NATIONAL AERONAUTICS AND SPACE ADMINSTRATION (NASA)
CENTENNIAL CHALLENGES PROGRAM

Watts on the Moon Challenge
Phase 1 Rules
October 20, 2020

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Definition of Terms

Artemis Program: A NASA program under which NASA will land the first woman and next man on the Moon by 2024, using innovative technologies to explore more of the lunar surface than ever before.

Centennial Challenges Program: A NASA program that uses prizes to generate revolutionary and innovative solutions to problems of interest to NASA and the nation. The program seeks innovations from diverse and non-traditional sources and engages the public in the process of advanced technology development. This Centennial Challenge, the Watts on the Moon Challenge, is referred to throughout this document as the "Challenge."

HeroX: HeroX is a platform that allows anyone to launch a crowdsourcing project in an area they care about. NASA has contracted with HeroX to support the administration and promotion of this Challenge.

Icy Regolith: A general term describing lunar surface material with an unspecified mineral and water-ice content.

Judging Panel: A panel of professionals and subject matter experts from government, academia, and industry who will evaluate and score Phase 1 Submissions.

Mission Activity: A hypothetical activity that represents one component of the Mission Scenario. This Challenge will have three Mission Activities; Teams may submit designs to address one or more Mission Activities.

Mission Scenario: A hypothetical scenario based on a real-world lunar mission. In this Challenge, Teams will propose solutions to address power delivery and environmental conditions for one or more activities within a Mission Scenario.

Mobility Platform: A hypothetical vehicle capable of carrying a variety of cargo or payloads to perform tasks requiring mobility.

NASA Power Plant: A hypothetical NASA-provided source of electrical power described in the Mission Scenario. In this Challenge, Teams use this source as the basis for their solutions; Teams are not responsible for generating electrical power.

Ombudsman: A liaison between the Teams and the Judging Panel when disputes and/or questions arise following the announcement of scores and/or winners.

Operational Power Requirements: The power requirements for each Mission Activity; a Team's submission will be judged, in part, on whether their proposed solution addresses these requirements.

Permanently Shadowed Region (PSR): A general term describing a location on the lunar surface that does not receive any direct illumination or heat from the Sun and therefore is always dark and cold.

Phase 1 Submission: A concept design for a proposed solution (including documents, data, illustrations, videos, and other materials) that Teams will submit to compete in Phase 1 of the Challenge.

Phase 2 Submission: A proposed solution (including hardware, software, and/or other materials) that Teams will submit for testing and demonstration in Phase 2 of the Challenge, if Phase 2 is initiated.

Team: One or more individuals or organizations that have registered to compete in the Challenge.

Team Agreement: A legal contract that all teams must sign in order to register for the Challenge.

Nomenclature Used in this Document

Power is expressed as either watts (W) or kilowatts (kW). Electrical power (W_E) is distinguished from thermal power (W_{TH}).

Energy is expressed as joules (J) or kilojoules (kJ), or as watt-hours (W-hr) or kilowatt-hours (kW-hr).

Electrical Potential is expressed as volts (V). Unless otherwise specified, all systems are direct current (DC) or volts direct current (VDC).

Mass is expressed as kilograms (kg).

Temperature is expressed as either degrees Celsius (ºC) or in absolute temperature, kelvins (K).

Heat Capacity is expressed as kilojoules/kilogram-ºC (kJ/kg-ºC).

Challenge Problem Statement

In this Challenge, NASA seeks to incentivize flexible, robust energy distribution, management, and storage solutions to power the next Moon missions.

Challenge Background and Objectives

As NASA works to extend human exploration of the solar system, unprecedented capacity for electrical and thermal energy distribution, management, and storage will be needed to support sustained human presence and the beginning of industrial activity.

Solar energy is abundant on the lunar surface but extended night hours (350 consecutive hours) and extreme environmental temperature change from daylight to nighttime operation creates complexity for solar power use. Analogous issues arise on Earth, where demand for additional renewable energy generation, including solar, is rising, but additional power management, distribution, and energy storage solutions are needed to address intermittency and resiliency, among other issues.

In this Challenge, Teams will propose solutions for energy distribution, management, and/or storage that address NASA technology gaps and can progress toward flight readiness and future operation on the lunar surface. Such solutions may also have important synergies with terrestrial energy needs, and this Challenge is expected to help advance similar technologies for terrestrial application and commercialization.

In general, NASA is seeking to work with innovators across disciplines to find solutions that address a variety of needs on the lunar surface and will be exploring options to transport potential solutions to the Moon for testing, demonstration, and operation in the coming years.

Challenge Overview and Technical Goals

Competition Overview

The Watts on the Moon Challenge will offer Teams up to $5 million in prize purses as well as potential opportunities to test their proposed solutions at NASA facilities. The Challenge will have two phases, totaling no more than 36 months.

The Challenge presents a Mission Scenario with three Mission Activities. Teams will choose one or more activities to address by proposing an energy distribution, management, and/or storage solution. Teams are eligible for a prize purse for each Mission Activity that they address, if they meet or exceed a minimum score (see Phase 1 Judging below). For example, in Phase 1, a Team that addresses three Mission Activities and meets or exceeds the minimum score for each will be eligible for three prize purses.

