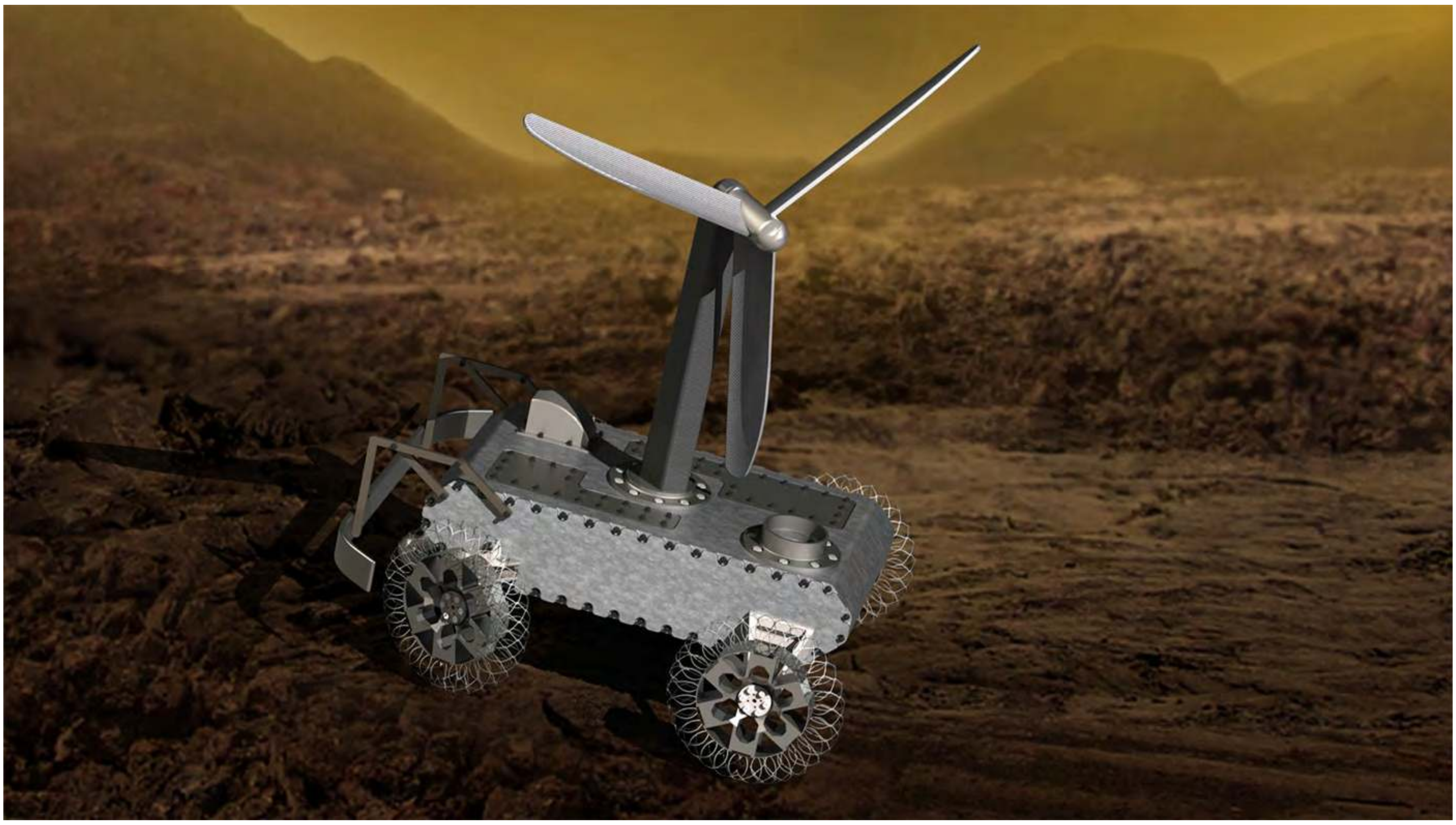
NEWS | FEBRUARY 21, 2020

NASA Wants Your Help Designing a Venus Rover Concept



Caption: An illustration of a concept for a possible wind-powered Venus rover. Credit: NASA/JPL-Caltech
› Larger view

To survive the planet's intense heat and crushing surface pressure, the rover would need an obstacle-avoidance system unlike any other.

