

National Aeronautics and
Space Administration



PERC HUMAN EXPLORATION ROVER CHALLENGE

20 25

HANDBOOK



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ALIGNMENT WITH NATIONAL STANDARDS IN ENGINEERING AND SCIENCE

The NASA Human Exploration Rover Challenge (HERC) is a rigorous and continuously evolving activity which engages students in hands-on engineering design related to NASA's missions. HERC aims to meet established educational objectives and provide continuous program improvement that satisfy the needs of its participants.

Through participating in HERC, students will develop a deeper understanding of content and enhance their communication, collaboration, inquiry, problem-solving, and flexibility skills that will benefit them throughout their academic and professional lives.

HERC aligns with the Next Generation Science Standards and Accreditation Board for Engineering and Technology (ABET) criteria outlined below:

Next Generation Science Standards (NGSS) – Middle School (6–8)

MS-PS3-1 Energy [MS-PS3-1](#)

Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

MS-PS3-3 Energy [MS-PS3-3](#)

Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-ETS1-1 Engineering Design [MS-ETS1-1](#)

Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2 Engineering Design [MS-ETS1-2](#)

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3 Engineering Design [MS-ETS1-3](#)

Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4 Engineering Design [MS-ETS1-4](#)

Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Next Generation Science Standards (NGSS) – High School (9–12)

HS-PS2-1 Motion and Stability: Forces and Interactions

Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-2 Motion and Stability: Forces and Interactions

Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

HS-PS2-3 Motion and Stability: Forces and Interactions

Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

HS-PS3-1 Energy

Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-3 Energy

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-ETS1-1 Engineering Design

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-3 Engineering Design

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ETS1-4 Engineering Design

Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

**Accreditation Board for Engineering and Technology (ABET) –
Criteria 3. Student Outcomes**

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- An ability to communicate effectively with a range of audiences
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

1. BACKGROUND: THE NASA HUMAN EXPLORATION ROVER CHALLENGE

Since its inception in 1994, the Human Exploration Rover Challenge (HERC) has been hailed as one of the most exciting student challenges taking place in Huntsville, AL, with support from NASA's Marshall Space Flight Center. Formally known as the Great Moonbuggy Race, the challenge was conceived in the spirit of NASA's Apollo missions to the moon, and the Apollo Lunar Roving Vehicle (LRV) that carried the first men in history across the lunar surface. Students created vehicles (dubbed "moon buggies") to face challenges similar to those engineers at NASA's Marshall Space Flight Center addressed in preparation for Apollo 15.

Today, humankind is returning to the moon through NASA's Artemis Mission with the goal of landing the first woman, first person of color, and first international partner astronaut on the moon. The Artemis mission will explore the moon for scientific discovery, technology advancement, and to learn how humans can live and work on another world as we prepare to propel ourselves further into space, to Mars. The next humans to land on the moon will use innovative technologies to explore more of the lunar surface than ever before and inspire the next generation of explorers—the Artemis Generation.

Each year the NASA Human Exploration Rover Challenge (HERC) features an engineering design challenge to engage students worldwide in the next phase of human space exploration. As an Artemis Student Challenge, HERC draws inspiration from both the Apollo and Artemis missions, emphasizing designing, constructing and testing technologies, as well as traversing unique environmental terrain.

During Apollo 15 astronauts utilized the first automotive vehicle on the moon, the Lunar Roving Vehicle (LRV). With this rover, astronauts were able to collect more lunar samples than the previous two Moon-landing missions combined and spent twice the time on Moon than Apollo 14.

NASA's 21st century lunar exploration program is called Artemis. Artemis missions will turn science fiction into science fact as we make new discoveries, advance technologies, and learn to live and work on another world. The commercial partners have already been chosen to design and construct the next-generation rover, the Lunar Terrain Vehicle (LTV).

NASA's goal with the Artemis mission is to send the first woman and first person of color for exploration at the Moon's South Pole and to develop a sustained human presence on the Moon. On the Moon we will learn what resources are available and abundant enough that we don't need to send them from Earth. Using resources, including water, found in space will help reduce our dependency on Earth as we move farther into the solar system.

With human exploration of Mars on the horizon, NASA is developing many of the technologies needed to send human farther into the solar system today. Our work on the Moon under the Artemis program will prepare us for that next giant leap sending astronauts to Mars.

Lunar science on the surface of the Moon will be conducted with polar and non-polar landers and rovers which will explore areas not investigated during Apollo missions. This student design challenge encourages the next generation of scientists and engineers to engage in the design process by providing innovative concepts and unique perspectives. HERC also continues the Agency's legacy of providing valuable experience to students who may be responsible for planning future space missions including crewed missions to other worlds.

This year, NASA will mark 31 years of engaging students in an engineering design challenge to design, build, and race human-powered vehicles over simulated lunar/Martian terrain. Just as space travel has evolved over the past 31 years and is now returning to its roots by revisiting the lunar surface, HERC has evolved and continues to re-align its core framework to NASA's current mission directorates and commercial partners.

In 2014 the motivation changed to mimicking design challenges faced by engineers designing rovers for future exploration missions to a variety of celestial bodies. As technology advanced and materials used in the building of space travel vehicles became lighter and stronger, size restrictions on the rover were changed from fitting inside a 4-ft. (1.2 m) cube. Beginning in 2014, the rover constraint was changed to a 5-ft. (1.5 m) cube.

Since 2016, to advance the rigor and to better align with the NASA engineering design process, teams must design and fabricate their own non-pneumatic tires/wheels. Purchasing commercially available products are prohibited. As the Artemis mission became the forward face of NASA, in 2020, the challenge was again adapted, and a new rule that the rover riders must be one male and one female was put into effect. Now, with the success of Artemis I and the launch of Artemis II on the horizon, mankind is getting closer to setting foot on the moon once again. As in the past, HERC is evolving; with new goals and ideas, to continue to challenge the next generation of rover riders; the Artemis Generation.

This year we are proud to announce a new pathway to experience HERC. Teams will choose to participate in either the traditional Human-Powered (HP) or the new Remote-Controlled (RC) divisions. This change not only better aligns HERC with current NASA missions, it expands the reach of the program to include more STEM disciplines and grade levels.

To learn more about the Artemis missions, including specific plans for how to achieve these goals, visit: <https://www.nasa.gov/specials/artemis/>

2. HERC OBJECTIVE AND NARRATIVE

Since its inception in 1994, the primary objective of HERC is for student teams to design, develop, build, and test human-powered rovers capable of traversing challenging terrain, and a task tool for completion of various mission tasks. The challenge is now expanded into two divisions with the addition of HERC: Remote Operated Vehicular Research (ROVR). Teams choosing to compete in the Human Powered (HP) division will focus their development on a safe and functional vehicle, while Remote Controlled (RC) division teams will work to solve complex scientific tasks with a purpose-built vehicle.

Teams earn points by successful completion of design reviews, designing and assembling a rover that meets all challenge criteria, and successfully completing course obstacles and/or mission tasks. The team with the highest number of points accumulated throughout the project year in each category will be the winner of their respective division (middle school/high school and college/university.)

The HP competition course requires two students, at least one female, to use the student-designed vehicle to traverse a course of approximately one half-mile that includes a simulated field of asteroid debris, boulders, erosion ruts, crevasses, and an ancient streambed. The challenge's weight and size requirements encourage the rover's compactness and stowage efficiency. Just as in the Apollo 14 surface mission, teams must make real-time decisions about which mission objectives to attempt and which to leave behind—all driven by a limited, virtual eight-minute supply of oxygen. Like in the Apollo 15 mission, competing teams must be prepared to traverse rough terrains over the course of two excursions on a roving vehicle. RC teams will find the obstacle course much easier, but are required to attempt two mission tasks to help determine a suitable location for a future NASA Human Landing System (HLS) crewed landing.

3. TIMELINE

Dates Are Subject to Change

August 1, 2024	Handbook Released
August 29, 2024	Proposal Expectations Webinar
September 19, 2024	Team Proposals Due
October 3, 2024	Team Selections Announced
October 3, 2024	Registration for Selected Teams Opens
October 10, 2024	Kickoff Webinar with Q&A Session
October 17, 2024	Team Social Media Presence Established and Social Media Links List Submitted
October 17, 2024	Registration for Selected Teams Closes
November 14, 2024	Design Review (DR) Report and Presentation Due
November 25 – December 18, 2024	DR Presentations
	Design Completed and Construction in Progress
February 6, 2025	Final Travel Roster of Team Members Due
	Team Photo Due
February 27, 2025	STEM Engagement Report Due
March 6, 2025	Operational Readiness Review Report and Presentation Due
	Photos of Completed Rover for Verification Due
March 10 – 28, 2025	ORR Presentations
	Rover/Components Completed, and Testing in Progress
April 10, 2025	Competition Day 1 <ul style="list-style-type: none"> • Team Check-In • Course Walk-Through • Event Expectations and Safety Briefing
April 11, 2025	Competition Day 2 <ul style="list-style-type: none"> • Excursion 1
April 12, 2025	Competition Day 3 <ul style="list-style-type: none"> • Excursion 2 • Awards Ceremony

4. GLOSSARY OF TERMS AND ACRONYMS

Assembly Tools

Any tools, straps, etc., that teams need to contain the rover in the 5-ft. cube configuration or to assemble the rover, but not needed for traversing the course or completing the tasks. These assembly tools may be left in the designated tool area adjacent to the assembly area as part of the timed assembly process.