In Phase 1, Teams will submit a concept design for their proposed solution. Teams will have six (6) months to register and submit concept designs. Phase 1 (including judging) will last approximately eight (8) months (see Competition Calendar below).

Prize purses for Phase 1 will total up to $500,000. NASA will award up to three (3) 1st Place prize purses in the amount of $100,000 each to the winning Team in each Mission Activity (a total of $300,000). NASA may also award up to four (4) additional prize purses in the amount of $50,000 each to the next highest scoring Teams in one or more Mission Activities (a total of up to $200,000). Teams must meet or exceed a minimum score in order to be eligible for a prize purse (see Phase 1 Judging below). The Phase 1 prize purse distribution is summarized in the table below.

Phase 1 Prize Purse Distribution

	Mission Activity 1	**Mission Activity 2**	**Mission Activity 3**
1st Place	$100,000	$100,000	$100,000
Next Highest Scores	Up to four $50,000 prize purses		

The initiation of Phase 2 is contingent on the emergence of promising submissions in Phase 1 that demonstrate a viable approach to achieving the Challenge goals. In Phase 2, Teams will build and demonstrate their proposed solution. Phase 2 is expected to last approximately 28 months. The rules for Phase 2 will be released prior to the opening of Phase 2.

Prize purses for Phase 2 are expected to total up to $4.5 million. Additional detail about the number of winners and division of prize purses in Phase 2 (including milestone prizes, if offered) will be included in the Phase 2 rules.

Mission Scenario and Mission Activities

The Mission Scenario and the three associated Mission Activities are based on anticipated mission operations and environmental features of human and robotic exploration of the lunar surface. The characteristics of the Mission Scenario are purposely intended to incentivize a wide variety of innovative technology solutions to the overall objectives of flexible, robust energy distribution, management, and/or storage solutions that will be critical to the well-being and productivity of human crew and fledgling lunar surface industries.

The three Mission Activities present different needs for power or energy capacity, different distances between a NASA power plant and the site of activity operations where power is needed, and different mobility features, and operational duty cycles. Each Mission Activity specifies distinct operational consumption of electrical and/or thermal energy, but each is open to solutions that involve conversion between one and the other.

All of the Mission Activities occur in the vacuum of the lunar environment and specifically at a lunar polar region where the availability of sunlight is irregular. In the polar regions, sunlight is highly dependent on latitude and longitude because of the small declination angle of the Moon, as well as variations in the surrounding terrain. When visible, the sun is always near the horizon.

Two Mission Activities take place inside a lunar crater that is a permanently shadowed region (PSR). In this PSR, sunlight rarely or ever intrudes; as a result, the environment is permanently cold and acts as a "cold trap" of volatile chemical species, especially ice.[1] Teams must assume that a solution will be immersed in the lunar environment as described here and must describe how their solution will survive and operate in that environment.

Although the Mission Activities do not specify a requirement for system mass, Teams should also consider how they would minimize the system mass of their proposed solution. System mass will be an important consideration for transporting any solution to the lunar surface in the future.

Mission Scenario Overview

Water and oxygen are fundamental to exploration and future habitat on the lunar surface. Specifically, collecting and processing of water-ice and oxygen-bearing minerals to produce propellant and other mission consumables is a desirable early capability goal of the Artemis Program. This Mission Scenario describes a set of activities related to harvesting, processing, and purifying water from icy regolith, as well as oxygen production.

The Mission Scenario is set both inside and on the rim of a lunar crater that is a PSR, in a polar region where the sky is a thermal radiation sink at 4 kelvins (K) (equivalent to -269 °C) to which surfaces radiate heat. Everything inside the lunar crater is entirely surrounded by the same 4K radiative sink, and items touching the lunar surface must also contend with heat conduction into low thermal diffusivity material at low temperatures on the order of 100 K (-173 °C).

The Mission Scenario assumes that a power plant provided by NASA is deployed on the rim of the crater. The power plant only produces electrical power during illuminated periods, which is at least 300 hours in duration at the beginning of any Mission Activity.

The Mission Scenario has three Mission Activities, each requiring an energy distribution, management, and/or storage solution:

- **Mission Activity #1**: Deliver power from the power plant to a mobility platform operating inside the crater. The mobility platform collects and delivers icy regolith to the water extraction plant.
- **Mission Activity #2**: Deliver power from the power plant to a water extraction plant operating inside the crater. The water extraction plant extracts and purifies water from the delivered material.
- **Mission Activity #3**: Deliver power from the power plant to an oxygen-producing pilot plant operating outside the crater. The oxygen-producing pilot plant extracts oxygen from the delivered material.

Teams are not responsible for generating power, only distributing, managing, and/or storing energy for each activity, per the activity description. Teams are not responsible for the design or implementation of any features of the lunar resource collection and processing assets, such as the mobility platform or plants. In their solutions, Teams may not assume a modification of any of these assets to change the operational power requirements. Teams may make assumptions about electrical or thermal connections between the asset and their solution as a basis for their

[1] "Ice" refers specifically to "water-ice" as opposed to other types of ice found in space locations, such as "carbon dioxide ice" found on Mars.

design. In addition, Teams may use the mobility platform in their energy distribution, management, and/or storage solution in any of the Mission Activities. Teams must assume that the mobility platform is located at the power plant at the beginning of each Mission Activity and must provide the operational power requirements of the mobility platform while it is being used (as described in each Mission Activity).