NASA's Jet Propulsion Laboratory in Pasadena, California, under a grant from the NASA Innovative Advanced Concepts program, is running a public challenge to develop an obstacle avoidance sensor for a possible future Venus rover. The "Exploring Hell: Avoiding Obstacles on a Clockwork Rover" challenge is seeking the public's designs for a sensor that could be incorporated into the design concept.

Venus is an extreme world. With a surface temperature in excess of 840 degrees Fahrenheit and a surface pressure 90 times that of Earth, Venus can turn lead into a puddle and crush a nuclear-powered submarine with ease. While many missions have visited our sister planet, only about a dozen have made contact with the surface of Venus before quickly succumbing to the oppressive heat and pressure.

The last spacecraft to touch the planet's surface, the Soviet Vega 2, landed in 1985. Now, engineers and scientists at JPL are studying mission designs that can survive the hellish landscape.

"Earth and Venus are basically sibling planets, but Venus took a turn at one point and became inhospitable to life as we know it," said Jonathan Sauder, a senior mechatronics engineer at JPL and principal investigator for the Automaton Rover for Extreme Environments (AREE) concept. "By getting on the ground and exploring Venus, we can understand what caused Earth and Venus to diverge on wildly different paths and can explore a foreign world right in our own backyard."

Exploring and studying different geologic units across the surface of Venus could help us understand the planet's evolution, and could contribute to a better understanding of Earth's climate.

Powered by wind, AREE is intended to spend months, not minutes, exploring the Venus landscape. AREE could collect valuable, long-term longitudinal scientific data. As the rover explores the planet, it must also detect obstacles in its path, such as rocks,

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crevices and steep terrain. And NASA is crowdsourcing help for that sensor design. The challenge's winning sensor will be incorporated into the rover concept and could potentially one day be the mechanism by which a rover detects and navigates around obstructions.

The difficulty of this challenge is in designing a sensor that does not rely on electronic systems. Current state-of-the-art electronics fail at just over 250 degrees Fahrenheit and would easily succumb to the extreme Venus environment. That is why NASA is turning to the global community of innovators and inventors for a solution.

"This is an exciting opportunity for the public to design a component that could one day end up on another celestial body," said Ryon Stewart, challenge coordinator for the NASA Tournament Lab at the agency's Johnson Space Center in Houston. "NASA recognizes that good ideas can come from anywhere and that prize competitions are a great way to engage the public's interest and ingenuity and make space exploration possible for everyone."

Participants will have an opportunity to win a first-place prize of $15,000. Second place wins $10,000; and third place, $5,000. JPL is working with the NASA Tournament Lab to execute the challenge on the heroX crowdsourcing platform. Submissions will be accepted through May 29, 2020.

"When faced with navigating one of the most challenging terrestrial environments in the solar system, we need to think outside the box," Sauder said. "That is why we need the creativity of makers and garage inventors to help solve this challenge."

For more information about the challenge and how to enter, visit:

https://www.herox.com/VenusRover

AREE is an early-stage research study funded by the NASA Innovative Advanced Concepts (NIAC) program within the agency's Space Technology Mission Directorate (STMD). NIAC is a visionary and far-reaching aerospace program, one that has the potential to create breakthrough technologies for possible future space missions; however, such early-stage technology developments may never become actual NASA missions.

NASA Tournament Lab is part of NASA's Prizes and Challenges program within STMD. The program supports the use of public competitions and crowdsourcing as tools to advance NASA R&D and other mission needs.

Learn more about opportunities to participate in your space program:

www.nasa.gov/solve

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2020-038

NASA Tournament Lab

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Challenge Overview

Imagine a world hot enough to turn lead into a puddle, where the atmospheric pressure can crush a nuclear-powered submarine. Now imagine sending a rover to explore that world.

Venus, ancient sister of Earth with a planetary environment just this side of hellish, has been visited by a handful of probes since the early days of space flight. Of the many missions to our celestial neighbor, only about a dozen have made contact with the surface of the planet. The longest-lived landers only managed to function for a couple of hours before succumbing to the relentlessly oppressive heat and pressure.

