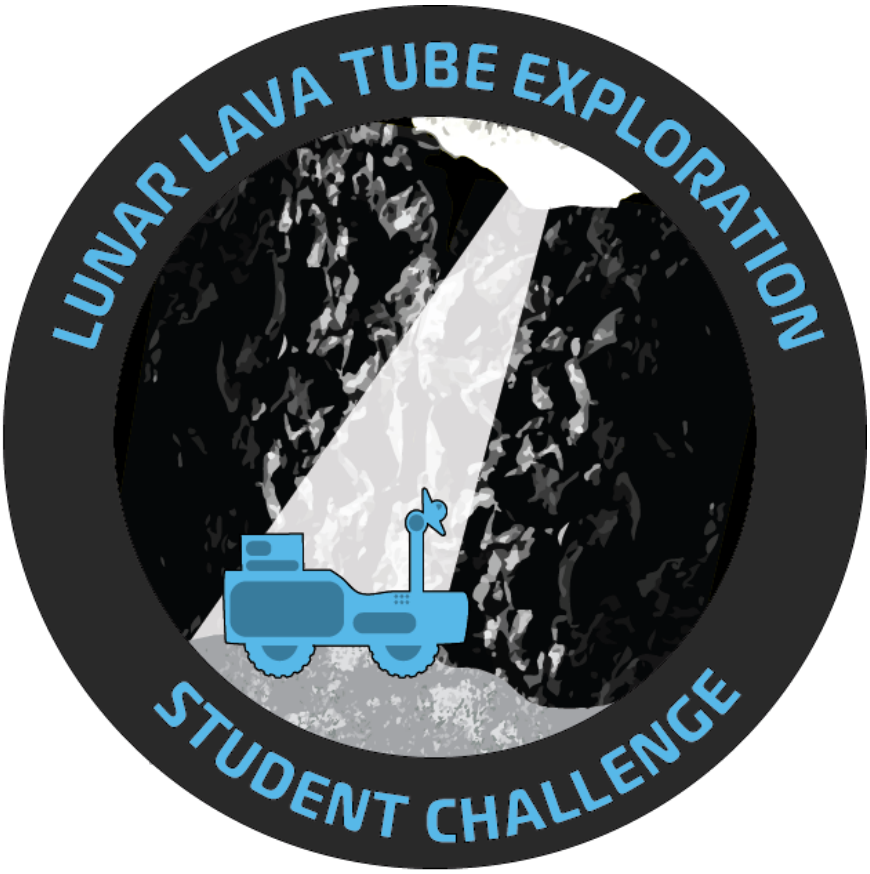
Version 1.0



2022 Participation Guide

WASHINGTON NASA SPACE GRANT CONSORTIUM

Partner

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About – Washington NASA Space Grant Consortium

Washington NASA Space Grant Consortium is comprised of more than a dozen institutions within the state of Washington, including universities, community colleges, private industry, educational organizations and museums.

The Consortium was established in 1989 with a grant from the National Aeronautics and Space Administration (NASA).

Its mission is to enhance higher education opportunities for students seeking to pursue careers in the fields of science, technology, engineering and math (STEM); to enrich and improve STEM education at Washington's diverse pre-college, college, university and community learning centers; and to provide public outreach for NASA missions, and thereby strengthen the future workforce for NASA and our nation.

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About – Challenge Overview

WSGC has created the framework for an undergraduate challenge with model lunar bases in multiple states across the U.S (WA, ID, MT, OR, TX, and WV). The challenge activities will take place in two cycles: School Year and Summer. Student teams will work to integrate science, engineering, and programming to successfully model exploration and utilization of lunar lava tubes that could support long term human exploration of the Moon.

The challenge is intended for undergraduate students of all levels of engineering design and programming skills. The goal is for WSGC to help you in learning or furthering your skills in these areas in a low-stakes, community based challenge.

WSGC will provide supply support to qualified teams, dependent on availability of funding. Details found in **Supplies** section.

Running a Team Challenge During COVID-19

We are confident that we are able to provide an enriching experience for registered teams during COVID-19. Students, graduate students, and faculty and staff participants will need to adhere to their local, state, and institutional COVID guidelines.

The Lunar Lava Tube Undergraduate Challenge will take inspiration from NASA's ability to communicate with technology between NASA centers on Earth and technology in different parts of space such as Mars and the Moon. The challenge will provide a structure for teams to have one point of contact with access to the challenge course. This individual will serve as the "Lunar Base" to allow the rest of the team working virtually or on the "Earth Base" to test their solutions in the challenge course without physically being in it. Details on this process can be found in the **Team Structure and Definitions** and **Challenge Objectives** sections.