The Mission Scenario assumes a NASA power plant with the following characteristics:

- Located outside the crater in a fixed location near the crater rim
- Unobstructed line of sight to any assets operating inside and outside the crater
- Provides 10 kW electrical power at 120VDC
- Complies with the SAE AS5698 power quality specification
- Provides power only during illuminated periods, which are at least 300 hours in duration
- The lunar resource collection and processing assets in the crater operate one (1) km or more distant from the power plant while performing their primary tasks

Mission Activity #1: Collecting Regolith

In Mission Activity #1, a mobility platform collects and delivers water-bearing material to a water extraction plant inside the crater. Teams must propose a solution to deliver power from the power plant to the mobility platform.

Concept of Operations:

The mobility platform is required to collect and deliver water-bearing material for 100 hours and operates one (1) km from the power plant on the crater rim. During the required total of 100 hours of collection, the vehicle may conduct specific electric motor driven tasks, such as excavation, loading, traversing to and from the water plant, and unloading—resulting in variations of power needs over time. The mobility platform is capable of descending into and climbing out of the crater if needed, but this capability is not required to perform the material collection and delivery task. Due to issues related to long-term exposure to the severe cold environment in the crater, Teams must provide continuous thermal protection heating. The total Mission Activity time may not exceed 200 hours.

Operational Power Requirements:

- Initial descent of the mobility platform into the crater is required, consisting of a 10-hour trip with a continuous 150 W_E load for vehicle mobility. The platform will have an additional 5 W_E load for every additional 1 kg of payload added by the solution. During the descent the vehicle requires an additional continuous 50 W_{TH} delivered at 50 °C for thermal protection. If needed for their solution, Teams may assume a thermal interface between an external heat source and the mobility platform that is 10 cm by 10 cm, providing 0.5 W/cm^2 flux.
- Inside the crater, electric power is required in repeated one-hour cycles of ½ hour at 100 W_E followed by ½ hour at 200 W_E.
- 50 W_{TH} is required continuously to maintain an operable environment for the mobility platform components.
- If climbing out of the crater is needed as part of the power delivery solution, the platform can reach the power plant in a 10-hour ascent, requiring continuous 150 W_E for vehicle mobility. The platform will have an additional 5 W_E load for every additional 1 kg of payload added by the solution. During the ascent the vehicle requires an additional continuous 50 W_{TH} delivered at 50 °C for thermal protection. If needed for their solution, Teams may assume a thermal interface between an external heat source and the mobility platform that is 10 cm by 10 cm, providing 0.5 W/cm^2 flux. Return descent requires the same time and power. During any time outside the crater, the platform will require continuous 50 W_E to operate, but no thermal protection power.

Mission Activity #2: Water Production Plant

In Mission Activity #2, a water extraction plant operating inside the crater extracts and purifies water from delivered material. Teams must propose a solution to deliver power from the power plant to the water extraction plant.

Concept of Operations:

The water production plant operates continuously to produce clean water from ice-bearing regolith delivered by the mobility platform. The stationary plant is located one (1) km from the power plant on the crater rim. The icy regolith is 2% ice mass fraction and 98% dry regolith (the average specific heat of regolith is 1.2 kJ/kg-ºC). The icy regolith is heated from -220 ºC to 200 ºC to fully extract the water. The plant produces 10 kg of water during a 100-hour operating cycle, at the end of which the water is dispensed from the plant for delivery. Supporting a water delivery is not a required part of this activity. Dry regolith at 150 ºC is continuously discarded. Due to issues related to long-term exposure to the severe cold environment in the crater, Teams must provide continuous thermal protection heating. Total mission activity duration is three water deliveries and up to 300 hours.

Operational Power Requirements:

- If the mobility platform is used in the proposed solution, an initial descent of the mobility platform into the crater is required, consisting of a 10-hour trip with a continuous 150 W_E load for vehicle mobility. The platform will have an additional 5 W_E load for every additional 1 kg of payload added by the solution. During the descent, the vehicle requires an additional continuous 50 W_{TH} delivered at 50 °C for thermal protection. If needed for their solution, Teams may assume a thermal interface between an external heat source and the mobility platform that is 10 cm by 10 cm, providing 0.5 W/cm^2 flux.
- Inside the crater, electric power is required in repeated one-hour cycles of ½ hour at 500 W_E followed by ½ hour at 1,000 W_E.
- A continuous thermal protection load of 200 W_{TH} delivered at 50 °C is required to maintain an operable environment for the plant components. If needed for their solution, Teams may assume an interface between the heat source and the water production plant that is 20 cm by 20 cm, providing 0.5 W/cm^2 flux.
- If the mobility platform is used in the proposed solution, the platform can reach the power plant in a 10-hour ascent, requiring continuous 150 W_E for vehicle mobility. The platform will have an additional 5 W_E load for every additional 1 kg of payload added by the solution. During the ascent, the vehicle requires an additional continuous 50 W_{TH} delivered at 50 °C for thermal protection. If needed for their solution, Teams may assume a thermal interface between an external heat source and the mobility platform that is 10 cm by 10 cm, providing 0.5 W/cm^2 flux. Return descent requires the same time and power. During any time outside the crater, the platform will require continuous 50 W_E to operate, but no thermal protection power.