Despite the punishing conditions, previous missions to Venus have nevertheless delivered important information, such as:

- Surface temperature: in excess of 450°C
- Surface pressure: 92 times that of Earth
- Wind speeds: 0.3 – 1.3 meters per second
  - Due to the extreme pressure, this low wind speed feels almost like gale-force winds here on Earth
- Length of Venusian day: 116 Earth days

NASA's Jet Propulsion Laboratory (JPL), under a grant from the NASA Innovative Advanced Concepts (NIAC) program, is studying a mission concept to return to the surface of Venus, known as the Automaton Rover for Extreme Environments (AREE), something not accomplished since the Soviet Vega 2 landed in 1985.

Current, state-of-the-art, military-grade electronics fail at approximately 125°C, so mission scientists at JPL have taken their design cues from a different source: automatons and clockwork operations. Powered by wind, the AREE mission concept is intended to spend months, not minutes, exploring the landscape of our sister world. Built of advanced alloys, AREE will be able to collect valuable long-term longitudinal scientific data utilizing both indirect and direct sensors.

As the rover explores the surface of Venus, collecting and relaying data to an orbiter overhead, it must also detect obstacles in its path like rocks, crevices, and steep terrain. To assist AREE on its groundbreaking mission concept, JPL needs an equally groundbreaking obstacle avoidance sensor, one that does not rely on vulnerable electronic systems. For that reason, JPL is turning to the global community of innovators and inventors to design this novel avoidance sensor for AREE. JPL is interested in all approaches, regardless of technical maturity.

This sensor will be the primary mechanism by which the potential rover would detect and navigates through dangerous situations during its operational life. By sensing obstacles such as rocks, crevices, and inclines, the rover would then navigate around the obstruction, enabling the rover to continue to explore the surface of Venus and collect more observational data.

JPL has issued this Challenge to the global community because the rover must have the ability to successfully navigate in such a demanding environment in order to qualify for additional developmental funding. While the mission to the surface of Venus may be years off, the development of a suitably robust rover sensor will strengthen the case for returning to Venus with a rover, something that has never been attempted before.

What You Can Do To Cause A Breakthrough

- Click ACCEPT CHALLENGE to sign up for the challenge
- Read the Challenge Guidelines to learn about the requirements and rules
- Share this challenge. Show your friends, your family, or anyone you know who has a passion for discovery.
- Start a conversation in our Forum, or join an existing conversation, ask questions or connect with other innovators.

SUBMIT YOUR SOLUTION

View legal agreement

NASA Tournament Lab

114,521 Follow (5.2K)