Why Lunar Lava Tubes?

NASA's Artemis program will not only return crewed missions to the moon — it seeks to also establish sustainable lunar exploration by the end of the decade. One critical component of sustainable exploration is constructing centers for research and human habitation on the moon.

Interestingly, the moon itself may be able to provide some of the structure for a crewed facility. As early as the 1960s, NASA has considered the possibilities of underground natural cavities — the moon's lava tubes.

The lunar surface is dotted by maria, or large basins, such as the Sea of Tranquility where the Apollo 11 mission landed in 1969. These maria are often marked channels, called rilles, that were caused by large lava flows. If the surface portion of these flows cools, then a lava tube can be formed once the remaining magma drains from the area. The presence of such lava tubes is evidenced by the presence of what looks like a pit on the maria.

These lunar lava tubes could be an invaluable resource for supporting longterm human presence on the moon. As natural cavities below the surface, the moon's lava tubes offer many advantages for a human-occupied lunar facility:

- A habitat could be placed inside with a minimal amount of building or burrowing;
- There's natural environmental control;
- There's protection from natural hazards (i.e., cosmic rays, meteorites and micrometeorite impacts, impact crater ejecta);
- They're ideal natural storage facilities for vehicles and machinery.

Like a mine shaft, the lava tubes could also provide access to valuable materials. They could be access points to pristine lunar material that has not been modified by micro-meteorite impacts or by space weathering from the interaction with the solar wind. They may also provide ready access to volatile chemical elements, such as sulfur, iron, and oxygen, as well as pyroclastic debris that could be used as a construction material.

However, by their very nature, lava tubes present exceptionally hazardous sites for exploration. Challenges likely include obstacles such as very rocky terrain, steep inclines, low light, and limited communications.

Your team's mission is to develop possible solutions to these challenges.

Challenge Timeline – School Year

This timeline may not encompass all challenge activities and is subject to change.

Date	**Activity**
January 10, 2022	Virtual Kickoff Event
January 31, 2022	Team Registration Closes
Early February	Science Matter Expert Event 1
February – March 2022	Team Trainings
February 15, 2022	Monthly Development Challenge 1
Mid March 2022	Science Matter Expert Event 2
Early April 2022	Science Matter Expert Event 3
April 8, 2022	Monthly Development Challenge 2
April 25, 2022	Registration Deadline for Final Challenge
May 2021	Final Challenge

Challenge Timeline – Summer

This timeline may not encompass all challenge activities and is subject to change.

Date	Activity
May 1, 2022	Team Registration Opens
June 13, 2022	Kickoff Event
June 17, 2022	Team Registration Closes
Late June	Science Matter Expert Event 1
June - July 2022	Team Trainings
July 11, 2022	Monthly Development Challenge 1
Late July 2022	Science Matter Expert Event 2
August 1, 2022	Monthly Development Challenge 2
August 8, 2022	Registration Deadline for Final Challenge
August 2022	Final Challenge

Event Definitions

Team Trainings

Team trainings will be opportunities for registered teams to become more familiar with challenge objectives, the challenge course, and identify technical areas where additional resources and training may be needed.

Science Matter Expert Events

Each of these events will feature a presentation from a Science Matter Expert (SME) working in a field related to the challenge objectives. Registered teams will be able to view the presentation live and ask questions of the SME.

Monthly Development Challenges

In order to ensure teams are able to get opportunity for collaboration and continual feedback, two Monthly Development Challenges will take place after the Team Trainings have taken place. These events will allow teams to showcase their progress, receive feedback, and share knowledge and ideas with other teams.

Final Challenges

These events will be the culmination of the challenge for most teams. Each team will have a fixed time period to have their robot run the challenge course and receive an evaluation from challenge judges. Communication will be allowed between Earth Base and Lunar Base. See requirements in Documentation, Communication and Submission for Regional Challenges section for more information.

Team Structure and Definitions

Team Structure

Each team needs to have:

- *Team Members (3 – 5):* Undergraduate Students enrolled at a two- or four-year institution, pursuing a STEM degree
- *Team Lead:* primary contact for team, included in Team Member count
- *Faculty or Graduate Student Mentor:* advises the team on progress towards meeting Mission Objectives, serves as secondary contact for team. Teams need at least one mentor but may have multiple. Teams seeking a mentor should email nasa@uw.edu to request assistance in finding one.

Each team will also be paired with:

- *Astronaut:* students at Lunar Bases who will test team rovers and programs in challenge course.
- *Challenge Staff:* members of WSGC staff who are primary contacts for challenge operations and data collection.