Mission Activity #3: Oxygen Production

In Activity #3, an oxygen-producing pilot plant outside the crater extracts oxygen from the delivered material. Team must propose a solution to address electrical and thermal energy needs of the oxygen production.

Concept of Operations:

Outside the crater, the oxygen-producing pilot plant experiences irregular periods of solar illumination and eclipse over the course of a 709-hour lunar diurnal cycle. The plant location was selected to ensure that the initial illuminated period in each diurnal cycle is 300 hours long. The remaining time is approximately split between 50% illuminated and 50% eclipsed on an

irregular schedule, with no eclipsed period longer than 30 hours and all illuminated periods at least 20 hours long. The power plant only operates during illuminated periods. However, to avoid damage from thermal cycling of high temperature components, the oxygen-producing pilot plant must produce oxygen continuously over the full 709-hour diurnal cycle. The oxygen-producing pilot plant, located 100 m from the power plant, extracts oxygen continuously at a rate of 1 kg/hour from dry regolith that is 14% oxygen by mass (average specific heat of regolith is 1.2 kJ/kg-ºC). Oxygen extraction requires heating regolith from 200 ºC to 1,800 ºC. The plant continuously discards regolith mass at 1,100 ºC at a rate proportional to the oxygen production rate.

Operational Power Requirements:

- If the mobility platform is used in the proposed solution, initial traversing from the power plant to the oxygen-producing pilot plant requires one hour, 50 W_E to operate plus an additional 5 W_E for each additional 1 kg of payload added by the Team.
- During both illuminated and eclipsed periods, the oxygen-producing pilot plant requires 5 kW_E continuously.
- Because of the large thermal mass produced by the plant, there is no additional thermal protection requirement.
- If the mobility platform is used in the proposed solution, the platform can traverse the distance between the oxygen plant and the power plant in one hour, requiring 50 W_E to operate plus an additional 5 W_E for each additional 1 kg of payload added by the Team.

Expectations for Phase 2

All Teams awarded a prize purse in Phase 1 will be encouraged to participate in Phase 2 (if Phase 2 is initiated). Phase 2 is expected to be open to any eligible Team, regardless of whether a Team participated Phase 1.

If Phase 2 is initiated, Teams will build and demonstrate their proposed solutions. Phase 2 submissions are expected to be tested at NASA facilities and/or other designated laboratories to measure and evaluate the following:

- How well solutions address Operational Power Requirements of the Mission Activities, as described above
- How solutions are expected to perform in lunar conditions, as described above, using testing in simulated lunar conditions and/or modeling
- The system mass and efficiency of the solution

In Phase 2, testing results are expected to be used in a scoring methodology to rank Teams. A Judging Panel would then evaluate the results and determine the winner(s). Appendix A includes a tentative framework for the Phase 2 scoring methodology.

Competition Calendar

The following is an overview of the expected timeline for Phase 1 of the Challenge. This calendar is subject to change, and any updates will be posted on the Challenge website: https://www.herox.com/WattsOnTheMoon.

A more detailed competition calendar for Phase 2 will be finalized as part of the Phase 2 rules.

PHASE 1	
Expected Date	**Description**
09/25/2020	• Phase 1 registration opens
October 2020 – February 2021	• Webinars to support registered Teams and potential Teams in developing concept design • Promotional activities and/or other support (TBD) for registered Teams
January or February 2021	• Judging Panel Summit (virtual) to brief judges on roles/responsibilities and Challenge rules
03/25/2021	• Deadline for registration • Deadline for Teams to submit Phase 1 Submission (concept designs)
April 2021	• Administrative review of concept designs to verify compliance with rules • Judging Panel conducts virtual interviews with Teams
May 2021	• Judging Panel reviews and scores designs • Judging Panel Summit (virtual) to determine Phase 1 winners
05/20/2021	• Phase 1 winners announced
PHASE 2 (if initiated)	
Expected Date	**Description**
June 2021	• *Phase 2 registration opens*
September 2023	• *Phase 2 winners announced*

Phase 1 Registration, Submissions, and Judging

Registration

All interested Teams must register for the Challenge by March 25, 2021, at 5:00 PM Eastern Daylight Time and meet the eligibility requirements in order to participate in the Challenge.

For this Challenge, the registration process will be administered by HeroX. Registration will take place through the official Challenge website: https://www.herox.com/WattsOnTheMoon.

As part of registration, Teams will submit the following:

- **Team Information**: Teams must submit a Curriculum Vitae, bio, and headshot for each Team Member. All Team Information should be uploaded in a single zip file, per the instructions on the Challenge website.

- **Team Agreement and other legal documentation,** as described in the Legal Requirements section below.

Additional details regarding the process for registration will be available on the Challenge website.

Phase 1 Submission

In Phase 1, Teams are required to submit a concept design and additional materials for evaluation and judging. The elements of the Phase 1 Submission are described in detail below. Teams must submit a Phase 1 Submission by March 25, 2021 at 5:00 PM Eastern Daylight Time.

Teams may submit multiple Phase 1 submissions. Each submission should address one Mission Activity. If a Team is proposing concept designs for more than one Mission Activity, each concept design should be a separate submission.