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Challenge Timeline

Start

Feb. 18, 2020, 6 a.m. PST
Enter

Feb. 18, 2020, 6 a.m. PST
Date Launched

May 15, 2020, 2:10 a.m. PDT
You are here

May 29, 2020, 2 p.m. PDT
Submission Deadline

June 1, 2020, 9 a.m. PDT
Judging

July 2, 2020, 9 a.m. PDT
Judging Closed

July 6, 2020, 9 a.m. PDT
Won

Finish

Challenge Guidelines

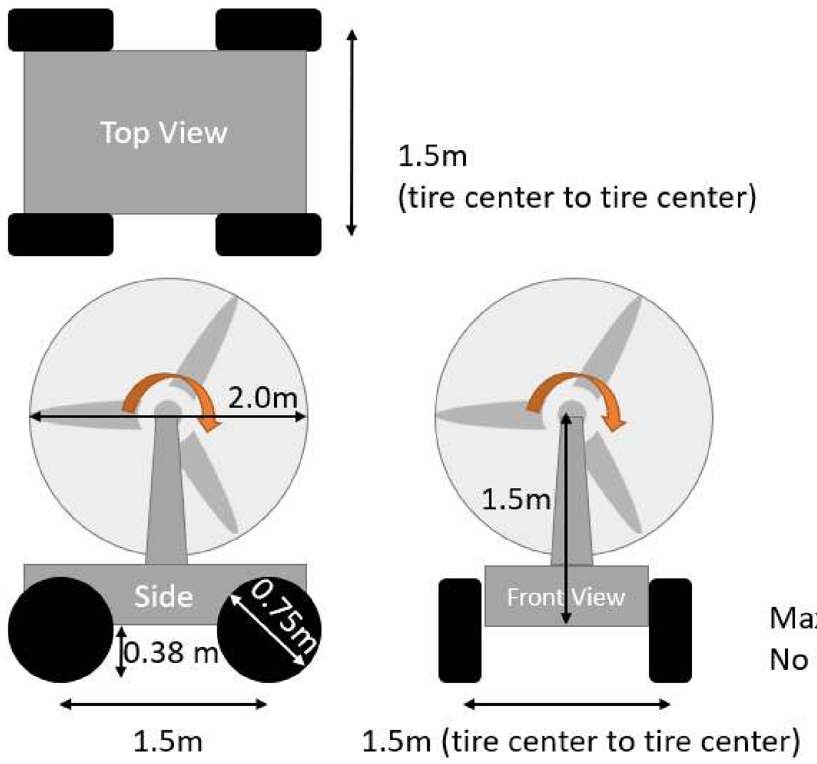
Challenge Breakthrough

Using ancient approaches and modern material science, design a mechanical obstacle avoidance sensor for usage on an off-world planetary rover.

Background

The goal of this single-stage challenge is to submit a fully mechanical sensor that meets the performance criteria listed below and can be incorporated into the existing AREE model – competitors do not need to demonstrate how their sensor will connect to the rover, only that their design can provide the desired functionality.

Below are several profile images of the rover, as currently envisioned by the design team:

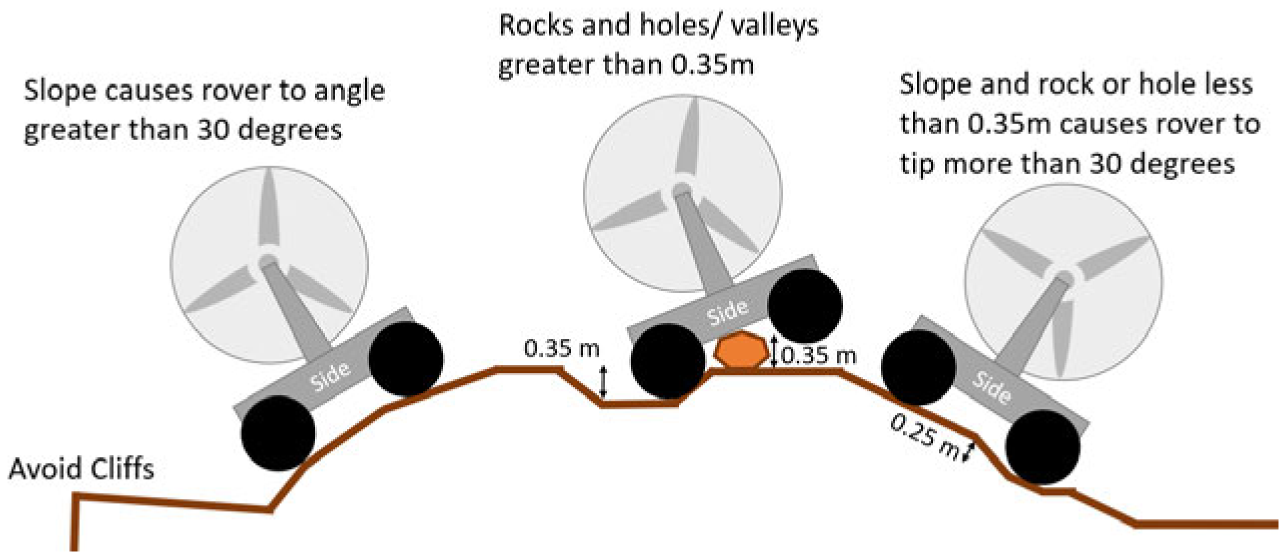


The actuator in any proposed sensor must be able to move a 6 cm diameter pin by a minimum of 3 cm with 25 N of force when an obstacle is encountered. This, in turn, will then trigger the rover to back off the obstacle and seek a new pathway forward.

The sensor must reliably respond when encountering:

- Slopes greater than 30 degrees (either up or down hill)
  - Slopes less than 25 degrees must not trigger the sensor.
- Rocks greater than 0.35 meters in height
  - Sensor must not trigger for rocks smaller than 0.3 meters in height
- Holes/valleys greater than 0.35 meters deep, except for small holes which would not entrap the wheels.
  - Sensor must not trigger for holes shallower than 0.3 meters in depth
  - Holes narrower than 0.1 meters wide *may* be ignored by the sensor but it is not required to do so
  - Holes less than 0.5 meters long in the direction of travel *may* be ignored by the sensor but it is not required to do so
    - Holes greater than 0.1 meters wide and greater than 0.5 meters long and greater than 0.35 meters deep must be detected.

