NASA'S WATTS ON THE MOON CHALLENGE

Phase 1 Instructional Webinar

November 6th @ Noon CT

Agenda

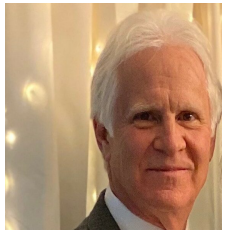
- Welcome, Introductions & Housekeeping
- Introduction to NASA Centennial Challenges
- Watts on the Moon Challenge Overview
- NASA Roadmap
- Rules Overview
- Overview of the Challenge Website
- Open Q & A
- Wrap-Up
- Next Steps

Introductions

Monsi Roman
Program Manager
NASA Centennial Challenges

Denise Morris
Deputy Program Manager
& WoM Challenge Manager
NASA Centennial Challenges

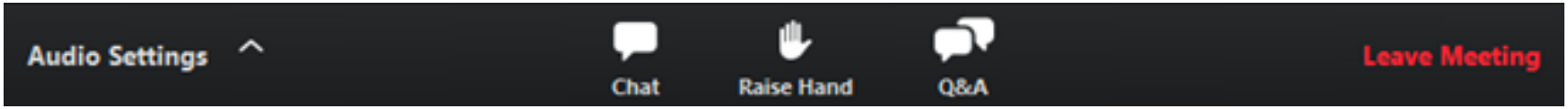
Alisa Ferguson
WoM Supporting Challenge Manager
NASA Centennial Challenges



Ray Beach
STMD Principal Technologist
NASA Glenn Research Center

Kyla Jeffrey
VP, Customer Success
HeroX

Before we get started…



Recording will be shared at
www.herox.com/WattsOnTheMoon

Registration & Eligibility

Registration

- All teams that wish to participate in the challenge must submit complete registration documents.
- Teams may participate in Phase 2 even if they did not participate in Phase 1

Eligibility Requirements – U.S. ONLY COMPETITION

- Individuals must be U.S. citizens or permanent residents of the United States and 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.

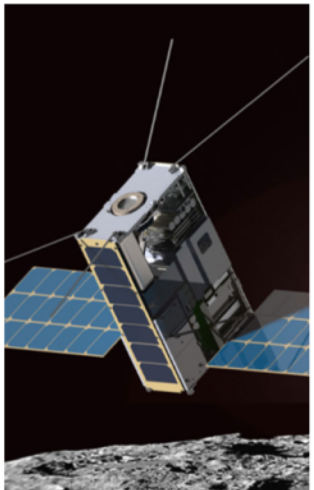
NOTE: Specific questions about a team or individual's eligibility should be submitted to gethelp@herox.com

Centennial Challenges Program

Daring you to ask…

What if?

Monsi Roman, Program Manager



ABOUT US:

- NASA's first prize program
- Established to conduct prize competitions in support of the Vision for Space Exploration and ongoing NASA programs
- Inspired by Orteig Prize and Ansari X Prize, among others
- Established (per NASA Prize Authority, 51 USC 20144): "to stimulate innovation in basic and applied research, technology development, and prototype demonstration that have the potential for application to the performance of the space and aeronautical activities of the Administration."
  - https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title51-section20144&num=0&edition=prelim
  - First competition opened in 2005

NASA
CENTENNIAL
CHALLENGES

NASA Prizes and Challenges

NASA Solve

- Centennial Challenges Program
- NASA Tournament Lab
- Space App
- Citizen Science
- NASA Education
- NASA @ Work

