NASA Tournament Lab

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Exploring Hell: Avoiding Obstacles on a Clockwork Rover

To explore the daunting surface of Venus, NASA needs an innovative obstacle avoidance sensor for its mechanical clockwork rover.

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Stage:
Won

Prize:
$30,000

Science | Space | Technology

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Challenge Guidelines

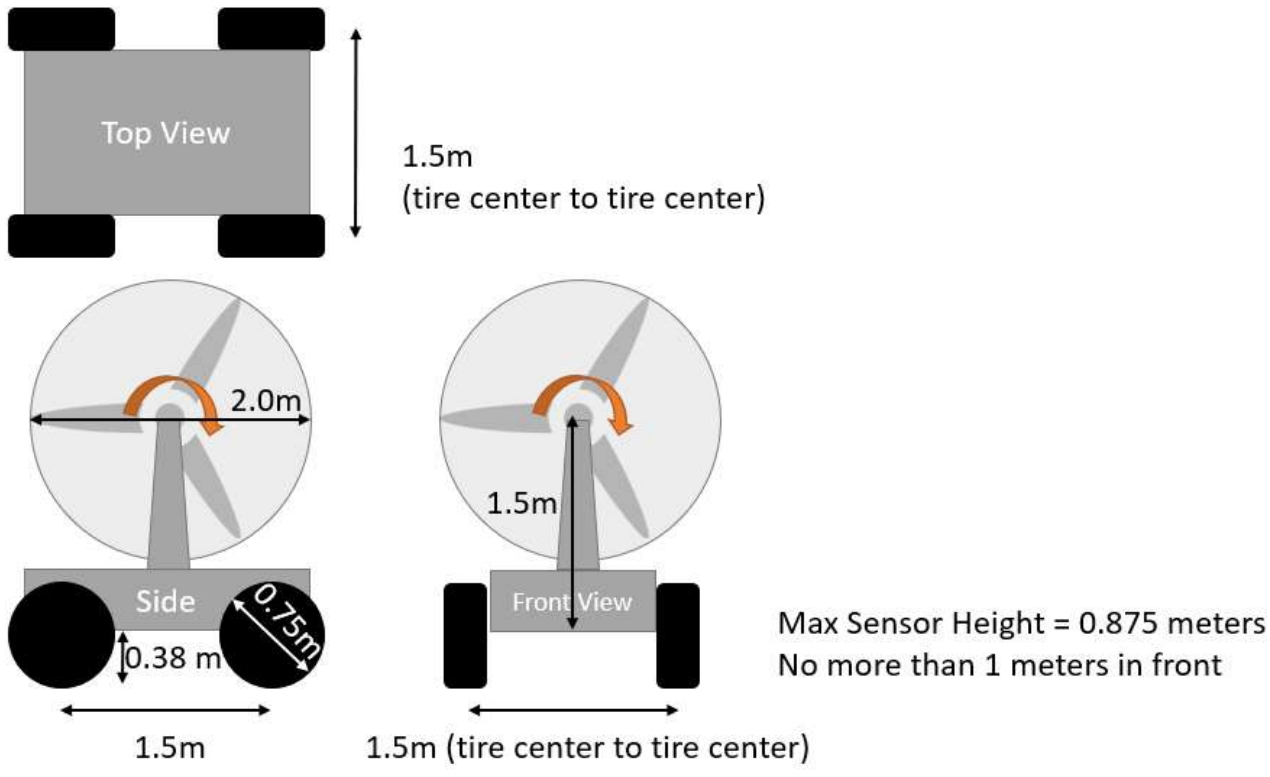
Challenge Breakthrough

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:

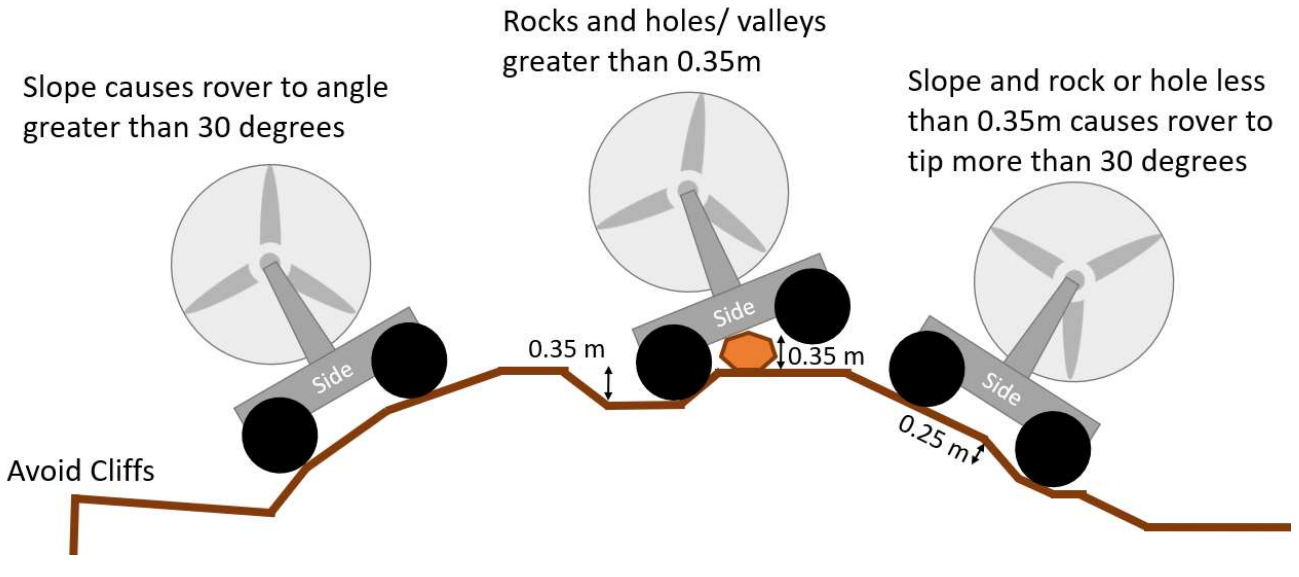


The actuator in any proposed sensor must be able to move a 6 cm diameter pin by a minimum of 3 cm with 25 N of force when an obstacle is encountered. This, in turn, will then trigger the rover to back off the obstacle and seek a new pathway forward.

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?**	**65% 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?	**Is 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 wherever restricted or prohibited by law.

Other Challenges You May Be Interested In

By Convergent Aeronautics Solutions | NASA

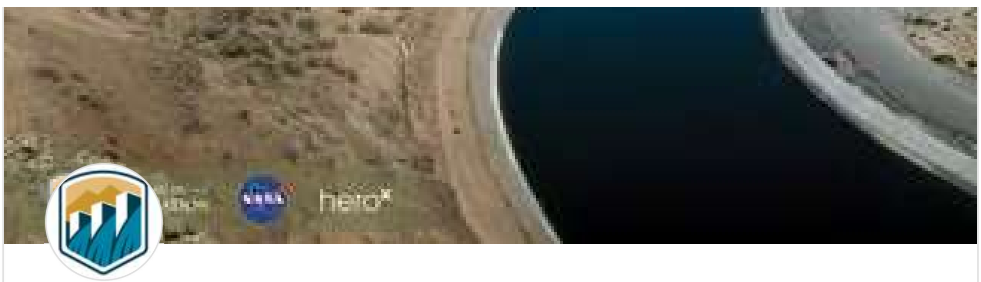
210 ☆

Future-Scaping Our Skies

Mapping societal, economic, technological, environmental, political, and regulatory trends to the future of aviation.

Enter - 51 Days Remaining

$21K Prize



By Bureau of Reclamation

203 ☆

Water America's Crops Challenge

Help us improve the reliability of water delivery for America's crops by advancing methods to reduce water seepage in canals.

Enter - 74 Days Remaining

$360K Prize

By NASA Tournament Lab

217 ☆

NIH Prize for Enhancing Faculty Gender Diversity

NIH Prize for Enhancing Faculty Gender Diversity in Biomedical and Behavioral Science

Enter - 5 Days Remaining

Our leadership team is thrilled with the results! We were able to successfully identify three winning solutions. The diversity of the innovators was so refreshing, we get how our solutions can literally live anywhere in the world.

- Gerdau

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