To assist competitors, the following image demonstrates possible scenarios that the rover may encounter during its mission:



Additional performance criteria:

- Proposed technology must be designed with an anticipated operational lifespan of at least 6 months
- Some basic electrical components are acceptable: wires, resistors and inductors
  - Capacitors, microchips or diodes are not acceptable without strong and compelling evidence for their inclusion
- Limited power for the sensor is available from the turbine:
  - Average of 1W of power with a maximum of 15W on a limited basis and with justification
- Proposed sensor must be compatible with the following physical constraints:
  - Sensor must not extend more than 1m from the body of the rover, or more than 1 meter beyond the sides of the body
  - Sensor must not be more than 0.875m off the surface (note, when detecting an obstacle it may rise higher than this height)
  - Sensor must have a mass at or below 25kg
  - Proposed design must be capable of being assembled using environmentally appropriate materials
- Inputs:
  - The maximum number of inputs are one rotating shaft and two wires
    - rotating shaft may be of any size, rotated at any speed, with any amount of torque desired
    - one wire for power, one for ground/neutral; maximum voltage difference across the wires shall be 18 V or less, and a maximum current of 600 mA (i.e. essentially can be driven by 2x 9V battery)
  - Can be assumed that the rover is capable of pushing the obstacle avoidance system with 150N of force
- Outputs:
  - Obstacle detection mechanism must move a pin(s) or shaft(s) 3 cm axially, with a force of 25N
    - Current rover design specifies a single pin, however, multiple pins could be considered in order to achieve the desired performance

Rover Specifications

- Rover body: 2.0 m by 1.2 meter rectangle
  - Wheel contact points are located on a 1.5m square
  - Ground clearance of 0.38m
- Rover wheels: 4 wheels, each 0.75m in diameter and 0.3m wide, located 1.5 m apart on center
  - All-wheel drive, only front wheels turn left/right
- Rover turbine: 2.0m diameter; 1.5m above ground clearance

Prize

The Challenge offers up to $30,000 USD in prize money.

- First place winner will receive up to $15,000
- Second place winner will receive up to $10,000
- Third place winner will receive up to $5000

In addition to the above cash prizes, competitors may also be considered for the following non-monetary awards:

- First place winner will receive public recognition at the 2020 NIAC Symposium. Winner will also receive invitation to attend (travel costs associated with attendance not included) in September.
- Invitation to visit JPL including a tour of the lab and to meet with the challenge owning engineering team to discuss the design (travel costs associated with getting to JPL not included)
- Opportunity to collaborate with NASA Jet Propulsion Laboratory to develop the mechanical sensor (travel costs associated with getting to JPL not included)

Timeline

Open to submissions February 18, 2020

Submission deadline May 29, 2020 @ 5pm ET

Judging June 1 to July 2, 2020

Winners Announced July 6, 2020

How do I win?

To be eligible for an award, your proposal must, at minimum:

- Satisfy the Performance Criteria described above
- Thoughtfully address the Submission Form questions
- Score higher than your competitors'!

Judging Scorecard

Criteria	Description	Weight
A. Likelihood of Successful Operation	**Is the concept likely to meet the challenge obstacles avoidance requirements?**	**55% total**
A.1	Does this submission include a compelling diagram/schematic of the proposed sensor?	15%
A.2	Does this submission include appropriate justification or citations for the proposed sensor?	5%
A.3	Would the system detect rocks/holes/valleys greater than 0.35 meters tall/deep?	10%
A.4	Would the system detect slopes or combinations of slopes/obstacles that could result in an angle of greater than 30 degrees?	10%
A.5	Would the system ignore rocks/holes/valleys less than 0.3 meters tall/deep?	10%
A.6	Would the design produce a 3 cm displacement of a shaft/pin with 25N of force?	5%
A.7	Is the design compatible with the current rover architecture? • Sensor must not extend more than 1m from the body of the rover • Sensor must not be more than 0.875m off the surface • Sensor must have a mass at or below 25kg • Proposed design must be capable of being assembled using environmentally appropriate materials	10%
B. Is the concept feasible to construct?	I**s the design something that could actually be constructed?** **Are there any practical limitations to implementing the design?**	**15%**
C. Can the concept be adjusted to work in Venus conditions	**Would the concept, if built out of the right materials, operate at Venus's high temperatures?** **Would the concept operate at Venus pressure?**	**20%**

Your Submission

NOTE: Competitors are encouraged to present citations (or other relevant supporting information) to bolster the case for their design's suitability for this application. Citations may be made inline with text or may be included as a piece of supporting documentation.