NASA CENTENNIAL CHALLENGES

Since 2005 the NASA Centennial Challenges Program is Making Exciting Progress

19 Challenges

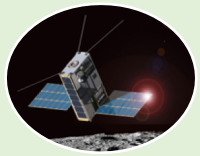
307 Teams

$10.33M Awarded

42 States 24 Countries

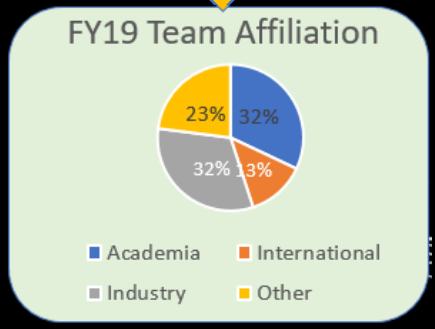
Lunar Lander
Masten

Astronaut Glove
Final Frontier



Cube Quest
3 Payloads in Artemis-1; one team with ISS

3D Printed Habitat
AI Space Factory, Branch Tech, ICON, SEARCh+



NASA CENTENNIAL CHALLENGES

CURRENT CHALLENGES

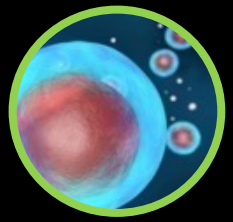
3D-Printed Habitat

$3,150,000

COMPLETED

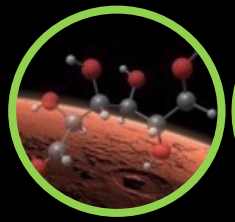
Cube Quest

$5,000,000



Vascular Tissue

$500,000



CO_2 Conversion

$1,000,000

Space Robotics

$1,900,000

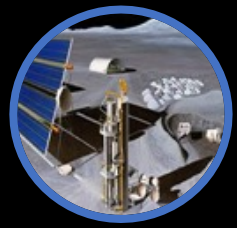
Watts on the Moon

Up to $5 M

ACTIVE

Deep Space Food

(Up to $3 M)



Break the Ice

(Up to $5 M)

DEVELOPMENT

NASA CENTENNIAL CHALLENGES


NASA
WE WANT YOU

Challenge Administrators

NASA Centennial Challenges: Challenge Owner (CCP)

- ***Challenge Role:*** *Leads challenge development and execution of the competition to ensure that the outcomes meet the overall goals of NASA; provide the NASA prize funds*

Glenn Research Center/GRC: Technology Lead

- ***Challenge Role:*** *Technical Lead and Subject Matter Expert; Primary for defining Challenge goals, success criteria, technology and infusion path*

HeroX: Challenge Contractor

- ***Challenge Role:*** *Supports the development and implementation of the Challenge; manages the competitor interface including the challenge website and confirmation of eligibility requirements.*

CHALLENGE OVERVIEW

Why a Challenge?

NASA'S WATTS ON THE MOON CHALLENGE

NASA seeks to incentivize flexible, robust energy distribution, management, and storage solutions to power the next Moon missions. This will be needed to support sustained human presence and the beginning of industrial activity.

Existing Technology

- NASA is already investing in power generation solutions, but seeking new ideas on how to manage, store and distribute the power on the Moon in extreme environmental conditions on the Moon.

Advancements in energy management, storage and distribution can

- Help sustain a long-term human presence on the Moon
- Be useful in addressing energy challenges on Earth, which might lead to commercial development.

Overview

The goal of the Watts on the Moon Challenge is to offer Teams up to $5 million in prize purses as well as potential opportunities to test their proposed solutions at NASA facilities.

Phase 1 presents a Mission Scenario with three Mission Activities. Competitors will choose one or more activities to address by proposing an energy distribution, management, and/or storage solution. Competitors will be eligible for a prize purse for each Mission Activity that they address, if they meet or exceed the minimum requirement.

Timeline of Events:

Prize Purse

PRIZE PURSE:

Up to $5M PRIZE PURSE

Phase 1: Up to $0.5 M/ 8 months

Phase 2: Up to $4.5 M/ 28 months

500,000 Total Prize Purse Available for Phase 1

- 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).
- 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).

NOTE: Teams must meet or exceed a minimum score in order to be eligible for a prize purse

Space Technology Plan – Advanced Power Systems

Space Technology Plan (STP) – Thrust Areas

NASA'S WATTS ON THE MOON CHALLENGE

LEAD

Ensuring American global leadership in Space Technology

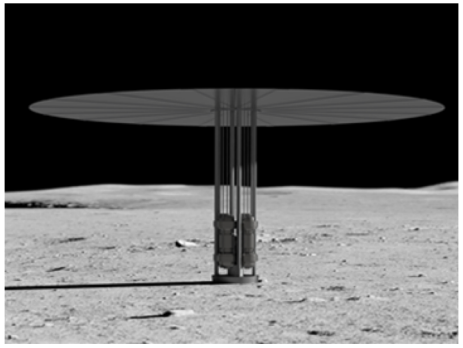
- **Lunar Exploration building to Mars and new discoveries at extreme locations**
- **Robust national space technology engine to meet national needs**
- **U.S. economic growth for space industry**
- **Expanded commercial enterprise in space**