Teams will submit their Phase 1 Submission(s) from the Challenge website. For some submission elements, Teams will fill out a form field with a character limit; for other elements, Teams will upload one or more attachments. The limits for submission elements are summarized in the table below.

Each Phase 1 Submission should include the following elements:

- **Concept Design Title**: This title may be displayed on the competition website post-submission.

- **Technical Abstract**: Provide a brief summary description of the solution. The Technical Abstract should be contained in a single paragraph. Focus on delivering a compelling overview so that the Judging Panel members assigned to score your application will want to read more. This is your opportunity to make a strong first impression, so make every word count!

- **Technology Readiness Level (TRL)**: Technology Readiness Level (TRL) is a measurement system used to assess the maturity of a particular technology. Provide an estimated current technology readiness level for your solution and a description that supports your assessment of the current TRL. NASA is seeking solutions of sufficiently high fidelity that, if and when Teams successfully complete testing at the end of Phase 2 of the Challenge, the technologies would achieve TRL 6, as defined here: https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf.

- **Technical Approach**: Teams must provide a technical description of the proposed solution, including description of the major hardware components of the system; a three-dimensional drawing or similar informational schematic; a quantitative analysis that estimates system behavior including interactions between sub-systems, thermal models addressing interactions with the environment, estimates of overall energetic and exergetic efficiencies, and the mass estimates of sub-systems; concept of operations describing deployment and steady-state operations; and any testing and evaluation data (published or unpublished) that validates the success of the technical approach, if available.

- **Intellectual Property**: Teams must explain who owns the intellectual property of the proposed solution. If the solution is built on existing or off-the-shelf technology, Teams should detail the permissions (if applicable) they have to use that technology. If a Team is part of an organization, the submission should indicate where the ownership of the intellectual property resides.

- **Addresses the Mission Scenario and Mission Activities**: Teams must describe how their solution(s) will address one or more Mission Activities, as described above. Teams should describe any potential impediments to evaluating their solution in simulated lunar conditions, including the possibility of operational testing in a vacuum chamber that can simulate the lunar thermal environment.

- **Development Plan**: Teams must provide a plan for developing their solution to a prototype fidelity in Phase 2. The plan should describe development tasks, the project schedule, key milestones and include an assessment of technical and other development risks as well as the expected approach to managing risks. Teams must provide a budget narrative that describes how the Team will fund technology development and a description of current investors, funding partners, sponsors, suppliers, and formal collaborators connected with the Team.

- **Terrestrial Impact**: Teams should describe relevance of their technology to the terrestrial energy sector (if any), such as intersections with distributed energy resources, grid-scale energy storage, grid ancillary services, microgrids, alternative fuel vehicles, innovative energy business models, harsh environments, or other applications.

- **Environmental Sustainability**: Teams are encouraged to take in consideration long-term environmental impacts on the Moon, including how to minimize waste, address disposal of hazardous materials, and/or opportunities for recycling. If applicable to their proposed solution, Teams should provide the following information:
    - Identify any potentially hazardous or toxic materials that are expected be part of the proposed solution

    - Identify any biological materials (living, dead, or remnants, as described in the new Moon NASA Interim Directive found here: https://nodis3.gsfc.nasa.gov/OPD_docs/NID_8715_128_.pdf) that are expected be part of the proposed solution
    - Describe possible approaches to recycle, reuse, or repurpose materials, components, or systems at their end-of-life

- **Team Video Pitch**: Teams must submit a short (90 second maximum) video to introduce the Team and pitch the proposed solution. In the video, Teams should address:

    - Introduce yourself and your organization and/or Team.
    - What is the Mission Activity or Activities that you are committed to solving?
    - What is your proposed solution?
    - What is unique about your proposed solution?
    - How would you measure success and achieve broad but meaningful impact?

Limits for Each Element of the Submission

Phase 1 Submission Element	Form Field Character Limit	Narrative Page* and Size Limits	Limits for Additional Attachments (such as data files, illustrations, etc.)
Concept Design Title	5 words/ 30 characters		
Technical Abstract	100 words/ 600 characters		
Technical Approach		Up to 5 pages in one (1) PDF no larger than 20 MB	Up to three (3) attachments each of which is no larger than 20 MB
Intellectual Property	50 words/ 300 characters		
Addresses the Mission Scenario and Mission Activities		Up to 5 pages in one (1) PDF no larger than 20 MB	Up to one (1) attachment no larger than 20MB
Development Plan		Up to 5 pages in one (1) PDF no larger than 20 MB	Up to one (1) attachment no larger than 20MB
Terrestrial Impact	500 words/ 3,000 characters		
Environmental Sustainability	500 words/ 3,000 characters		
Team Video Pitch			Teams will upload a link to a YouTube site

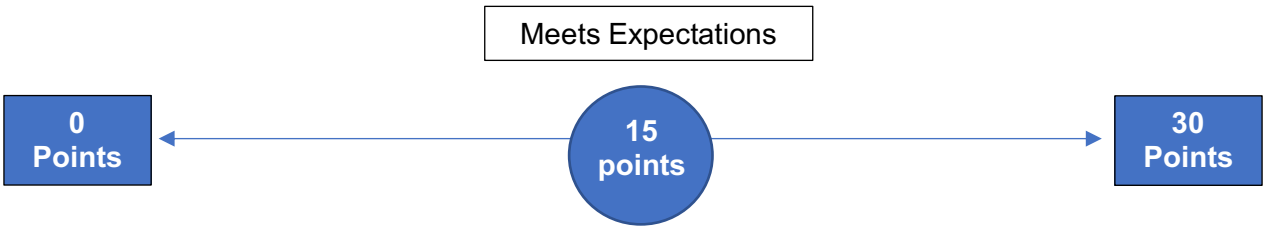
* For purposes of the Phase 1 Submission, a “Page” is defined as Letter size paper with 12-point font (Times New Roman) and 1-inch margins.