Additional Definitions

- *Lunar Base:* location where a challenge course is set up for the Astronaut to help the teams test their solutions.
- *Earth Base:* location of each Team Member without access to challenge course.
- *Development Session:* virtual meeting scheduled with assigned Astronaut where Astronaut will run Team's rover in challenge course and provide data and feedback for further development.

Requirements to Participate

Citizenship Status

All enrolled STEM undergraduates are welcome to participate regardless of their citizenship or immigration status. The Team Lead role is limited to U.S. citizens, and therefore subsequent supply support may only be coordinated through the Team Lead (see the information in the Supplies section below).

Student and Mentor Requirements

Student participants meet the following qualifications:

- Enrolled at a two-year or four-year college or university, pursuing a degree in a STEM field (students from tribal colleges or community colleges are highly encouraged to participate).
- Reliable communication and internet access.
- Able to participate January – May for School Year Challenge (or end of academic year at home institution) or June – August for Summer Challenge.

Faculty or Grad Student Mentors must meet the following qualifications:

- Enrolled at or holding a faculty appointment at a two-year or four-year college or university.
- Reliable communication and internet access.
- Able to participate January – May for School Year Challenge (or end of academic year at home institution) or June – August for Summer Challenge.
- Attend monthly meetings with Challenge Staff.
- Willing to assist team in securing additional funding or supply support as needed.

Registration

Interested teams may register at http://www.waspacegrant.org/students/artemis/register/

Teams will need to have the following information to register:

- Names, contact information, and majors of student Team Members, with one student Team Lead identified
- Name and contact information of Faculty or Graduate student Mentor

Supplies and Stipends

The Lunar Lava Tube Undergraduate Challenge will be able to supply robot kits and related materials to qualified teams dependent on availability of funding. We do have limited resources and will use our discretion to provide supplies to support to teams based on registration information and demonstrated need. Estimated cost of participation is $2,000. Student teams who are provided with supply support through the challenge will receive support up to this amount. Supplies with be coordinated through each Team Lead.

The Lunar Lava Tube Undergraduate Challenge will also provide a $1,250 stipend qualified team members as funding allows. We do have limited resources and will use our discretion to provide supplies to support to teams based on registration information and demonstrated need. Students who are receiving course credit at their institution for participating will not be eligible for a stipend.

Teams will need to meet the following requirements to receive supply and/or stipend support:

- Complete Lunar Lava Tube Undergraduate Challenge Registration Form
- Complete Media Release from all team members
- Complete Profile Form from all team members

We highly encourage all teams to apply for funding through their college, university, or state Space Grant for additional support. Contact nasa@uw.edu if you need assistance with looking for additional funding sources or have questions about stipends.

Challenge Objectives

The overall challenge goal is to build a rover and develop programs that allow the rover to navigate the challenge course, a model lunar lava tube. The lunar lava tube will not have a light source, teams should expect to incorporate a light source into their rover design and/or be prepared to navigate in a dark tunnel.

Mission Objectives (MOs):

- ***MO-1.*** **Skylight Entry:** rover needs to enter the challenge course through the skylight without human contact
- ***MO-2.*** **Obstacle Avoidance:** rover should not come into contact with obstacles such as lava columns
- ***MO-3.*** **Rough Terrain Navigation:** rover needs to be able to navigate rock and sand covered paths, slopes, and rock steps with minimal difficulty
- ***MO-4.*** **Future Habitat Development:** develop a barrier solution to be deployed by the rover to block off a tunnel branch for a possible future habitat
- ***MO-5.*** **Sample Imaging:** capture an image of a rock sample in the Hall of Resources (location shown in Challenge Course Diagram)

Lunar Base and Earth Base Interactions

Teams will be required to work with their assigned Astronaut to refine their solutions to these Mission Objectives in the challenge course. The team will need to develop two identical rover solutions and send one from their Earth Base to Lunar Base. The rover sent to Lunar Base will be used by the Astronaut to provide data and feedback to the Team Members.

Challenge Divisions

Each team will select a challenge division to match the level of experience of the team members as well as the type of supplies and equipment they will use to complete challenge objectives. Corresponding with the supplies, challenge divisions also dictate the amount of autonomy the rover is expected to have while completing the Mission Objectives.

ORION

Ideal for teams with limited or no programming or engineering design experience.

Equipment	WSGC Provided Robot kit (Modifications or pieces outside of robot kit allowed)
Rover Control	Primarily manual, some autonomous if able

GATEWAY

For teams with some prior programming and engineering design or mechanical engineering experience.