Aviation Challenge

Location at U.S. Space & Rocket Center where event is held in April.

CAD

Computer Aided Design; the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design.

CLPS

Commercial Lunar Payload Services – NASA is working with several American companies to deliver science and technology to the lunar surface. Companies, ranging in size, bid on delivering payloads for NASA. This includes everything from payload integration and operations, to launching from Earth and landing on the surface of the Moon.

Challenge Ready Configuration - Is defined as both pilots seated in the rover with all task materials and PPE, including seat restraints, fixed in place, feet on drive input devices, and hands up to signal completion.

DR

Design Review; demonstrates that the maturity of the design is appropriate to support proceeding with full-scale fabrication, assembly, integration, and test. It determines that the technical effort is on track to complete the mission operations, meeting mission performance requirements within the schedule constraints.

ERR

Excursion Readiness Review; event that occurs prior to any course excursion and include safety and task material inspection. The ERR will be combined with the MRR for the first excursion.

ESDMD

The Exploration Systems Development Mission Directorate defines and manages systems development for programs critical to NASA's Artemis

program and planning for NASA's Moon to Mars exploration approach. ESDMD manages the human exploration system development for lunar orbital, lunar surface, and Mars exploration.

Excursion

An attempt to traverse the course tasks and complete challenges to accumulate points. Teams will have two excursion opportunities (weather permitting), both on Friday with Saturday as a rain date. Final rankings are based on the greater point total of the two possible excursion attempts and points accumulated during design and readiness reviews. Teams are not required to attempt excursions both times.

FMEA

Failure Modes and Effect Analysis

HERC

Human Exploration Rover Challenge

HERC Implementation Team

NASA employees, both contractor and civil servant, who design, plan, and execute the NASA Human Exploration Rover Challenge program.

HP

Human-Powered rover division

HLS

NASA's Human Landing System spacecraft

kg

Kilograms

LRV

Lunar Roving Vehicle

MRR

Mission Readiness Review; the event occurs the morning before excursion runs. This includes the volume constraint, weighing the vehicle and unfolding/assembling the vehicle. The MRR will be combined with the ERR for the first excursion.

MSFC

Marshall Space Flight Center

mL

Milliliter

NASA

National Aeronautics and Space Administration

NASA STEM Gateway

Comprehensive tool designed to allow individuals to apply to NASA STEM engagement opportunities. The information collected will be used by the NASA Office of STEM Engagement (OSTEM) and other NASA offices to review applications for participation in NASA STEM engagement opportunities and to fulfill federally mandated performance reporting on these activities.

ORR

Operational Readiness Review; examines the actual system characteristics and procedures used in the system or end product's and establishes that the system is ready to transition into an operational mode through examination and analysis.

Overall Score

The total cumulative points awarded to a team, including DR, ORR, STEM Engagement, MRR, plus the Obstacles and Tasks Competition.

PPE

Personal Protective Equipment

PER

The Post-Excursion Review, or PER occurs after course completion and includes task completion inspection.

Pit Area

The area designated for preparing the team's vehicle and task components.

Pilot

Synonymous with crew; one or both student team members (at least one female) that propels the vehicle over the course.

Pit Crew & Machine Shop

Employees of the NASA Metallic Materials and Processes Division of the Materials and Processes Laboratory and Jacobs Engineering utilizing a machine shop to assist with repairs.

RC

Remote-Controlled rover division

Requirements

The set of standard rules for all participants that must be followed to compete in the Human Exploration Rover Challenge.

ROVR

Remote Operated Vehicular Research — the RC rover division in HERC

STEM

Science, Technology, Engineering and Mathematics

Student Team Lead

Student team member who leads the school's team. They, along with Team Advisor, are the main points of communication with the HERC Implementation Team during the HERC competition. Student Team Leads are also responsible for turning in all deliverables during competition.

Task Materials

Task materials include all equipment needed for completing the tasks on the course. This may include items such as collection tool, storage containers, etc.

Team Advisor

School or institution faculty/staff member who leads and mentors the HERC team. They, along with the Student Team Lead, are the main points of communication with the HERC Implementation Team during the HERC competition.

Team Lead

NASA STEM Gateway designation for the person who is in charge of the team's Gateway information. This person will be the only contact if Gateway issues arise. This person cannot be changed once the team is entered into Gateway.

Team Mentor

Experts in given field that is needed by with HERC team that gives guidance and assistance to student team members to support them through their process of learning during the competition. Graduate students and industry partners are examples of mentors who work with student teams.

TS

Task site(s)

USSRC

U.S. Space & Rocket Center

Vehicle

Synonymous with rover, the vehicle is the student-built rover designed to traverse the course during excursions.

To learn more about NASA's acronyms, visit the official site: [Acronyms | Science Mission Directorate \(nasa.gov\)](#)

5. GUIDELINES AND REGULATIONS

5.1 General Regulations

5.1.1 Individuals or teams may be excluded from participation at the discretion of NASA for unauthorized behavior, including but not limited to (i) impersonating a NASA official whether intentionally or in a manner that results in confusion; (ii) misuse of the logos or identifiers of NASA, any sponsoring organization, or any infringement of a commercial logo or trademark; (iii) failure to abide by competition rules, directives or instructions from the competition host or organizer; and (iv) asserting or implying a NASA affiliation or sponsorship where none exists. [NASA Images and Media](#)

5.1.2 Additionally, the NASA Human Exploration Rover Challenge does not host pre-competitions or competitions conducted by any organization other than NASA Marshall Space Flight Center's Office of STEM Engagement. This NASA competition is neither affiliated with, nor sponsors or endorses any Rover Challenge competition other than the NASA Human Exploration Rover Challenge. Outside competitions have no bearing on the NASA Human Exploration Rover Challenge qualification or registration process, and representation to the contrary is strictly prohibited. No competition may imply any affiliation with NASA or use the NASA logo without permission of NASA Headquarters. Any assertions made by organizations that represent themselves as "NASA Outreach Program Europe Director," "Official NASA Rover Ambassador," "International Judge," or any similar titles suggesting a tie to NASA are unauthorized. Representations or suggestions that any organization or individual can assure teams of being accepted for registration or participation in the challenge are unauthorized. All requirements for participation in the NASA Human Exploration Rover Challenge are outlined in this handbook.

5.1.3 Participants hereby waive any claims against NASA, its employees, its related entities (including, but not limited to, contractors and subcontractors at any tier, grantees, investigators, volunteers, customers, users, and their contractors and subcontractors at any tier), and employees of NASA's related entities for any injury, death, or property damage/loss arising from or related to the NASA Human Exploration Rover Challenge, whether such injury, death, or property damage/loss arises through negligence or otherwise, except in the case of willful misconduct.

5.1.4 All team members shall be currently enrolled students from a middle school, high school, an accredited institution of higher learning, or an institution such as a science center, museum, planetarium, or youth-serving organization. Multi-institutional teams are permitted for same level of education, i.e., two or more high schools on one team. Students from middle schools, high schools, and college/university shall not be combined to make a team.

5.1.5 Middle School teams will be composed of students ages 11 through 14.

5.1.6 High School teams will be composed of students ages 14 through 19.

5.1.7 Accredited institutions of higher learning (College/University) teams shall be composed of undergraduate students.

5.1.8 Graduate students may only participate as mentors for the team and not participate as team members.

5.1.9 Accredited institutions of higher learning (College/University) undergraduate teams will be composed of students ages 18 and older. Students who are younger than 18, may require age and enrollment verification.

5.1.10 Center or youth-serving organization teams can be a mixture of middle school and high school students but will compete at the highest level based on the above age ranges. No combination of middle school/high school and college/university students is allowed.

5.1.11 Age and enrollment verification may be requested at any time.

5.1.12 Each team, regardless of division, shall identify and be accompanied by an adult age 21 or older to serve as an advisor. This person shall be employed by the registered institution or organization.

5.1.13 All team members are required to be engaged in the design and build of the rover. Each person must have an active role that must be communicated to the NASA panel during Design Review (DR) and Operational Readiness Review (ORR) presentations. Teams will identify two team members as pilots (at least one female) to propel the vehicle through the course.

5.1.14 Students on the team will do 100% of the project to include design, construction of the vehicle and task components (including performing work that is supported by a professional machinist for the purpose of training or safety), written reports, presentations, and competition preparation. Any team found in violation of this will be disqualified.

5.1.15 Excessive re-use of prior material (vehicles, reports, presentations, etc., from previous HERC challenge years), determined at any milestone during the competition year, will result in disqualification. Teams should identify vehicle components that are re-used in their Design Review.

5.1.16 Any team member or advisor found to be exhibiting unsportsmanlike conduct may be disqualified from the challenge individually or as a team.

5.1.17 Teams not meeting all requirements (section 6) listed may be disqualified.

5.1.18 All scoring decisions for the reviews, excursions, and other deliverables are final. During excursions, if an appeal is warranted, the Team Advisor or the Student Team Lead shall submit the appeal in writing for consideration to the Activity Lead within 30 minutes of the posting of score(s) in question. The final decision of the Activity Lead and Technical Coordinator shall prevail.