Phase 1 Judging

Following the submission deadline, the Judging Panel will review the Phase 1 Submissions and meet (in-person or on video conference) to discuss, evaluate, and rank the Teams. The Judging Panel will evaluate Phase 1 Submissions on the following five (5) factors. Teams must score at least 50 points in order to be eligible for a prize purse.

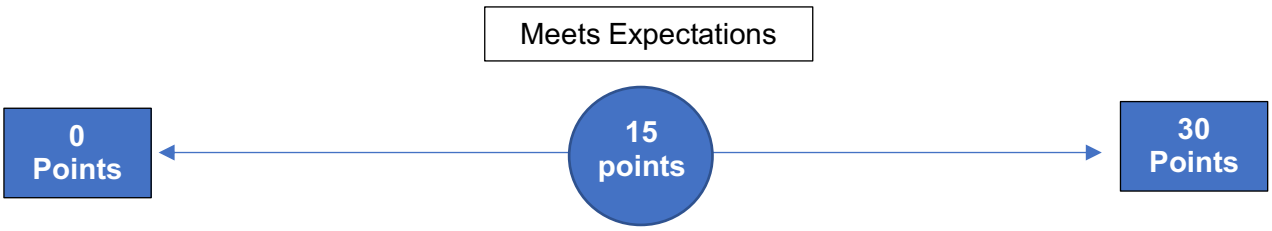
Scientific/Technical Merit

Does the submission demonstrate a clear understanding of the problem and the current state-of-the-art? Is the concept design technically sound? Does it clearly and thoroughly provide and address the requested information needed to adequately evaluate the effort?



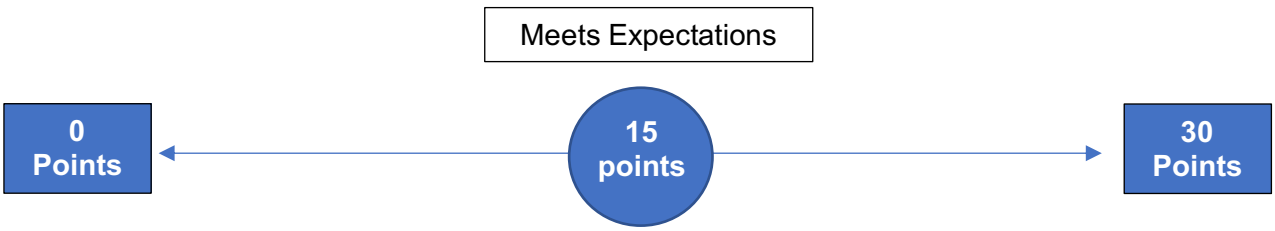
Addresses the Mission Scenario and Mission Activities

Does the submission present a compelling case that the concept design addresses the Mission Scenario and relevant Mission Activit(ies), including how the proposed solution would meet the operational power requirements; survive and perform in the unique environmental conditions of the lunar environment; and minimize system mass?



Feasibility of Proposed System

Does the submission present a compelling case that building and operating the proposed solution in Phase 2 is feasible? Does it communicate that the Team clearly understands the potential risks of building and demonstrating the proposed solution and how the risks would be addressed?

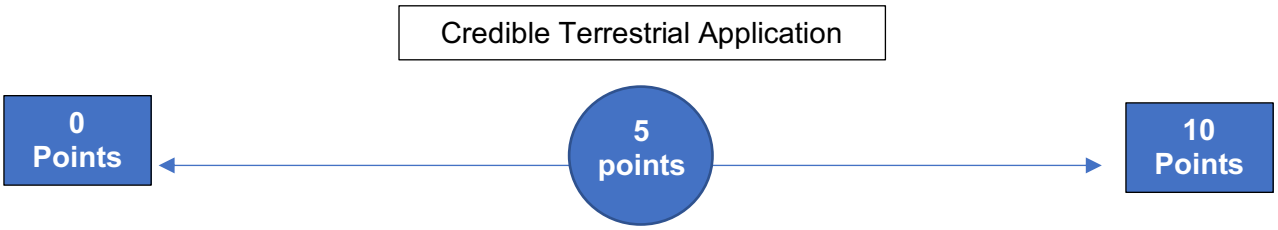


System Fabrication and Test Plans

Does the submission describe a clear pathway for the fabrication and testing of the proposed solution in Phase 2? Does it show that the Team has the necessary technical capabilities and experience, as well as access to the necessary instrumentation, facilities, and other resources required to successfully build and test the proposed system?

Bonus:
Relevance to Terrestrial Applications

Does the submission describe one or more credible terrestrial applications? Does the Team address what modifications (technical or other) might be necessary to deploy the system on Earth?



