how the competition will be judged. Teams are also encouraged to use the downloadable [Proposal Checklist](#) to ensure all required proposal items are accounted for prior to submitting.

No revisions can be accepted after the submission deadline, so please proof your proposal file very carefully before submitting it. If there are any technical problems with the content of your proposal (for example, your file was corrupted), we will try to contact you immediately, so it is very important that you provide us with up-to-date contact information on the submission form.

**Late proposals will not be accepted**, and the submission form will close promptly at midnight (ET).

#### The following information will be requested on the Proposal Submission Form:

- Name of college/university
- University and/or Industry partners (if any)
- Project title
- Primary part of the metal product pipeline lifecycle proposed
- Name and contact information of the primary faculty advisor and student team leader
- Space Grant Affiliation and Space Grant Director contact information
- Name and contact information for any additional faculty or industry advisors
- A 500-character description of the proposed concept
- Phase 1 Budget, Phase 2 Budget, and Total Budget (exact costs only, please...no rounding)
- File upload for Main proposal PDF document
- File upload for the [Excel version Budget Spreadsheet](#), using provided template
- URL link for team’s public or unlisted YouTube video

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- Mailing address and Point-of-Contact information for award checks (for use only if a team is selected as a finalist in the competition)
- Vendor W9 Form for the primary proposing university (to be completed by the accounting department at the university)
  - Please download, complete, and submit this [Template Vendor W9 Form](#).
  - W9 vendor form must be completed/dated in the same year as the proposal submission
- Acceptance of the BIG Idea Challenge [Intellectual Property and Media Release statements](#)

## Scoring and Evaluation

The judges' panel is comprised of NASA and industry experts who will evaluate and score all the competition deliverables, including the proposal submissions. Submissions will be evaluated and judged based on adherence to the guidelines and constraints and the published [evaluation criteria](#).

### PROPOSAL EVALUATION CRITERIA

- **Technical Innovation (Max - 30 points)**
  - How innovative is the proposed solution?
  - How well does the proposed technology advance the state of the art?
  - How compelling is the proposed concept's goals and objectives?
  - How well does the proposed concept align with [NASA's Plan for Sustained Lunar Exploration and Development](#)?
- **Technical Credibility (Max - 25 points)**
  - Does the technology help solve a real problem?
  - How feasible is the proposed technology?
  - Is credibility of the proposed solution presented?
  - Is the TRL advancement plan of the proposed technology viable?
  - What level of risk is associated with development and verification of the concept?
  - What is the risk mitigation plan?
  - Has the team proposed a rigorous systems engineering approach?
  - Is the technology operationally resilient? (ability to withstand adverse circumstances and the harsh lunar environment, the capability to degrade gracefully)
- **Technical Management (Max - 20 points)**
  - Is the cost plan, including cost feasibility, value, and risk adequate, thorough, and reasonable?
  - Is the proposed implementation plan adequate and thorough?
  - What is the probability of team success? [i.e., team expertise (including faculty and any industry support), access to required facilities, etc.]
- **Performance Verification Testing Plan (Max - 25 points)**
  - How feasible is the verification and validation testing plan for the proposed technology?
  - Is the team's proposed verification testing thorough?
  - Does the planned testing environment adequately represent the lunar environment?

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### Deliverables for Finalist Teams

Teams selected to receive funding and attend the on-site Forum will be responsible for the following Project Deliverables:

- Mid-Project Report
  - 5-page report demonstrating where team is in the development process
  - Teams must successfully pass this mid-project review gate to receive the 2nd half of their stipend award.
- Verification Demonstration
  - Finalist teams will be required to perform comprehensive verification testing demonstrations and provide results to the judges in the technical report and presentation. Teams are encouraged to be creative and design their own accurate and realistically simulated verification testing as possible. **Reminder:** physics-based modeling may support verification, but is not a sufficient replacement for hardware testing.
- 15-25 page Technical Paper
- 20-25-minute Presentation, with an additional 25 minutes of Q&A at the BIG Idea Forum
- Technical Poster (for Poster Session conducted during on-site Forum)
  - Both paper and digital poster files will be required

Additional details on these deliverables will be communicated to finalist teams after selection for funding.

### Resources

Please visit the *Resources* section of the [2023 Challenge Details](#) page on the BIG Idea website for information useful in developing your BIG Idea Challenge concept.

### Intellectual Property (IP) and Media Release

**Proposers must acknowledge that they have read and agree to abide by the [full Intellectual Property and Media Release Statements](#).**

#### INTELLECTUAL PROPERTY - SUMMARY

In addition to any rights granted to NIA and/or the Space Grants Consortium Cooperative Agreement Recipients, as applicable, recipients of monetary awards under the Big Idea Challenge agree to grant to NASA and the Federal Government, as the source of awards funding, the Rights in Data and Patent Rights set forth in detail below. In summary, awardees agree to grant to NASA and the Federal Government (i) a license to use, distribute, reproduce, perform, display, and prepare derivative works, any data first produced by recipient in carrying out recipient's responsibilities under this award in which the recipient asserts copyright, or data for which copyright ownership was acquired under the grant for Federal purposes and to have or permit others to do so for Federal purposes only, and (ii) a license to practice



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or have practiced for or on behalf of the United States any invention of the recipient conceived or first actually reduced to practice in the performance of work under this award if recipient chooses to retain title to such invention, and NASA may elect to obtain title or patent such invention if recipient chooses not to do so, all as set forth more particularly in the below Rights in Data and Patent Rights provisions.

Please review the full [Intellectual Property Statement](#).

### MEDIA RELEASE

The recipients of monetary awards under the Big Idea Challenge (“Teams”) agree to give permission to be recorded, photographed and/or videotaped by or for NIA, NASA or their representatives or designees for the purpose of announcements and other outreach or informational purposes, including public announcements, concerning the Challenge.

The Teams further give permission to NIA, NASA or their representatives or designees to use, reproduce, prepare derivative works, publish, distribute to the public, perform publicly, and/or publicly display all deliverables, including excerpts and any ancillary material, which may include each team participants’ names, affiliations (schools), images, voice, and/or likenesses. NIA or NASA may distribute the materials, including excerpts therefrom, and any ancillary material through a variety of media in existence now or in the future, including but not limited to print, television, websites, radio, or any other means. NASA may also permit a third party to exercise NASA’s rights, including but not limited to the right to display or distribute the recording, including excerpts therefrom, and any ancillary material, in any manner NASA deems appropriate.

The teams also understand that this permission to use each participant’s name, image, voice and/or likeness in such materials is not limited in time and team participant will not receive compensation for granting this permission.

Teams acknowledge that NASA has no obligation to use any participant’s name, affiliation, image, voice, and/or likeness in any materials produced by NASA, but if NASA so decides to use them, each participant waives the right to inspect or approve any such use. Teams hereby unconditionally release NASA and its representatives from any and all claims and demands arising out of the activities authorized under this Media Release.

## Contact Information

For BIG Idea inquiries, please contact the BIG Idea Program Team at [BigIdea@nianet.org](mailto:BigIdea@nianet.org).

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