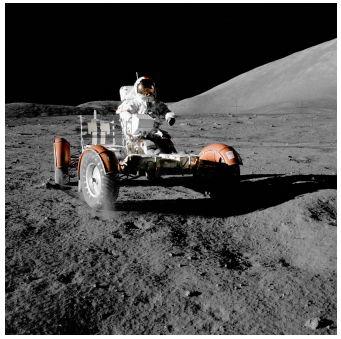
Note: Multiple Capabilities are cross cutting and support multiple Thrusts. Primary emphasis is shown

THRUSTS	CAPABILITIES
Go ***Rapid, Safe, & Efficient Space Transportation***	• Advanced Propulsion • Cryogenic Fluid Management
Land ***Expanded Access to Diverse Surface Destinations***	• Human & Robotic Entry, Descent and Landing • Precision Landing
Live ***Sustainable Living and Working Farther from Earth***	• Advanced life support and human performance • Advanced Materials, Structures and Manufacturing • Advanced Power Systems • In-situ Propellant and Consumable Production • Autonomous Systems and Robotics
Explore ***Transformative Missions and Discoveries***	• On-Orbit Servicing, Assembly and Manufacturing • Small Spacecraft Technologies • Advanced Avionics • Advanced Communications and Navigation

Advanced Power Systems STP – Heritage Systems

- Solar Power Systems
  - International Space Station, Satellites, SEP
  - PV Array, Battery, RFC, PMAD
- Nuclear Power Systems
  - Surface Power, NEP, RPS
  - Energy Conversion, Power Generation, PMAD
- Ancillary Power Systems
  - Rovers, Suits, Landers
  - RPS, Fuel cells, Battery, PMAD





Advanced Power Systems STP – Power Generation

NASA'S WATTS ON THE MOON CHALLENGE

		Power Generation												
	Tech No.	1	2	3	4	5	6	7	8	9	10	11	12	13
	Power Technologies	RPS	RPS	RPS	Fission	Fission	Fission	Solar PV	Solar PV	Solar PV	Solar Concentrators	Primary Batteries	Primary Fuel Cells	CHIPS
Missions	Target power/voltage	<1 W	100 W	1 kW	≤10 kW	50-100 kW	>1 MW	≤10 kW	20-50 kW	>100 kW	20-50 kW	1 kW	1 kW	1 kW
GO														
Human Lunar SEP	50 kW													
Human Mars SEP	300 kW													
Human Mars NEP	>1 MW													
Robotic Science SEP	<20 kW													
Robotic Science REP	<1 kW													
Robotic Science NEP	<20 kW													
LAND														
Lunar CLPS-Class	<5 kW													
Lunar HLS-Class	<10 kW													
Human Mars Lander	<10 kW													
LIVE														
Lunar Hab	10-20 kW													
Lunar ISRU - Propellant Demo	10-20 kW													
Lunar ISRU - Propellant Production	100s kW													
Lunar ISRU - Construction	10-20 kW													
Lunar Unpressurized Rover	2 kW													
Lunar Pressurized Rover	5-10 kW													
Mars Hab	10-20 kW													
Mars ISRU - MAV Fueling	20-40 kW													
Mars ISRU - Propellant Production	100s kW													
Mars Pressurized Rovers	5-10 kW													
EXPLORE														
Small Spacecraft & Cubesats	<1 kW													
Science Probes, < Earth	500 W													
Science Probes, Earth to Jupiter	1-5 kW													
Science Probes, > Jupiter	1 kW													
Interstellar Probe	tbd													
Lunar Astronomy	5-10 kW													
Lunar Science Rovers	<2 kW													
Mars Science Rovers	<2 kW													
Aerial Vehicles	<1 kW													
Venus Atmosphere	100 W													
Venus Surface	100 W													
Ocean World Surface	100 W													
Ocean World Sub-surface	tbd													
Ice Giant Surface	200 W													