NOTE: Responses should include a schematic or diagram of their proposed avoidance sensor design. The diagram should be attached as a supporting document. Acceptable file formats include: WORD, PDF or JPEG. Competitors wishing to include CAD files may do so: 2D CAD files can be shared as a PDF, 3D CAD files should be shared as a Parasolid . x_t file.

1. Please describe, in a non-confidential way, the operation of your sensor.
2. Please provide a schematic diagram of your proposed sensor. Permitted file extensions: .doc, .pdf, or .jpg. CAD files may be uploaded as PDF (for 2D models) or . x_t (for 3D models). Zipped file folders acceptable.
3. Please provide any additional information you would like included with your submission, citations, additional diagrams, etc.). Zipped file folders acceptable.
4. Please indicate the performance criteria your sensor can achieve:
    a. Move a 6cm pin a minimum of 3cm
    b. Detect slopes greater than 30 degrees (up or down)
    c. Detect rocks greater than 0.35m in height
    d. Detect holes deeper than 0.35m
5. Please describe how your sensor is suitable for the operational environment on Venus. Consider describing how your sensor design will cope with high temperatures, high atmospheric pressure, wind, launch vibrations, etc while in operation.
6. Please describe the materials you anticipate needing for constructing the sensor.
7. Please describe the electrical power requirements of your sensor. Describe what electrical components are included in your sensor and why. If none, please indicate "Not applicable".
8. Please describe how your proposed sensor will trigger the pin(s).
9. Please describe how your sensor meets the physical constraints of the current rover design (i.e. assembled of environmentally appropriate materials, mass ≤ 25kg, not more than 1m from rover body, not more than 0.875m off the surface)
10. Please indicate the current maturity level of your sensor:
    a. Conceptual
    b. Prototype
    c. Engineering model available
    d. Commercialized
11. Anything else you like to include about yourself and/or your proposed sensor? Possible topics: a short blurb that could be used to describe you, should you be selected as a winner in this Challenge. What inspired you to compete in this Challenge?
12. If you would like to supplement the information provided above with a demonstration video of your sensor, please provide a private Youtube or Vimeo link here. Please keep the duration under 5 minutes.
13. If you would like to supplement the information provided above with a short video pitch for your proposed sensor, please provide a private Youtube or Vimeo link here. Please keep the duration under 5 minutes.

You may submit multiple solutions.

Rules

Participation Eligibility:

The Prize is open to anyone age 18 or older participating as an individual or as a team. Individual competitors and teams may originate from any country, as long as United States federal sanctions do not prohibit participation (see: https://www.treasury.gov/resource-center/sanctions/Programs/Pages/Programs.aspx). If you are a NASA employee, a Government contractor, or employed by a Government Contractor, your participation in this challenge may be restricted.

Submissions must be made in English. All challenge-related communication will be in English.

No specific qualifications or expertise in the field of mechanical sensors is required. NASA encourages outside individuals and non-expert teams to compete and propose new solutions.

To be eligible to compete, you must comply with all the terms of the challenge as defined in the Challenge-Specific Agreement.

Intellectual Property

Innovators who are awarded a prize for their submission must agree to grant NASA a royalty free, non-exclusive, irrevocable, world-wide license in all Intellectual Property demonstrated by the winning/awarded submissions. See the Challenge-Specific Agreement for complete details.

Registration and Submissions:

Submissions must be made online (only), via upload to the HeroX.com website, on or before 5:00 pm ET on May 29, 2020. No late submissions will be accepted.

Selection of Winners:

Based on the winning criteria, prizes will be awarded per the weighted Judging Criteria section above.

Judging Panel:

The determination of the winners will be made by HeroX based on evaluation by relevant NASA specialists.

Additional Information

- By participating in the challenge, each competitor agrees to submit only their original idea. Any indication of "copying" amongst competitors is grounds for disqualification.
- All applications will go through a process of due diligence; any application found to be misrepresentative, plagiarized, or sharing an idea that is not their own will be automatically disqualified.
- All ineligible applicants will be automatically removed from the competition with no recourse or reimbursement.
- No purchase or payment of any kind is necessary to enter or win the competition.
- Void where restricted or prohibited by law.