5.1.19 All listed times connected to deliverables, webinars, office hours, presentations, and events will be either Central Standard Time (UTC-6) or Central Daylight Time (UTC-5) depending on time of the year. HERC is supported by Marshall Space Flight Center located in Huntsville, Alabama.

— Daylight saving time occurs from the second Sunday of March to the first Sunday of November. During daylight saving, Central Time Zone is only 5 hours behind Coordinated Universal Time (UTC-5), as opposed to the usual UTC-6.

5.2 Deliverable Guidelines and Information

5.2.1 All potential teams are required to submit a proposal to compete. A written proposal submission shall follow and answer the requirements outlined in Deliverable, Proposal section 7.1.

5.2.2 The Student Team Lead will submit the team's proposal for consideration via email to HERC@mail.nasa.gov. Please follow proper deliverable nomenclature.

5.2.3 Team proposals will be scored based on a rubric developed from the Proposal Requirements.

5.2.4 Teams may propose only **ONE** team per school or institution for consideration unless entering both divisions — Remote Controlled (RC) and Human Powered (HP). If a school or institution submits a proposal for both divisions, team members must participate on one of the two teams. A student team member cannot be on both RC and HP team.

5.2.5 Proposals shall be written solely by the team student members.

5.2.6 Proposals submitted after the deadline (date and time received) will not be considered.

5.2.7 Top scoring proposals will be selected to compete. Registration of all team members will be required for the competition through NASA STEM Gateway. Student Team Leads (College/University), and Team Advisors (MS/HS) will need to complete their own application in the system, then they will receive an

offer email from NASA STEM Gateway and will need to accept the offer. Once accepted, the Student Team Lead/Team Advisor will send invitations through NASA STEM Gateway to each team member to register as part of the team. The HERC Implementation Team will send out a detailed email on October 3, 2024, to those selected teams with detailed instructions.

5.2.8 *Each* team member must complete a NASA STEM Gateway application for the registration to be valid. Those who are not fully registered in Gateway will not be considered part of the team and will be unable to travel to Huntsville, AL.

5.2.9 A team member's registration will be confirmed via Gateway email upon approval of registration and not from the HERC Implementation Team. Student Team Leads/Advisors will have the capability to see registration status of all team members for verification.

5.2.10 While no endorsement exists or should be implied, teams in the past have found that either Chrome or Edge web browsers work best with NASA STEM Gateway.

5.2.11 Each team is required to submit a Design Review (DR) report and presentation and participate in a virtual presentation that, together, will make up 20% of the team's overall score. DR must be completed to progress onto the ORR portion of the challenge.

5.2.12 Each team is required to submit an ORR report and presentation and participate in a virtual presentation that, together, counts towards 20% of the team's overall score. ORR must be completed to progress onto the excursion portion of the challenge.

5.2.13 Each team is required to submit a STEM Engagement report that counts 10% towards the team's overall score to be considered for overall awards.

5.2.14 Late submissions of DR, ORR and/or STEM Engagement report deliverables will be accepted up to 24 hours after the submission deadline but will incur a 10% penalty. Teams who have not turned in a deliverable by **midnight** of the day *after* the due date will be sent an email asking for the document; the sending of this email *begins a 24 hour window*. **Submissions will not be accepted after the 24-hour window.** Teams that fail to submit a deliverable document will be ineligible for overall awards and possibly *eliminated from the competition*.

5.3 Competition Guidelines, Regulations, and Information

5.3.1 Rovers may be shipped to the U.S. Space & Rocket Center (USSRC) in advance of the competition via the following address (the USSRC will not receive any rovers that do not have pre-paid return shipping documents with their rover equipment). Drop off window is Monday through Friday from 9:00 AM CT to 4:00 PM CT. Shipping Address: U.S. Space & Rocket Center, 1 Tranquility Base, Huntsville, Alabama 35805 Attn: Warehouse Manager.

5.3.2 By the end of the competition, rovers are required to be fully packaged in an appropriate crate by the team and include all necessary label(s) for return shipping pickup. Some information needed, but not limited to, includes school name, full address, point of contact name, and mobile number, as well as BOL (Bill of Lading) for international shipping. Pick up window is Monday through Friday from 9:00 AM CT to 4:00 PM CT.

5.3.3 Neither the USSRC nor HERC staff will provide a facility, tools, or equipment for assembling or disassembling rovers (in any condition), and/or opening crates.

5.3.4 The consumption of alcoholic beverages and/or controlled substances is strictly prohibited by HERC teams on USSRC grounds and use of or possession by any HERC participant or affiliate at any time during the event is grounds for disqualification of the team and/or other repercussions.

- 5.3.5** U.S. federal, Alabama state, and Huntsville city laws and regulations solely define what is legally permitted on the grounds. As such, firearms and other weapons are not permitted to be carried by facility visitors on USSRC property.
- 5.3.6** In accordance with Federal Aviation Administration (FAA) regulations, the use of drones during any HERC activity is strictly prohibited.
- 5.3.7** Driving the rover on the course, or in the parking lot, in a reckless or unsafe manner is not permitted, and may result in disqualification.
- 5.3.8 Participant safety is our biggest priority.** Pilots who are injured, bleeding, or incapacitated will be safely attended to and receive any necessary medical attention. Injuries may occur when adjusting vehicle components, such as the drive-train components, during the excursion. Each team must develop a signal system between the two pilots to ensure safety hazards are clear before proceeding. Pilots will be asked to describe their communication plan before the excursion.
- 5.3.9** Using poles or other devices to propel or push the rover is not allowed. A pilot's use of his or her hands on the wheels (as with a wheelchair) is not permitted to facilitate vehicle movement.
- 5.3.10** Obstacles must be attempted from a seated position on the rover.
- 5.3.11** Upon successful completion of Mission Readiness Review (MRR)/Excursion Readiness Review (ERR), teams are permitted two excursions of the course if time permits.
- 5.3.12** Pilots must be on the vehicle, with safety belt fastened, and all PPE in place before driving their rover during an excursion attempt.
- 5.3.13** Teams have a total of 8 minutes to complete each excursion. Teams will receive points by successfully traversing obstacles and completing mission tasks. Teams must complete at least one of the two excursions in 8 minutes or less to be considered for overall awards and ranking.
- 5.3.14** The excursion time stops when a team either crosses the finish line or reaches the 8-minute limit, whichever comes first. Teams will be allowed to finish their excursion via taking bypasses if it isn't impeding progress of successive teams.
- 5.3.15** Course judges may make pilots aware of their unofficial excursion times periodically, however teams are encouraged to use their own timing devices as unofficial timers while on the vehicle for strategic on-course decisions. Teams should not be reliant on excursion times announced by judges. The timing judges will maintain the official excursion time.
- 5.3.16** The pilots for the first excursion shall be the same as those who conducted MRR/ERR. Pilot substitutions, if needed, may be made for the second excursion.
- 5.3.17** Communication devices are allowed if at least one pilot can hear ambient sounds/instructions from judges.
- 5.3.18** Indirectly approaching an obstacle, getting off the vehicle (pushing, pulling), or veering from an obstacle will be considered an unsuccessful attempt.
- 5.3.19** The HP course is comprised of 10 obstacles. Obstacles will have a bypass, where teams can strategically choose to either attempt the obstacle for points or bypass it for zero points.
- 5.3.20** Judges have the authority to remove a disabled or temporarily suspend a slow rover from the course when it will affect the excursion time of the next successive rover. The excursion time for the slow vehicle halts at the point of suspension and resumes once the successive vehicle has passed.
- 5.3.21** Individuals (team members and/or supporters) may not run with the rover around the course during the excursion time. Teams seen violating this safety precaution could face penalties up to and including elimination from the event.

5.3.22 Official team numbers will be provided in the event packet and shall be affixed to the front and left side of the rover, in an unobstructed view for the judges.

5.3.23 While at the HERC event, NASA MSFC volunteers are posted in various locations at Aviation Challenge for your team's safety. Listen to their instructions when provided. Teams seen violating this safety precaution could face penalties up to elimination from the event.

5.3.24 Loud noise, as well as noise makers are not permitted around any of the judging spaces. Pit areas may have some music or celebratory noise, but it must be respectful to the neighboring pit teams. Teams violating this safety precaution could face penalties up to and including elimination from the event.

Miscellaneous:

- Transportation:
 - Huntsville International Airport (local), Birmingham-Shuttlesworth (AL) International Airport (less than 2 hours)
 - Nashville (TN) International Airport (2 hours)
 - Hartsfield-Jackson Atlanta (GA) International Airport (3 hours, 30 minutes).

Huntsville has few vehicle rental options so reserve early if needed. Uber and Lyft are available. Teams are responsible for all transportation to and from the event location. Parking will be on the west parking lot at USSRC with shuttle buses available each day.

- Lodging: Huntsville has many hotels within a 10-mile radius of U.S. Space & Rocket Center, as well as many short-term, home-stay options that can be booked through apps.
- Weather: Huntsville weather is very unpredictable in April. Be prepared for any type of weather and check before traveling to our event.

5.4 Team Pit Area Guidelines and Regulations

5.4.1 Each HP team is provided a 16 ft. × 18 ft. marked area for their team's pit and must fit all equipment and/or trailers needed in the space provided. All other vehicles and/or trailers shall be parked in the designated general parking area. Teams seen violating this safety precaution could face penalties up to and including elimination from the event. RC pit areas may be smaller as space permits — exact information will be released before the event.