Scoring Table with Hypothetical Scores

Criteria	Improvement Needed	Meets Expectations	Exceeds Expectations	Exceptional	Perfect
Scientific/ Technical Merit	10	15	20	25	30
Addresses the Mission Scenario and Mission Activities	10	15	20	25	30
Feasibility of Proposed System	10	15	20	25	30
System Fabrication and Test Plans	2.5	5	7.5	10	10
Bonus: Relevance to Terrestrial Applications	0	5	5	10	10
TOTAL SCORE	**32.5**	**55**	**72.5**	**95**	**110**

Following the announcement of scores, Teams may file an appeal through the Ombudsman. A Team Leader must submit any appeal in writing to the Ombudsman within one (1) day of the release of scores to the Team Leader and prior to prizes being awarded. All correspondence relating to an appeal will be conducted through the Ombudsman. An Ombudsman will act solely as the mediator between the Teams and the Judging Panel, if any appeals are raised. No Team Members will approach the Judging Panel with an appeal or attempt to sway the judges' decision. The Ombudsman's decision of the appeal will be rendered by the Ombudsman before the award of prizes and will be considered final.

All Teams awarded a prize purse in Phase 1 will be encouraged to participate in Phase 2 (if Phase 2 is initiated). Phase 2 is expected to be open to any eligible Team, regardless of whether a Team participated Phase 1.

Legal Requirements

In General

Teams are responsible for understanding and complying with all legal requirements as stated below and in the Team Agreement. The Team Agreement contains additional legal requirements and instructions.

Eligibility

NASA welcomes applications from individuals, teams, and organization or entities that have a recognized legal existence and structure under applicable law (State, Federal, or Country) and that are in good standing in the jurisdiction under which they are organized with the following restrictions:

- **Individuals must be** U.S. citizens or permanent residents of the United States **and must be** 18 years of age or older.
- **Organizations must be** an entity incorporated in **and** maintaining a primary place of business in the United States.
- **Teams must be** comprised of otherwise eligible individuals or organizations and led by an otherwise eligible individual or organization.

U.S. government employees may enter the competition, or be members of prize-eligible teams, so long as they are not acting within the scope of their Federal employment, and they rely on no facilities, access, personnel, knowledge, or other resources that are available to them as a result of their employment, except for those resources available to all other participants on an equal basis.

U.S. government employees participating as individuals, or who submit applications on behalf of an otherwise eligible organization, will be responsible for ensuring that their participation in the Challenge is permitted by the rules and regulations relevant to their position and that they have obtained any authorization that may be required by virtue of their government position. Failure to do so may result in the disqualification of them individually or of the entity which they represent or in which they are involved.

Foreign citizens may only participate through an eligible U.S. entity as:

- An employee of such entity;
- A full-time student of such entity, if the entity is a university or other accredited institution of higher learning;
- An owner of such entity, so long as foreign citizens own less than 50% of the interests in the entity; **OR**
- A contractor under written contract to such entity.

Each individual, whether acting alone or as part of a Team, must identify their nationality. No Team Member shall be a citizen of a country on the NASA Export Control Program List Category II: Countries determined by Department of State to support terrorism. (The current list of designated countries can be found at http://oiir.hq.nasa.gov/nasaecp/). This includes individuals with dual citizenship unless they are a U.S. citizen or a lawful permanent U.S. resident (green card holder). Further, pursuant to Public Law 112-55, NASA is prohibited from

participating, collaborating, or coordinating bilaterally in any way with China or any Chinese-owned company. Thus, NASA will review submissions to ensure no Team or entity falls under this prohibition.

A Team-designated Team Leader shall be responsible for the actions of and compliance with the rules, including prize eligibility rules, by all members of their Team.

Ineligible Persons or Entities

Teams will be ineligible to win a prize purse if any Team Member is a Federal entity or Federal employee acting within the scope of their employment. This includes any U.S. Government organization or organization principally or substantially funded by the Federal Government, including Federally Funded Research and Development Centers, Government-owned, contractor operated (GOCO) facilities, and University Affiliated Research Centers. No U.S. government funds may be used to participate in the Challenge. Any such entity or individual shall obtain prior written approval from their cognizant ethics officer that such participation does not violate federal personnel laws or applicable agency policy. A copy of this approval to participate in the Challenge shall promptly be provided to HeroX.

Current employees and consultants of HeroX may only participate as Team Members when the Team is not competing for a prize purse from NASA. Participation of such parties as Team Members on a Team will make a Team ineligible for any prize purse.

Use of Names, Trademarks, and Insignias

Team may not use the name, trademark or insignia of HeroX, its contractors, collaborators, or NASA on its printed materials related to the participation of Team in the Challenge without HeroX's or its contractor's, collaborator's, or NASA’s prior written consent, whichever Party is applicable.

Team agrees that unauthorized use of such names, trademarks, and insignias shall result in elimination from participation in the Challenge if Team continues unauthorized use after being notified to cease and desist by HeroX or NASA, as applicable.