Advanced Power Systems STP - PMAD

NASA'S WATTS ON THE MOON CHALLENGE

		Power Management & Distribution							System	
	Tech No.	18	19	20	21	22	23	24	25	26
	Power Technologies	Converters, Regulators, Switchgear	Converters, Regulators, Switchgear	EP Power Processing Units	EP Power Processing Units	Power Cabling	Power Beaming	Power Beaming	Operations & Sustaining Engr	Autonomous Control
Missions	Target power/voltage	28-160V	300-1000V	<20 kW	>100 kW	>300V	≤10 kW	10-100kW	N/A	N/A
GO										
Human Lunar SEP	50 kW									
Human Mars SEP	300 kW		X			X				
Human Mars NEP	>1 MW									
Robotic Science SEP	<20 kW									
Robotic Science REP	<1 kW									
Robotic Science NEP	<20 kW									
LAND										
Lunar CLPS-Class	<5 kW									
Lunar HLS-Class	<10 kW									
Human Mars Lander	<10 kW									
LIVE										
Lunar Hab	10-20 kW									
Lunar ISRU - Propellant Demo	10-20 kW									
Lunar ISRU - Propellant Production	100s kW									
Lunar ISRU - Construction	10-20 kW									
Lunar Unpressurized Rover	2 kW									
Lunar Pressurized Rover	5-10 kW									
Mars Hab	10-20 kW									
Mars ISRU - MAV Fueling	20-40 kW									
Mars ISRU - Propellant Production	100s kW									
Mars Pressurized Rovers	5-10 kW									
EXPLORE										
Small Spacecraft & Cubesats	<1 kW									
Science Probes, < Earth	500 W									
Science Probes, Earth to Jupiter	1-5 kW									
Science Probes, > Jupiter	1 kW									
Interstellar Probe	tbd									
Lunar Astronomy	5-10 kW									
Lunar Science Rovers	<2 kW									
Mars Science Rovers	<2 kW									
Aerial Vehicles	<1 kW									
Venus Atmosphere	100 W									
Venus Surface	100 W									
Ocean World Surface	100 W									
Ocean World Sub-surface	tbd									
Ice Giant Surface	200 W									

Advanced Power Systems STP – Energy Storage

		Energy Storage			
	Tech No.	14	15	16	17
	Power Technologies	Supercaps	Rechargeable Batteries	Regen Fuel Cells	Regen Fuel Cells
Missions	Target power/voltage	1-10 kW-hr	<100 kW-hr	<100 kW-hr	>1000 kW-hr
GO					
Human Lunar SEP	50 kW				
Human Mars SEP	300 kW				
Human Mars NEP	>1 MW				
Robotic Science SEP	<20 kW				
Robotic Science REP	<1 kW				
Robotic Science NEP	<20 kW				
LAND					
Lunar CLPS-Class	<5 kW				
Lunar HLS-Class	<10 kW				
Human Mars Lander	<10 kW				
LIVE					
Lunar Hab	10-20 kW				
Lunar ISRU - Propellant Demo	10-20 kW				
Lunar ISRU - Propellant Production	100s kW				
Lunar ISRU - Construction	10-20 kW				
Lunar Unpressurized Rover	2 kW				
Lunar Pressurized Rover	5-10 kW				
Mars Hab	10-20 kW				
Mars ISRU - MAV Fueling	20-40 kW				
Mars ISRU - Propellant Production	100s kW				
Mars Pressurized Rovers	5-10 kW				
EXPLORE					
Small Spacecraft & Cubesats	<1 kW				
Science Probes, < Earth	500 W				
Science Probes, Earth to Jupiter	1-5 kW				
Science Probes, > Jupiter	1 kW				
Interstellar Probe	tbd				
Lunar Astronomy	5-10 kW				
Lunar Science Rovers	<2 kW				
Mars Science Rovers	<2 kW				
Aerial Vehicles	<1 kW				
Venus Atmosphere	100 W				
Venus Surface	100 W				
Ocean World Surface	100 W				
Ocean World Sub-surface	tbd				
Ice Giant Surface	200 W				