5.4.2 If the team's rover was shipped to USSRC within the proper time frame, it will be located in your team's pit area by noon on the Thursday prior to the event.

5.4.3 Teams will be able to unload all equipment on Thursday in preparation for the event. Once the vehicles are unloaded, the team must vacate and return to Davidson Center parking lot. Team members are to ride the shuttle bus back down to the pit area. Bus service will start by noon on Thursday.

5.4.4 On Friday and Saturday, **ALL** team members and supporters are to ride the buses down to Aviation Challenge due to all activity occurring in this location. Supplies and snacks will need to be transported on the buses and not delivered to the pit area. Teams seen violating this safety precaution could face penalties up to and including elimination from the event.

5.4.5 After the award ceremony on Saturday, teams will be able to retrieve their equipment from the pit areas. Teams must make sure that their pit areas are cleaned of all debris before leaving location. Teams seen violating this safety precaution could face penalties.

5.4.7 Teams shall exercise appropriate safety precautions during the design, build, and test phases of this competition, and utilize appropriate personal protective equipment (PPE) when performing construction activities whether at school or the HERC event, such as: welding (which can be done at the event with NASA MSFC Pit Crew assistance), handling metal components, and using tools anywhere on the USSRC property or neighboring areas. Failure to follow proper safety procedures may result in disqualification.

5.4.8 Be weather aware. Team pits are in an open location with various terrains. Some teams bring canopies to protect from sun and rain, as well as other supplies because team pits are your team's home during the event weekend.

5.4.9 Loud noise, as well as noise makers are not permitted around any of the judging spaces. Pit areas may have some music or celebratory noise, but must be respectful of their neighboring pit teams. Teams seen violating this safety precaution could face penalties up to and including elimination from the event.

5.5 Mission Readiness Review Guidelines

5.5.1 Teams will complete MRR during the predetermined time window on Competition Day 2. Time windows, and the method for obtaining a time window will be communicated to teams in advance of the competition.

5.5.2 Teams must arrive on time and ready to participate in their MRR as scheduled. Failure to arrive on time or perform MRR as scheduled will result in a penalty to the team's overall score.

5.5.3 HP Vehicles will be inspected for the 5 × 5 × 5-ft. volume constraint in the stowed configuration during MRR. A jig (PVC cube) will be placed over the rover for volume constraint verification.

5.5.4 No modifications or team rover interaction is permitted during this verification.

5.5.5 Tapes, straps, and/or other devices may be used to confine the rover in the collapsed or stowed configuration. However, all such devices will be included in the total weight measurement of the rover.

5.5.6 There are no constraints for overall height and length of the assembled rover. However, a rover with pilots that is found to have a too high center of gravity and/or found to have a weight imbalance will be assessed and may not be allowed to traverse the course if judges determine the risk of tipping over is too high.

5.5.7 The vehicle will be weighed in the stowed position with all necessary mission components. Point breakdown for weight categories is listed in section 8.

5.5.8 From the stowed position, a signal will be given, and a timer will start for the two pilots to unfold and/or assemble their rover. The timer stops when the vehicle is in challenge-ready configuration with pilots in place, and all assembly tools and implements properly stowed on the rover, or in the marked tool area adjacent to the assembly location. Point breakdown for assembly time is listed in section 8.

5.5.9 The MRR will be combined with the ERR for the first excursion.

5.5.10 RC vehicles must fit fully within a 2.5 ft. × 2.5 ft. × 2.5 ft. cube.

5.6 Excursion Readiness Review Guidelines

5.6.1 Teams must arrive on time and ready to participate in their ERR as scheduled. Failure to arrive on time or perform ERR as scheduled will result in a penalty to the team's overall score.

5.6.2 Judges will photograph each vehicle and conduct an inspection of safety requirements.

5.6.3 Communication plans between pilots may be discussed during ERR.

5.6.4 The ERR will be combined with the MRR for the first excursion.

6. REQUIREMENTS

6.1 Safety Requirements – Human Powered

- 6.1.1. Each rover shall have robust, practical seat restraints for each of the pilots. The restraints must be capable of preventing the pilots from being ejected from their seats should the vehicle be forced to a sudden stop. The preferred method of restraint is a 3-point motor vehicle seat belt. Seat restraints shall always be worn when the vehicle is being driven on or off the course. A vehicle will be stopped by an official or judge if either pilot is not secured by the seat restraint while the vehicle is in motion. Vehicles will be held in the stopped position until the required restraint(s) are firmly in place.
- 6.1.2. Each rover shall have at least one adequate mechanical braking system. Braking system(s) shall be able to hold the rover and accompanying pilots when placed in-line on a 30-degree incline. Braking system(s) can be cable, hydraulic, or other mechanical mechanism that applies or translates a braking force to the rotating member(s) of the rover. No use of hands or body can be used on the wheels and/or drive train to slow or stop the rover from motion during regular excursion activity.
- 6.1.3. Teams shall design to eliminate or guard against any sharp edges or, as necessary to ensure safety of the pilot's, participants and HERC Staff. Final evaluation will be made by the safety judge at the HERC event.
- 6.1.4. Team pilots shall always utilize appropriate PPE when on rover during event. Specific PPE is listed below:
 - 6.1.4.1. Eye protection, e.g., safety glasses, goggles, or face shield.
 - 6.1.4.2. Commercially manufactured head protection, e.g., bicycle helmet.
 - 6.1.4.3. Full-fingered gloves.
 - 6.1.4.4. Long-sleeved and long-torso shirts.
 - 6.1.4.5. Long pants (dangling pants shall be wrapped and/or taped down.)
 - 6.1.4.6. Long Socks.
 - 6.1.4.7. Enclosed shoes (shoelaces shall be wrapped and/or taped down).
 - 6.1.4.8. No apparatuses, such as stilts, may be used on the feet of the pilots.

6.2 Communication & Documentation Requirements

- 6.2.1. All verbal and written communication shall be in English (this includes communication with team members during DR and ORR presentations and office hours.) This is a potential safety issue during review presentation Q&A discussion.
- 6.2.2. Communication to the HERC Implementation team shall be through the team advisor and/or student team lead. All communication shall be sent via email to HERC@mail.nasa.gov. The subject line shall include the subject matter of the communication and school name (Subject Description – Your School's Name). Please be aware when replying to HERC emails. Parent and other email will be referred to the Team Advisor.

- 6.2.3. Teams shall establish a social media presence to inform the public about day-to-day team activities. Teams are encouraged to update their social media accounts weekly.
- 6.2.4. Accepted teams shall send all deliverables via Box links that will be sent to teams closer to the deadline specified in the handbook. All deliverables shall be in PDF format and meet the requirements outlined in this handbook. File name must follow the nomenclature *School Name_Year Deliverable Type*.
- 6.2.5. The DR and ORR reports shall follow format and outline guidance found in Deliverable Guidelines and Information, section 7.
- 6.2.6. The team must provide computer equipment necessary to perform a video-conference with the NASA scoring panel during DR and ORR presentations. This includes, but is not limited to, a computer system, video camera(s), speakers, and a stable wifi connection.
- 6.2.7. All deliverables must be submitted by deadlines to be considered for overall team awards.

6.3 Vehicle Requirements – Human Powered

- 6.3.1. Vehicles, inclusive of pilots, shall have a center of gravity low enough to safely handle slopes of 30 degrees front-to-back and side-to-side.
- 6.3.2. Vehicles shall be capable of turning radius of at most 10 ft.
- 6.3.3. The competition ready rover shall be no wider than five feet, with the GREATEST distance considered.
- 6.3.4. Rovers with pilots in position, shall have clearance greater than or equal to 12 inches between the ground and the lowest point of the pilot's appendage as shown in Figure 1.



Figure 1: Vehicle Height Requirement.

- 6.3.5. Teams shall design and fabricate non-pneumatic wheels, inclusive of the outer surface (treads) contacting the terrain and the supporting structure (rims, spokes, etc.) The only commercial wheel component that can be used as part of a team's wheels are wheel hubs containing bearings and/or bushings.
- 6.3.6. Vehicles shall be human powered. Energy storage devices, such as springs, flywheels, or batteries are not allowed to be used as part of the drive train.

6.4 Vehicle Requirements – Remote Controlled

- 6.4.1. Vehicles shall be battery powered. No use of flammable liquids is allowed.
- 6.4.2. Teams are allowed to use the control system from a commercial RC vehicle (controller, circuitry, radio components, etc.) Middle school/high school teams are also allowed to use a commercial chassis and drive system, however, wheels and tires must be designed and manufactured.

Failure to meet any of the requirements listed above may result in penalties including ineligibility for overall prizes or complete disqualification at the discretion of the HERC Implementation Team.

7. DELIVERABLES

7.1 Proposal

The purpose of the proposal is to demonstrate that the team has the knowledge, resources, and administrative support to participate in the HERC program effectively and completely. Emphasis is placed on a team's available facilities, financial and technical support from the educational institution and community, and the team's ability to plan and schedule appropriately for the commitment HERC demands. The designs in this section are expected to be conceptual sketches and ideas.

Student Team Lead shall submit the proposal on their team's behalf via email to HERC@mail.nasa.gov by the deadline specified in the handbook. Proposal File name must follow the nomenclature:

SchoolName_Year_Proposal.