Equipment	WSGC Provided Robot kit or custom built rover (Modifications or pieces outside of robot kit allowed)
Rover Control	Mostly manual, some autonomous functions required

SHACKLETON

SHACKLETON AUTONOMOUS

For teams confident in their programming and engineering design or mechanical engineering experience.

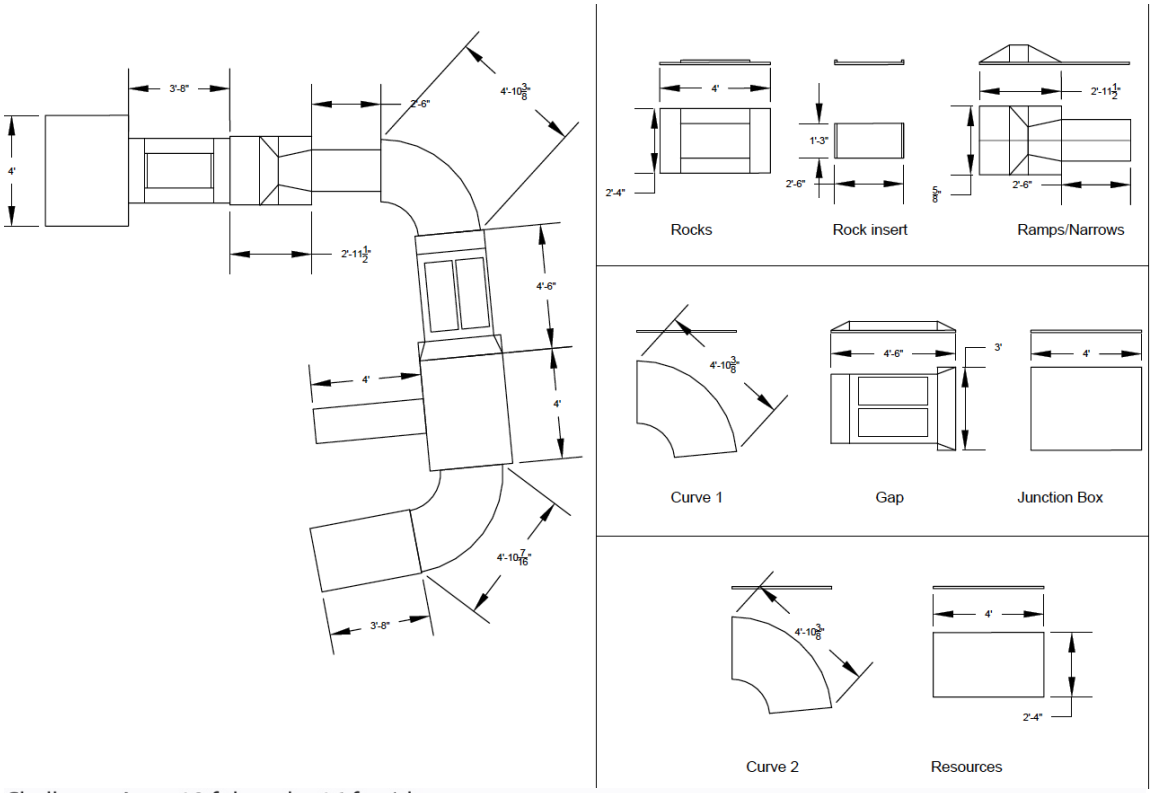
Equipment	Custom built rover
Rover Control	Autonomous navigation, MO-1 and MO-4 can be accomplished with manual controls