RULES REVIEW

Challenge Rules Update

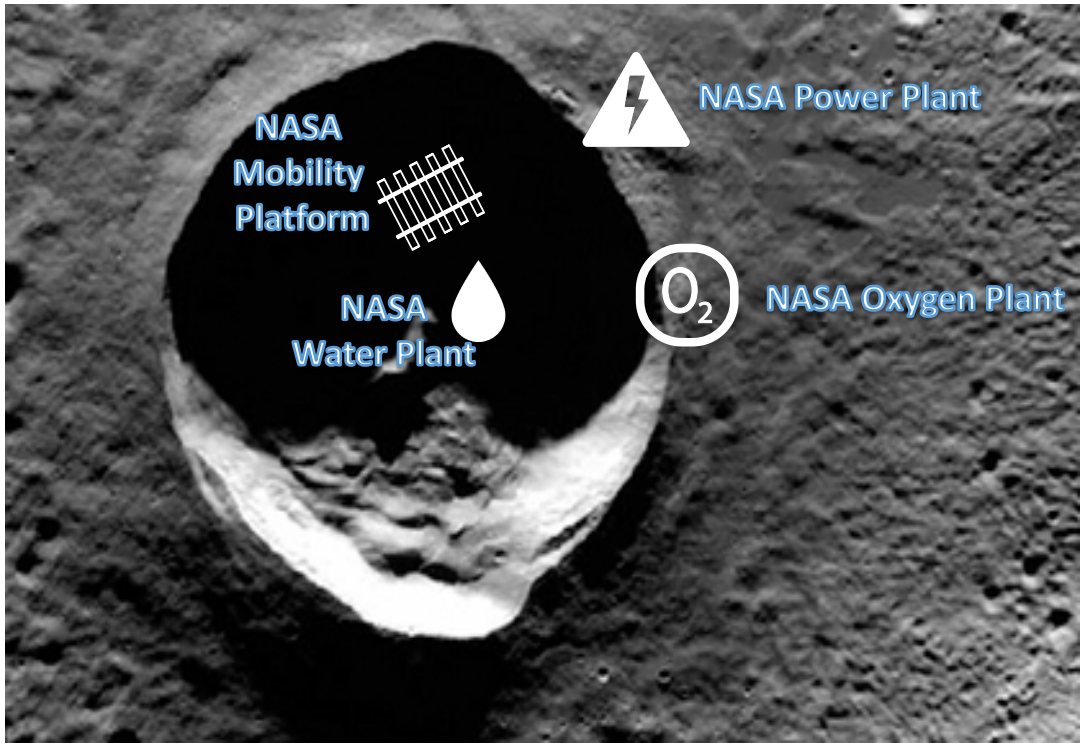
Please note that the Challenge Rules were updated on October 20, 2020

You can view and download the Challenge Rules at the Challenge website:

www.herox.com/WattsOnTheMoon/guidelines

Mission Scenario

- The Challenge is designed around a hypothetical "Mission Scenario" similar to a real-world NASA mission
- Teams will propose solutions for electrical and thermal **energy distribution, management, and/or storage** to support a water collection and extraction mission
- NOTE: Teams are **not responsible for generating power** in the Mission Scenario



Key Assumptions

Location: Lunar polar region, inside and on the rim of a permanently shadowed region (i.e. a crater)

Temperatures: The sky is a thermal radiation sink at 4 K (-269 °C) to which surfaces radiate heat. Items touching the lunar surface should assume heat conduction into low thermal diffusivity material at low temperatures on the order of 100 K (-173 °C)

Vacuum: The mission occurs in the vacuum of the lunar environment

Power Generation: A 10kW NASA power plant provides power only during illuminated periods (at least 300 hours)

Mission Activities

- The Mission Scenario has three Mission Activities, each requiring an energy distribution, management, and/or storage solution
- Teams may compete in **any or all** of the three activities; each Mission Activity is a separate competition track and will be judged separately

Mission Activity 1

- Deliver power from the power plant to a mobility platform operating inside the crater
- Address thermal requirements

Mission Activity 2

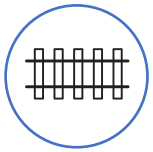
- Deliver power form the power plant to a water extraction plant operating inside the crater
- Address thermal requirements

Mission Activity 3

- Deliver power from the power plant to an oxygen-producing pilot plant operating outside the crater

Mission Activity #1

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.



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.
- 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. During any time outside the crater, the platform will require continuous 50 W_E to operate, but no thermal protection power.

Mission Activity #2

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.

Operational Power Requirements:

- 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 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.
  - 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. 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

In Mission 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.

Operational Power Requirements:

- 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:*
  - 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.
  - 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.