At a minimum, the proposing team shall identify the following in a written proposal due by the date specified in the timeline:

Format

- Proposals must be submitted in a PDF format.
- Size 12 Times New Roman font or similar.
- 8.5 in. × 11 in. paper size with 1-in. margins.
- A cover page that includes:
 - The name of the middle school/high school, college/university, or institution along with full mailing address
 - Division: Middle School or High School or College/University, and HP (Human Powered) or RC
 - Date
 - Name, Title, and Email Address of:
 - The team advisor.
 - The student team lead.
 - The student safety officer.
 - List of participating student team members (inclusive of the Student Team Lead and Safety Officer) who will be committed to the project and their proposed duties.

Rubric

Percentages given are an estimate of the total weight out of 100% for each section.

- Introduction: 5%
- Facilities/Equipment: 40%
- Safety Plan: 15%
- Design: 10%
- Project Plan: 30%

Proposal Outline

Page Limit: Proposals will only be scored using the first 10 pages of the report (not including cover page and table of contents.) Any additional content will not be considered while scoring.

1. Facilities and Equipment

- 1.1. Description of the facilities, equipment, and supplies that are required to design and manufacture the vehicle components. Identify hours of accessibility, training, and necessary personnel that are required for any facilities.
- 1.2. Approximate number of student participants who will be committed to the project and their proposed duties. Identify the key managers and technical personnel.

2. Safety

- 2.1. Provide a written safety plan for addressing the safety of the materials and tools used, and the student responsible, i.e., safety officer, for ensuring that the plan is followed.
 - 2.1.1. This section is **NOT** a Hazards Analysis. This section is intended to address **HOW** your team will institute safety during your design, build, and operation.
- 2.2. Describe the plan for briefing students on hazard recognition and accident avoidance.
- 2.3. Describe methods to include necessary caution statements in plans, procedures, and other working documents (including the use of proper PPE.)

3. Technical Design

- 3.1. A basic design overview of rover concept and components.
- 3.2. Wheel design ideas and fabrication plans.
- 3.3. Drivetrain concept and design with fabrication plans.
- 3.4. Identify task sites the team plans to attempt and provide preliminary designs for associated task tool.
- 3.5. Address major technical challenges and possible solutions the team will face during the engineering design and manufacturing phase.

4. Project Plan

- 4.1. Provide a detailed development schedule/timeline covering all aspects necessary to meet all milestones and complete the project successfully.
- 4.2. Provide a budget to cover all aspects necessary to complete the project successfully, inclusive of team travel. The budget should include both materials and supplies the team already has on hand, and those the team will need to purchase.
- 4.3. Provide a funding plan including sources of funding and estimated (or confirmed) amounts.
- 4.4. Include any endorsements from school to include anticipated or awarded grants, awards, donations, etc.

5. STEM Engagement

- 5.1. Include plans and evaluation criteria for the required STEM Engagement activities.

The following criteria for the design review and operational readiness review apply to the Human Powered Division only. Remote Controlled Division DR and ORR requirements are listed in section 11.

7.2 Design Review (DR) – Human Powered

The purpose of the DR is to demonstrate that the overall design meets all requirements with acceptable risk, within the cost, schedule, and technical performance constraints, and establish the basis for proceeding with fabrication, assembly, and integration. It should show that the correct design options have been selected, and interfaces have been identified. Full baseline cost and schedules, as well as all risk assessment, management systems, and metrics, should be presented.

- The Design Review Report accounts for 20% of the overall score for the competition.
- The Design Review Presentation will be worth 10% of the total Design Review points.

Teams shall submit their Design Review Report and Design Review Presentation via Box link. Submit by the deadline specified in the handbook. Design Review file name must follow the nomenclature *School Name_Year_Design Review*.

Format

- Design Review must be submitted in a PDF format.
- Size 12 Times New Roman font or similar.
- 8.5 in. × 11 in. paper size with 1-in. margins.
- A cover page that includes:
 - The name of the middle school/high school, college/university, or institution along with full mailing address
 - Division: Middle School or High School or College/University
 - Date
 - Name, Title, and Email Address of:
 - The team advisor.
 - The student team lead.
 - The student safety officer.
 - List of participating student team members (inclusive of the Student Team Lead and Student Safety Officer) who will be committed to the project and their proposed duties.

DR Presentation: It is expected that the team participants deliver the report in a professional manner and answer all questions to their best ability. The advisor may attend but shall not deliver the presentation or answer any questions pertaining to the project other than when directed. The entire presentation will be delivered in English and translators will not be permitted.

- There is a 30-minute time-limit for presentation. A 15-minute feedback discussion will follow the presentation.
- The presentation should include an overview of each section of DR report.

Rubric

- Percentages given are an estimate of the total weight out of 100% for each section.
- Vehicle Criteria: 40%
- Performance Predictions: 5%
- Safety (PHA/FMEA): 20%
- Project Plan (Requirements, Timeline, Budget): 25%
- Presentation: 10%

Design Review Report Outline

Page Limit: DRs will only be scored using the first 30 pages of the report (not including cover page, abstract, and table of contents.) Any additional content will not be considered while scoring.

1. Table of Contents

2. Vehicle Criteria – Selection, Design, and Rational of Vehicle Design

- 2.1. Review the design at a system level (i.e., wheel design, drivetrain design, suspension), going through each system's alternative designs, and evaluating the pros and cons of each alternative.
- 2.2. For each alternative, briefly present research on why the alternative should not be chosen.
- 2.3. After evaluating all alternatives, present the chosen vehicle design.
- 2.4. Describe each subsystem and the components within those subsystems
- 2.5. Describe how the design meets size, weight, volume, assembly, and clearance constraints.
- 2.6. Provide dimensional drawings of the leading design.

3. Analysis of Design

- 3.1 Provide analysis of the rover and any subsystems demonstrating design sufficiency for expected obstacle performance requirements. Include any simulated vehicle data and/or calculations.

4. Safety

- 4.1 Provide a preliminary Personnel Hazard Analysis (PHA). This should include all phases of operation including construction/fabrication, testing, performance/competition.
- 4.2 Provide a preliminary Failure Modes and Effects Analysis (FMEA) of the proposed design of the vehicle and components.
- 4.3 The focus of the safety analyses at the design review is identification of hazards/failure modes, their causes, and resulting effects.
- 4.4 Preliminary mitigations and controls should be identified, but do not need to be implemented at this point unless they are specific to the construction of the vehicle or components. (i.e., cost, schedule, personnel availability.) Rank the risk of all hazards and failure modes for both likelihood and severity.

5. Project Plan

- 5.1 Requirements verification to demonstrate all requirements in section 6 of this handbook are being met.
- 5.2 Provide a timeline update to demonstrate that the team is on schedule to meet the requirements of this project. Include deliverable dates, and planned fabrication and testing.
- 5.3 Provide a budget update to demonstrate that the team is within budget. Include funding updates since proposal.

7.3 Operational Readiness Review (ORR) – Human Powered

The ORR examines construction, tests, demonstrations, and analyses to determine the overall rover and task tool readiness for a safe and successful excursion. The rover is expected to be complete and begin the testing phase. Performance data should be included validating the analyses from Design Review and that the team is ready to safely compete in the in-person competition.

- The Operational Readiness Review Report accounts for 20% of the overall score for the competition.
- The Operational Readiness Review Presentation will be worth 10% of the total ORR points.
- The ORR report and presentation should be given as a stand-alone deliverable. No information from the Design Review should be assumed as known by the scorers and panel participants. All relevant design information should be stated again.

Teams shall submit their ORR Report and ORR Presentation via Box link. Submit by the deadline specified in the handbook. Operational Readiness Review file name must follow the nomenclature *School Name_Year_Operational Readiness Review*.

Format:

- ORR Report must be submitted in a PDF format.
- Size 12 Times New Roman font or similar.
- 8.5 in. × 11 in. paper size with 1-in. margins.
- A cover page that includes:
 - The name of the middle school/high school, college/university, or institution along with full mailing address
 - Division: Middle School or High School or College/University
 - Date
 - Name, Title, and Email Address of:
 - The team advisor.
 - The student team lead.
 - The student safety officer.
 - List of participating student team members (inclusive of the Student Team Lead and Student Safety Officer) who will be committed to the project and their proposed duties.

ORR Presentation: It is expected that the team participants deliver the report in a professional manner and answer all questions to their best ability. The advisor may attend but shall not deliver the presentation or answer any questions pertaining to the project other than when directed. The entire presentation will be delivered in English and translators will not be permitted.

- There is a 30-minute time-limit for presentation. A 15-minute feedback discussion will follow the presentation.
- The presentation shall include an overview of each section of the ORR Report.

Rubric

Percentages given are an estimate of the total weight out of 100% for each section.

- Vehicle Criteria: 30%
- Performance Predictions: 20%
- Safety: 20%
- Project Plan (Requirements, Testing, Timeline, Budget): 20%
- Presentation: 10%

Operational Readiness Review Report Outline

Page Limit: ORRs will only be scored using the first 30 pages of the report (not including cover page, abstract, and table of contents). Any additional content will not be considered while scoring.