SHACKLETON REMOTE CONTROLLED

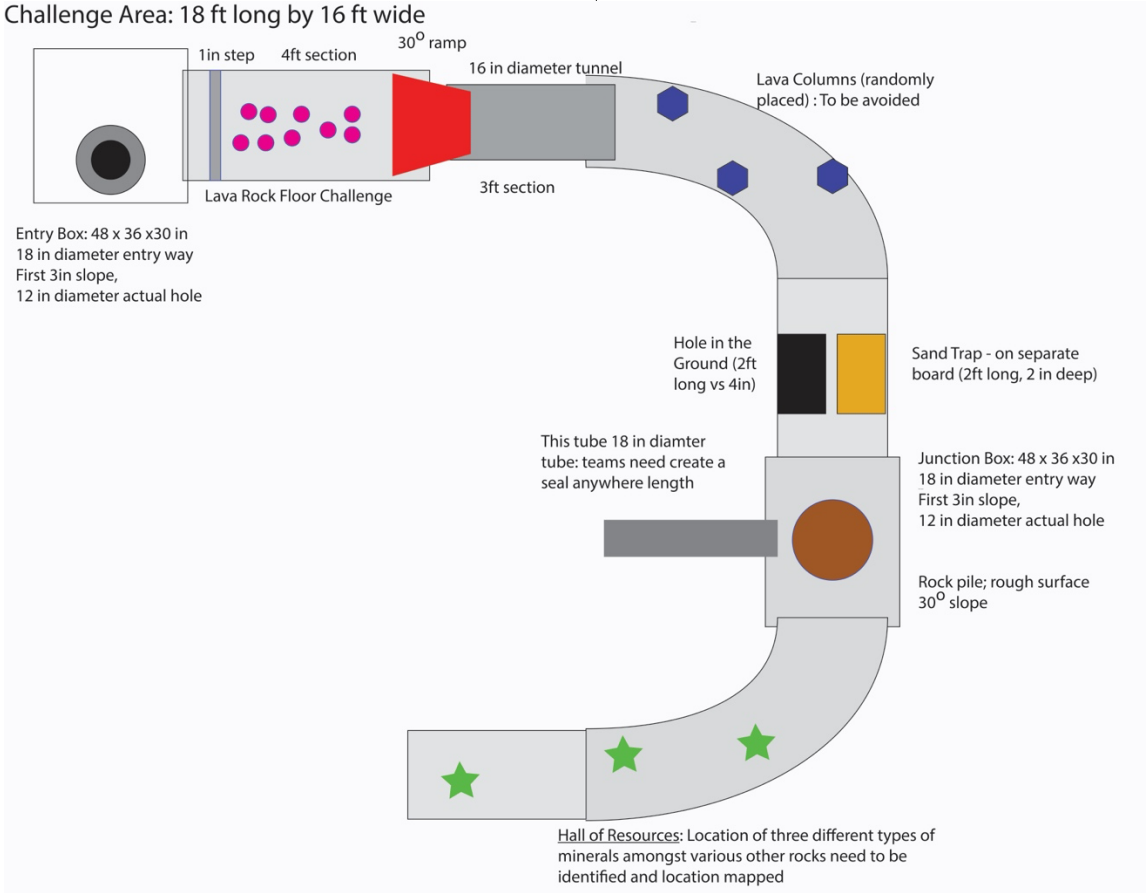
For teams with engineering design or mechanical engineering experience but limited to no programming experience.

Equipment	Custom built rover
Rover Control	Remote/manual control of rover allowed for all MOs

Challenge Course Diagrams



Challenge Area: 18 ft long by 16 ft wide



Documentation and Submission for Regional Challenges

Documentation

Teams are expected to keep a Challenge Log of their progress in the following areas:

1. *Virtual or Socially Distanced Collaboration:* what methods is your team using to meet virtually or while following appropriate COVID guidelines? What challenges are you facing in this area?
2. *Project Management:* what is each team member's role? What are you implementing to work together as a team to complete tasks? What feedback are you getting from your mentor(s) and how are your applying that to your work?
3. *Engineering Design:* include relevant steps of the design process. Have you made updates or changes to your initial rover design? Do you have models or drawings to help develop your designs? How is your rover design going to help you complete the Mission Objectives? What is your process for completing MO-1 and MO-4 with different mechanical elements?
4. *Coding Milestones:* include relevant steps of your progress developing programs for your rover. What language are you using? How are you debugging your code? What resources are you using to refine your code?
5. *Development Sessions:* include relevant feedback and information gathered during your Development Sessions with your assigned Astronaut. Did you run into unexpected issues? What will you do to modify your rover and/or code as a result?

The log can be in any format easily accessible someone outside of the Team such as a Google Doc. Pictures and videos of progress are highly encouraged!

Communication

Teams are welcome to use whatever platforms they have available to communicate internally. Monthly meetings with Challenge Staff will be held on Zoom (or Microsoft Teams if any Zoom restrictions are in place at your institution). Slack and Trello will also be used by Challenge Staff and Teams are highly encouraged to use these platforms as well. Questions about Slack and Trello can be directed to nasa@uw.edu.

Submission for Final Challenge

To participate in the Final Challenge, teams will need to:

1. Submit Challenge Log with sections outlined above
2. Have a functional rover design that has been sent to Earth Base
3. Have completed at least one Development Session with assigned Astronaut at Lunar Base
4. Be up to date with all reporting/data requests from Challenge Staff
5. Completed at least one Monthly Development Challenge

Prizes

While this is a challenge intended to help undergraduates further develop their skills, prizes will be available for top teams. Prize details TBD based on COVID restrictions but will include an exclusive NASA event or experience.

Resources

How-to videos, project management guides for teams, and related resources will be available on the challenge website in January 2022.