Phase 1 Submission

In Phase 1, teams will submit a **concept design** that includes:

Element	Description
Title and Technical Abstract	Brief summary of the concept design
Technical Approach	Description of the major hardware components of the system, three-dimensional drawing, quantitative analyses and models addressing key performance criteria, concept of operations, and any existing testing data
Mission Plan	Description and supporting data showing how the proposed solution addresses the performance requirements and environmental conditions of the Mission Scenario and Mission Activities
Development Plan	• Project plan for implementing their solution to a prototype fidelity in Phase 2 • Assessment of technical and other development risks and risk management plan • Budget narrative that describes how the Team will fund technology development
Terrestrial Relevance	Description of the relevance to the terrestrial energy sector (if any)
Environmental Sustainability	Description of how to minimize waste, address disposal of hazardous materials, and/or opportunities for recycling
Team Video Pitch	Up to 90-second video highlighting the Team and its proposed solution

Phase 1 Judging

The Judging Panel will evaluate teams on four main criteria plus a bonus

Scientific/ Technical Merit
(up to 30 points)

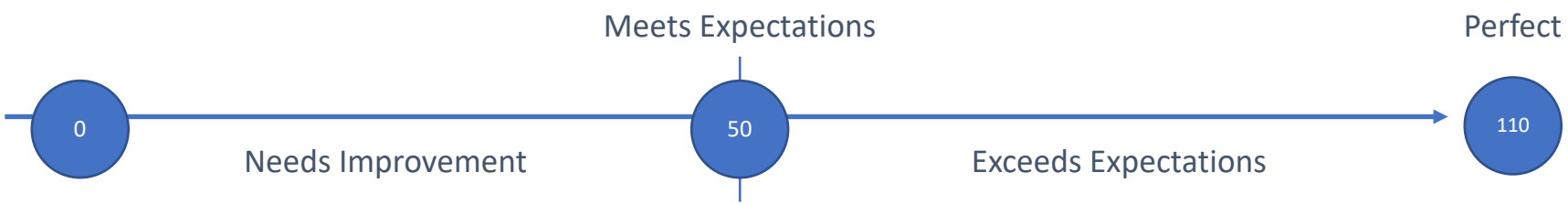
Feasibility of Proposed System
(up to 30 points)

Addresses the Mission
(up to 30 points)

System Fabrication and Test Plans
(up to 10 points)

Bonus: Relevance to Terrestrial Applications
(up to 10 points)

Teams will be awarded points for each criteria, up to a total of 110 points
Teams must score at least 50 points in order to be eligible for a prize purse



OVERVIEW OF THE CHALLENGE WEBSITE

I’m Eligible – Now What?

- ✓ Go to the Official Challenge Website and **download the Competitor Documents** which include:
  - ✓ Team Agreement
  - ✓ Adoption Agreements
  - ✓ Acknowledgment Forms
  - ✓ Foreign Participation Forms
- ✓ **Designate a Team Leader** and create your team on HeroX
  - ✓ Ensure all team members are registered as part of your team and your Team Leader is designated as the Team Captain on the HeroX platform
- ✓ **Review the Team Agreement closely** and ensure all team members abide by the Eligibility Requirements
- ✓ **Complete all of the applicable forms**
- ✓ **Obtain all of the required documents** from all team members
- ✓ **Review the Competitor Checklist** and collect all the necessary documentation for your team.
- ✓ **Upload all of the required documents** as part of your submission.
- ✓ Submit your registration documents with your submission no later than **March 25, 2021 at 5:00 pm EDT.**

OPEN Q&A

SUBMIT YOUR QUESTIONS VIA THE Q&A CHAT BOX

Next Steps

- ✓ **COMPLETE THE REQUIRED PAPERWORK AND SUBMIT THE SUPPORTING DOCUMENTS AND FORMS BY: 5:00PM EDT on MARCH 25, 2021**

- ✓ **STAY CONNECTED:**
  - ✓ *Visit the Community Forum*
  - ✓ *Follow the Challenge on Social Media*


@NASAPrize


NASAPrize


/NASACC

- ✓ **QUESTIONS?**

  Email: gethelp@herox.com

  Post in the Challenge Forum

NOTE: *Any questions or inquiries sent to any other contact or sent directly to any of the Challenge Administrators will not be answered. This includes NASA, NASA Centennial Challenges, NASA Glenn Research Center, and NASA Tournament Labs.*


NASA'S
WATTS
ON THE
MOON
CHALLENGE
THANK YOU!