1. Table of Contents

2. Vehicle Criteria – Design and construction of the vehicle

- 2.1 Provide a final design summary of the as-built rover. Include dimensions, materials, and masses of major subsystems.
- 2.2 Describe any major changes to the rover from the Design Review and explain why those changes are necessary.
- 2.3 Prove that the vehicle is fully constructed and explain the construction process for major subsystems.
- 2.4 Include schematics and/or images of the completed rover.

3. Excursion Performance Predictions

- 3.1. Describe a strategy for optimizing points earned by your team's excursion performance on the course.
- 3.2. Estimate how long it will take to complete each obstacle to be included in your excursion strategy.
- 3.3. Explain how the rover will overcome each obstacle your team plans to attempt. This should include the physical aspect or parameter of each obstacle that is most important to complete it. Explain how your rover interfaces with those aspects or parameters.

- 3.4. Identify parts or subsystems of that rover that are most critical (i.e., greatest potential for failure). Provide data showing these systems will perform successfully under nominal conditions.
- 3.5. Include contingency planning. How and why might your rover team adjust your excursion strategy while on the course?

4. Safety

- 4.1. Update the Personnel Hazard Analysis and the Failure Modes and Effects Analysis to include:
 - 4.1.1. Finalized hazard descriptions, causes, and effects of the vehicle and mission components the team has built.
 - 4.1.2. A completed list of mitigations addressing the hazards and/or their causes.
 - 4.1.3. A completed list of verifications for the identified mitigations. This should include methods of verifying the mitigations and controls are (or will be) in place, and how they will serve to ensure mitigation.
- 4.2. Include a list of procedures and checklists for competition days.

5. Project Plan

- 5.1. Update the requirements verification plan demonstrating that all requirements from Section 6 in this handbook are met.
- 5.2. Discuss any remaining test plans. Estimate test dates.
- 5.3. Discuss the final budget and expense report.

7.4 STEM Engagement

- As part of the HERC competition, teams should engage a minimum of 250 participants in direct educational, hands-on science, technology, engineering and mathematics (STEM) activities. These activities can be conducted in-person or virtually. To be considered for scoring, all events shall occur between project acceptance and the STEM Engagement Report due date and must be submitted for each event via Box link by the due date. Content of the STEM engagement activities should be related to HERC activities (ex: mechanical design, vehicle infrastructure, physics, engineering design process, etc.)
- Teams must engage a minimum of 250 participants in Educational/Direct Engagement activities in order to be eligible for STEM Engagement scoring and awards. For a definition of what constitutes an Educational/Direct Engagement Activity see below. These definitions are also found in the STEM Engagement Report for reference.
- Teams are encouraged to engage as many other participants as possible in other types of STEM Engagement activities. Although they will not count for points, activities completed before or after the submission window are encouraged and can still be submitted.
- Engagement Activity Types
 - **Education/Direct Engagement** (minimum 250 participants required)
Instructional, hands-on activities where participants engage in learning a STEM related concept by actively participating in an activity. This includes instructor-led facilitation or inquiry around an activity regardless of media (e.g., face-to-face, video, conference, etc.)
Example: Students learn about basic rover challenges through designing and building their own

basic rover or students learn how to use CAD software to design the engineering parts. This type of interaction will count towards your requirement for the project/STEM Engagement Scoring.

- **Education/Indirect Engagement**

Participants are engaged in learning a STEM concept through instructor-led facilitation or presentation. *Example: Students learn about center of gravity and balance of weight forces in basic movement of objects through a presentation or lecture.*

- **Outreach/Direct Engagement**

Participants do not learn a STEM concept but are able to get hands-on exposure to STEM-related hardware. *Example: The team does a presentation for students about their HERC project by bringing their rover and components to the event then demonstrates their rover performance to the students.*

- **Outreach/Indirect Engagement**

Participants interact with the team in an informal setting.

Example: the team sets up a display at a local museum during science night. Students come by, talk to the team and learn about their project.

Teams shall submit their STEM Engagement Report via Box link. Submit by the deadline specified in the handbook. STEM engagement report file name must follow the nomenclature *School Name_Year_STEM Engagement*.

Format:

- STEM Engagement Report must be submitted in a PDF format.
- Report should follow the template on the following pages and include:
 - Size 12 Times New Roman font or similar.
 - 8.5 in. × 11 in. paper size with 1-in. margins.
 - A cover page that includes:
 - The name of the middle school/high school, college/university, or institution along with full mailing address.
 - Division: Middle School or High School or College/University
 - Date
 - Completed chart below for total of all participants:

Total number of events	Total number of participants	Total number in-person participants	Number of participants Preschool – 4 grade	Number of participants 5–8 grade	Number of participants 9–12 grade	Under graduates	Educators	Adult (non- educators)

STEM Engagement Report

The STEM Engagement report submitted should represent all engagement activities. The template can be found below. Your team's report should be fully completed and list all the event dates and information for each activity.

- The Engagement Activity Type must be correctly identified for the activity. The NASA Review Panel reserves the right to change the activity type if the activity is categorized incorrectly.
- Activity descriptions should be clear and thorough. Learning targets should be clear and specific.
- Include with your report examples of any documents, evaluations, surveys, questionnaires, handouts, videos or presentations, etc., used in your activity.
- If you hold multiple events using the same activity, include dates and numbers needed to represent the multiple events, but submit one description for the activity. For example, your team leads the same engineering design activity in six different classrooms of students.
- For numerous NASA STEM engagement ideas, educational resources, games, videos, and PowerPoint presentations; visit www.nasa.gov/stem. NASA educational resources can be searched and filtered by subject (e.g., space science, NASA history, technology, etc.) Below are several examples of Educator Guides that can be utilized for working with students. Many NASA STEM educational resources have Spanish versions as well.
 - [Landing Humans on the Moon Educator Guide](#)
 - [Aterrizaje de seres humanos en la Luna](#)
 - [Build, Launch, Recover Educator Guide](#)
 - [Construir, lanzar, recuperar](#)
 - [Deep Space Communications Educator Guide](#)
 - [Comunicaciones en el espacio profundo](#)
 - [Lunar Surface Exploration Educator Guide](#)
 - [Guia de exploracion de la superficie lunar](#)
 - [Beginning Engineering, Science, and Technology Educator Guides](#)
- Include a Table of Contents that lists each activity submitted in the STEM Engagement report.

STEM Engagement Report Outline

Please use this outline format for each activity conducted by your team.

Activity Title: _____

Type of Activity: _____

Choose from the four Types of Engagement Activities:

- Education/Direct Engagement
- Education/Indirect Engagement
- Outreach/Direct Engagement
- Outreach/Indirect Engagement

Learning target for the activity: Describe the learning target for this activity. What did you want your participants to learn from this activity? Be specific.

Describe your activity with this group: Please also submit any pictures, presentations, or documents which you would like to share.

Did you conduct an evaluation of your learning target? If so, what were the results? Please include a copy of your evaluation and a summary of your results.

Describe any feedback received from your participants about your activity overall: Please include any feedback forms or surveys that were used. Submit actual feedback from participants if able.

Event information: For each event that was held for this activity, please enter the information in a table with the following headings. Each participant for each event should only be counted once.

Event Date	Name of Group	In-person or Virtual	Number of participants Preschool – 4 grade	Number of participants 5 – 8 grade	Number of participants 9 – 12 grade	Under graduates	Educators	Adult (non-educators)

Please submit any pictures, presentations, or feedback documents which your team would like to share with activity.

8. POINTS BREAKDOWN AND ALLOCATION – HUMAN POWERED

Points Breakdown

Points Breakdown	Points	Weight (%)
DR	20	20%
ORR	20	20%
MRR	10	10%
OBSTACLES	40	40%
STEM ENGAGEMENT	10	10%
TOTAL POSSIBLE POINTS	100	100%

Mission Readiness Review

Item	Description	Possible Points	Summary of Points Breakdown
MRR Late Penalty	Teams arriving outside their time window for MRR, or not being ready for the MRR.	5-point penalty (-5 Points)	Penalty can be assessed once at MRR and will carry over in the MRR score for both excursions.
MRR Readiness Penalty	Teams not able to demonstrate the vehicle is ready to proceed to ERR, not being ready to compete.	5-point penalty (-5 Points)	Penalty can be assessed once at MRR and will carry over in the MRR score for both excursions.
Volume Constraint (This point total is carried over both excursions.)	Vehicle measured to fit inside 5 x 5 x 5-foot volume constraint.	3	3 points for success 0 points for failure
Weight (This point total is carried over both excursions.)	Vehicle will be weighed.	5	5 points for less than 130 lbs. 3 points for 131 – 170 lbs. 1 point for 171 – 210 lbs. 0 points for more than 210 lbs.
Unfolding/Assembly (This point total is carried over both excursions.)	Teams will be assessed on the amount of time it takes to unfold/assemble and ready the vehicle for course excursion.	2	2 points for 0:00 – 0:30 seconds 1 point for 0:31 – 1:00 minutes 0 points for more than 1:00 minutes

Excursion Readiness Review

Item	Description	Points	Summary of Points Breakdown
Late Penalty	Teams arriving outside their time window, not being ready for excursions.	5-point penalty (-5 Points)	Penalty can be assessed once per excursion for arriving outside their excursion window or not being ready to compete.
ERR Inspection	Teams will be inspected for safety requirements and task material requirements. Photos of Rover taken. The MRR will be combined with ERR for the first excursion.	N/A	See each task for point reference earned at ERR.
Post-Excursion Review	Inspection	N/A	See each task for point reference earned at PER.