Insurance and Indemnification

Each Team Member agrees to assume any and all risks and waives claims against HeroX and the U.S. Government and its related entities, except in the case of willful misconduct, for any injury, death, damage, or loss of property, revenue, or profits, whether direct, indirect, or consequential, arising from each Team Member's participation in the Challenge, whether such injury, death, damage, or loss arises through negligence or otherwise. For the purposes of this section, the term "related entity" means a contractor or subcontractor at any tier, and a supplier, user, customer, cooperating party, grantee, investigator, or detailee.

Team agrees to obtain any and all insurance policies and coverage required by its local, state, or Federal governments to conduct any and all virtual activities related to or required by participation of Team and the Team Members in the Challenge. In addition, HeroX requires that each Team obtain liability insurance in the amount of $5,000 USD minimum that covers each Team Member or otherwise demonstrate financial responsibility for that amount. The Team's liability insurance shall provide coverage for all claims by (A) a third party for death, bodily injury, or property damage, or loss resulting from an activity carried out in connection with participation in the Challenge, with the Federal Government and HeroX named as an additional insured under the Team's insurance policies; and (B) the Federal Government, HeroX, and its contractors for damage or loss to Government or HeroX property resulting from or related to Challenge activities. The Team and all Team Members agree to indemnify the Federal Government and HeroX against third-party claims for damages arising from or related to Challenge activities.

Proof of insurance in such form as reasonably required by HeroX shall be provided to HeroX, no later than ten (10) days prior to the Submission Deadline as outlined in Exhibit C of the Team Agreement. Alternatively, if Team intends to fulfill this requirement by demonstrating financial responsibility in the requisite amount, Team shall submit to HeroX in writing such information as demonstrates to HeroX, in HeroX's reasonable discretion, that Team has sufficient financial responsibility to cover the potential claims cited in the requisite minimum amount as outlined in Exhibit C of the Team Agreement.

Delay, Cancellation or Termination

Team acknowledges that circumstances may arise that require the Challenge to be delayed indefinitely or cancelled. Such delay or cancellation, and/or the termination of the Challenge, shall be within the full discretion of NASA, and Team accepts any risk of damage or loss due to such delay, cancellation, and/or termination.

Appendix A: Tentative Framework for Phase 2 Scoring Methodology

About This Appendix

The following is a tentative framework for the Phase 2 scoring methodology. This framework is provided here in the Phase 1 rules to help potential Teams understand the key performance criteria that NASA is seeking to incentivize in the overall Challenge. However, nothing in this proposed framework should be considered definite or binding. An updated and final version of the Phase 2 scoring methodology will be included in the Phase 2 rules, if Phase 2 is initiated.

Tentative Framework for Phase 2 Scoring Methodology

In Phase 2, Teams will build and demonstrate their proposed solutions. During Phase 2, solutions are expected to be tested at NASA facilities and/or other designated laboratories to measure and evaluate the following:

- How well solutions meet Operational Power Requirements
- How solutions are expected to perform in lunar conditions (using simulated lunar conditions and/or modeling)
- The system mass and efficiency of the solution

Phase 2 testing results are expected to be used in a scoring methodology to rank Teams. A Judging Panel will evaluate the results and determine the scores.

Because Teams are not responsible for energy generation in this Challenge, it will be necessary to include a mechanism in the scoring methodology that accounts for the energy efficiency of A Team's proposed solution. Lower-efficiency solutions will have consequences for the amount of mass (including for energy generation equipment) required to be transported to the lunar surface in a real-world mission.

Therefore, NASA plans to develop a scoring methodology in Phase 2 where the mass of proposed solutions is modified by the mass of energy generation equipment that would be necessary to complete the Mission Activity, such as the following:

$$Modified\ Mass = System\ Mass + \frac{Energy\ Consumed}{Mission\ Activity\ Time \cdot Specific\ Power}$$

Where:

- System Mass (kg) is the total mass of a Team's solution that must be launched;
- Energy Consumed (Wh) is the energy used, measured at the NASA power plant, to complete the Mission Activity;
- Mission Activity Time (h) is the total time allotted for the Mission Activity; and
- Specific Power (W/kg) is the power density of the equipment NASA expects to use to generate electrical power for missions, equal to 300 W/kg.

This approach may be refined in the Phase 2 rules, if Phase 2 is initiated

Appendix B: Additional Information Regarding Phase 2

The initiation of Phase 2 is contingent on the emergence of promising submissions in Phase 1 that demonstrate a viable approach to achieve the Challenge goals.

If Phase 2 is initiated, it is expected to be open to any eligible Team, regardless of whether a Team participated Phase 1.

During Phase 2, Teams can expect the following:

- Phase 2, including testing and judging, will last approximately 28 months.
- The total prize purse for Phase 2 will be $4.5 million. NASA may choose to offer a portion of this amount to incentivize milestone achievements in addition to a final round of testing and judging.
- Phase 2 rules will be available upon the opening of registration for Phase 2.
- At the end of Phase 2, there will be a deadline for Teams to submit solutions followed by a period of testing and evaluation by the Judging Panel.
- Testing may include evaluation at NASA facilities and/or other third-party laboratories. Other evaluation methods, such as modeling to simulate performance in lunar conditions, may also be used to evaluate solutions.
- Up to a TBD number of Teams may be invited to attend one or more showcase events during Phase 2.
- Teams will be expected to pay for their travel costs and accommodations (if any) related to testing and showcase events.