* Detailed point breakdown included in each obstacle task description. (TS – Judged at Task Site; PER – Judged at Post-Excursion Review)

Challenge Obstacle

Obstacle	Description	Points	Points Breakdown
1	Undulating Terrain	3	3 points for successful completion 1 point for attempt 0 points for bypass/no attempt
2	Crater with Ejecta	3	3 points for successful completion 1 point for attempt 0 points for bypass/no attempt
3	Transverse Incline	4	4 points for successful completion 1 point for attempt 0 points for bypass/no attempt
4	High Butte	6	6 points for successful completion 1 point for attempt 0 points for bypass/no attempt
5	Large Ravine	4	4 points for successful completion 1 point for attempt 0 points for bypass/no attempt
6	Crevasses	5	5 points for successful completion 1 point for attempt 0 points for bypass/no attempt
7	Ice Geyser Slalom	4	4 points for successful completion 1 point for attempt 0 points for bypass/no attempt
8	Bouldering Rocks	4	4 points for successful completion 1 point for attempt 0 points for bypass/no attempt
9	Loose Regolith	4	4 points for successful completion 1 point for attempt 0 points for bypass/no attempt
10	Pea Gravel	3	3 points for successful completion 1 point for attempt 0 points for bypass/no attempt

* Detailed point breakdown included in each obstacle task description. (TS – Judged at Task Site; PER – Judged at Post-Excursion Review)

9. COURSE DESCRIPTIONS AND DESIGN

Note: All course obstacles and tasks outlined below are subject to change. Photos and drawings are provided for illustration purposes only and may or may not represent actual course design.

HERC 2025 Narrative

With the goal of permanent habitation of the moon, rovers will play a vital role in both exploring and conducting research on the lunar surface. Water will be the key to humans thriving on the moon, and NASA has many upcoming missions designed to locate the precious molecule. Rover-collected sample and measurement data will be used to help determine suitable sites for HLS crewed landings. Many view the moon as a proving ground for technology and strategies to be adopted for later missions to Mars and beyond, but humans will occupy our satellite for many years before any longer trips are attempted.

RC Mission

“You have been selected as part of the NASA Commercial Lunar Payload Services initiative to design, build, and pilot a remote-controlled vehicle to be launched on an upcoming mission. NASA has designated four core mission tasks, of which you will select two, to be performed by your rover. While Command and Control will be handled on Earth, some complex tasks may be automated to ensure success. Space is limited on the lunar lander, so be sure your vehicle fits the mission specifications.”

HP Mission

“The Lunar Terrain Vehicle (LTV) is an essential component of future Artemis missions, allowing astronauts to explore further than ever and to perform scientific tasks anywhere on the Lunar Surface. You are tasked to design, fabricate, and pilot a Human-Powered rover to demonstrate the critical role that each subsystem of a rover has on final performance. The lunar surface has been widely photographed and observed, but extremely narrowly explored by humans. To test the abilities of your design to perform on the lunar surface, 10 demanding obstacles have been prepared to mimic real challenges on the lunar surface. Artemis missions are bringing new technology to the moon, to include pressurized-cabin rovers and habitats, however; your mission will be on an open-air LTV and limited by the amount of time your life support systems can function. All mission activity will cease when your crew is out of oxygen, so plan accordingly.”

RC Tasks

All ROVR vehicles must have a cargo bay to hold a pre-defined sensor package that will be delivered into the vehicle before start. The cargo bay will have predetermined dimension requirements of 6 in. × 4 in. × 2 in. The module will contain HERC-provided sensors to detect any spikes in EMF or UV waves and will be tracked with an on-board microcontroller. This mirrors a current objective of lunar rovers from NASA's Commercial Lunar Payload Services (CLPS) initiative; to provide protection from cosmic rays using the Radiation Tolerant Computer (RadPC). Teams will have to design their rovers to accommodate this payload.

All tasks will be performed in the "potential HLS crewed landing site" located after Obstacle 7.

No rover instruments may be complete as-built off-the-shelf components.

TASK SITE A: Optical Spectrometry

Rovers will use an optical spectrometer to scan two samples and collect data to differentiate them. Spectrometry is essential to finding water on the lunar surface and has been used extensively on Mars rovers. While nearly all Artemis generation rovers use spectrometry, this task is inspired by the VIPER rover which carries 3 spectrometers and will be the first lunar rover to have headlights.

Samples will be liquids and will be located within a 4 × 4 ft. marked square. Two sets of samples will be accessible to scan:

The first pair will be a surface sample. Two 3.5 in. diameter tubes will be buried flush with the ground and the liquid samples will be within 1 in. of surface level.

The second pair of samples will be raised samples in clear glass containers at least 12 in. high and no thicker than 4 in. (excluding the glass). Team members are allowed to operate any light source they choose on the other side of the sample from the rover.

One of the sample containers will contain water.

Teams must determine, using data gathered by the spectrometer alone, which container has water.

TASK SITE B: Lunar Vacuum

Rovers will collect samples from two ground-sites using only vacuum force and store them with no cross-contamination. Option for mechanical or autonomous completion. This task is inspired by the Blue Ghost lunar lander which will deliver the Lunar PlanetVac (LPV) to the moon's surface.

Samples will be dyed sand in two separate piles within a 4 × 4 ft. marked square.

Sample piles will be no taller than 2 in.

Sample piles will be approximately 12 in.-diameter circles.

TASK SITE C: Terrain Mapping

Rovers will use an Infrared (IR) or laser rangefinder to determine the distances of two semi-distant objects. This task is inspired by the Lunar Trailblazer orbiter which will use various technologies to map the surface of the moon.

Sample objects will be between 5 and 20 ft. away.

Sample objects will be at least 2 ft. tall and 1 ft. wide.

Sample objects will not be polished or glossy surfaces.

TASK SITE D: Sample Drilling

Rovers will use a sample collection tool to collect and store two ground samples without cross contamination. Option for mechanical or autonomous completion. This task is inspired by the Polar Resources Ice Mining Experiment 1 (PRIME-1) mission which will give invaluable information on potential landing sites and resources for future Artemis missions.

Samples will be dyed sand in two separate piles within a 4x4ft marked square.

Sample piles will be between 2 – 4 in. deep.

Sample piles will be approximately 12 in. diameter circles.

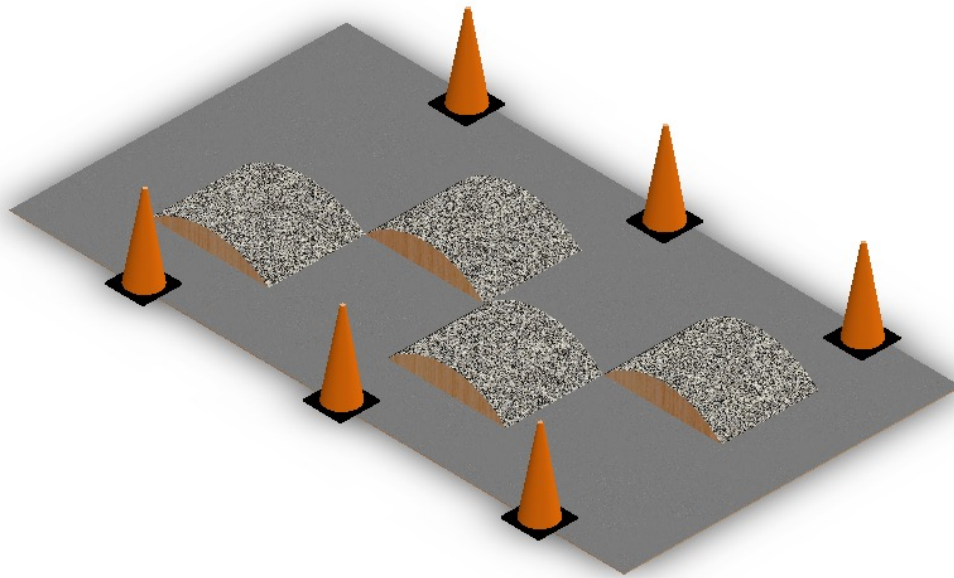
OBSTACLE**1****Undulating Terrain**

Figure 2. Obstacle 1—Undulating Terrain (3 Points)

This gently uneven surface is replicated by four wooden ramps located alternating pattern causing the rover to be tilted to the right or to the left as only the wheels on one side of the rover are elevated at a time. The ramps range from 6 – 12 in. in height with gradual ingress and egress slopes, all covered with gravel. The length of each ramp is around 5 ft. long and the width is around 4 ft. as shown in Figure 2.

OBSTACLE 2

Crater with Ejecta

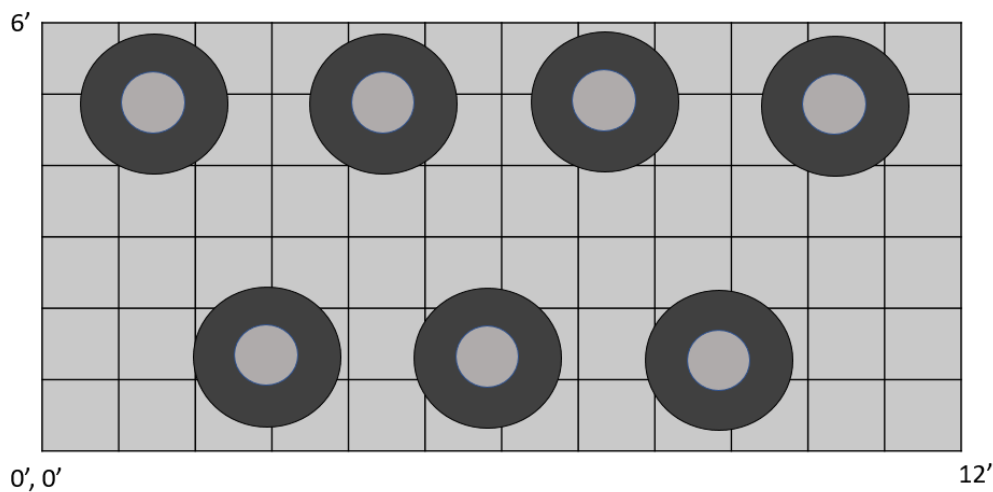


Figure 3. Obstacle 2—Crater with Ejecta (3 Points)

This large crater is about 2 ft. in diameter with a vertical height of 8 in. The craters are located offset from one another on opposite sides. The schematic in Figure 3 is for illustration purposes only and may or may not represent actual course design. Rays of ejecta, the material thrown out of the crater on impact, with the whole assembly is covered by gravel. The length of the obstacle is approximately 12 ft. and the width is around 6 ft. Straws are added to direct the rovers to traverse the large crater.

OBSTACLE 3

Transverse Incline

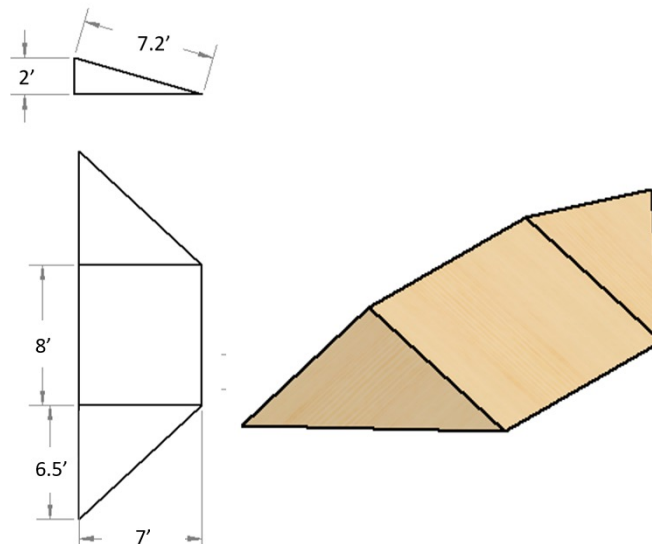


Figure 4. Obstacle 3—Transverse Incline (4 Points)

The slope of this obstacle is perpendicular to the direction of rover traverse. The simulated lava or rock outcropping surface is smooth, and the angle of elevation of the incline is about 20 degrees. The total length of the obstacle is 21 ft. as shown in Figure 4.

Obstacle will have a 1/3 scale version for the RC division.

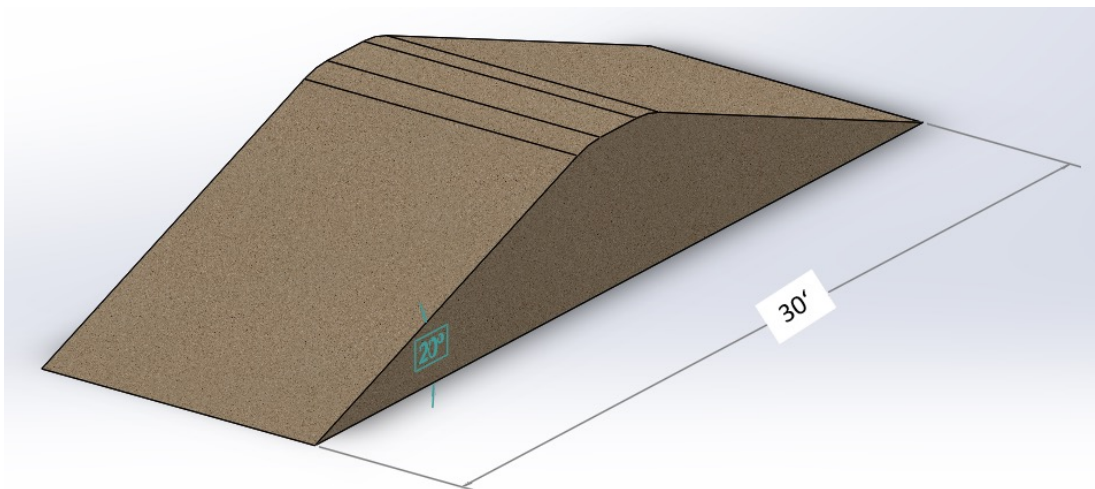
OBSTACLE
4**Martian Terrain High Butte**

Figure 5. Obstacle 4—Martian Terrain High Butte (6 Points)

This feature is a test of the rover's climbing ability. This butte is 5 ft. high with a 20-degree incline before and after the peak and with a flat surface of 2 ft. at the top. The butte is made from stone and soil. Figure 5 shows the dimensions of obstacle 4.

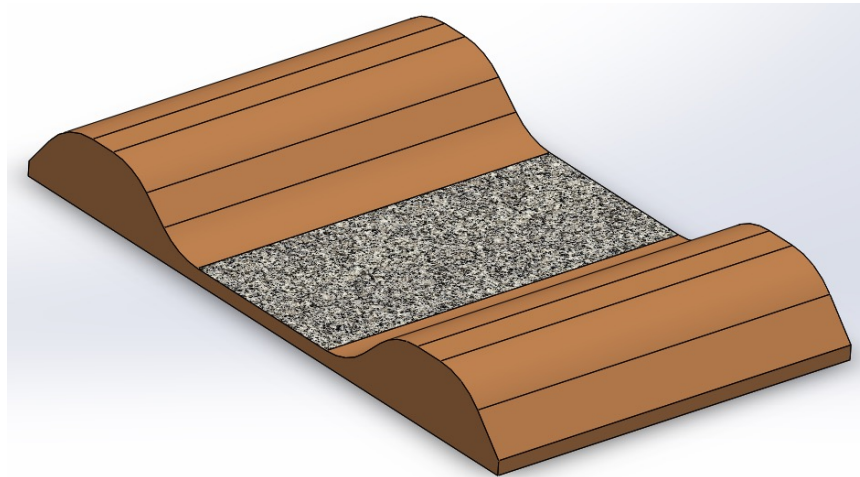
OBSTACLE
5**Large Ravine – Martian Terrain**

Figure 6. Obstacle 5 – Large Ravine – Martian Terrain (4 Points)

A remnant of an ancient erosion channel, this two-foot depression, about 8 ft. wide, provided a conduit for liquid runoff on the Martian surface. The bottom of the depression is filled from gravel to simulate the Martian surface.

OBSTACLE 6

Crevasses

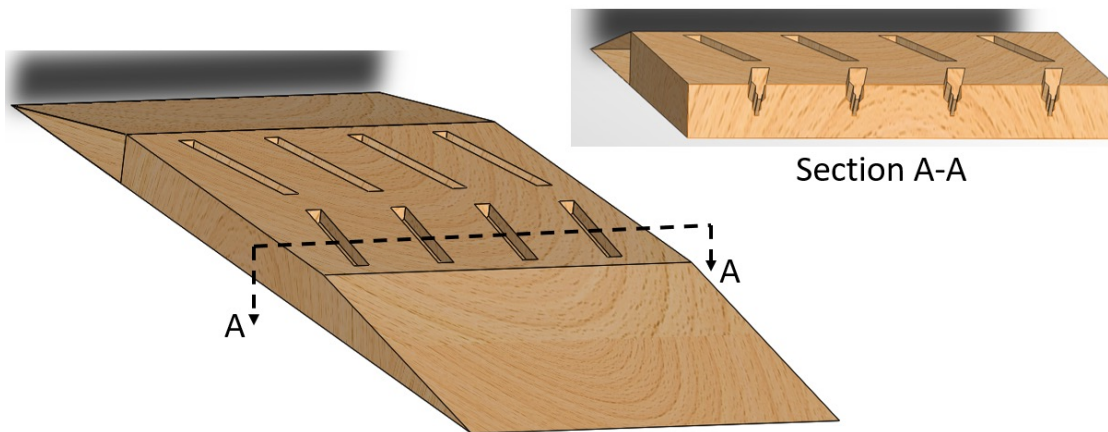


Figure 7. Obstacle 6—Crevasses (5 Points)

Crevasses result from cracks in the surface regolith or from erosion by liquid and/or molten material forming ruts in underlying material. There are four sets of parallel cracks located along with the direction of rover traverse. Each crevasse consists of multi-level cracks, and the depth of each crack varies between 4 – 7 in. and the width varies throughout between 1 – 4 in. as shown in Figure 9. The length of each set of cracks is around 4 ft. long and the total length of the obstacles is around 12 ft. Teams shall design the wheel of the rover to avoid having the rover wheels stuck in these cracks.

Obstacle will have a 1/3 scale version for the RC division.

OBSTACLE 7

Ice Geyser Slalom

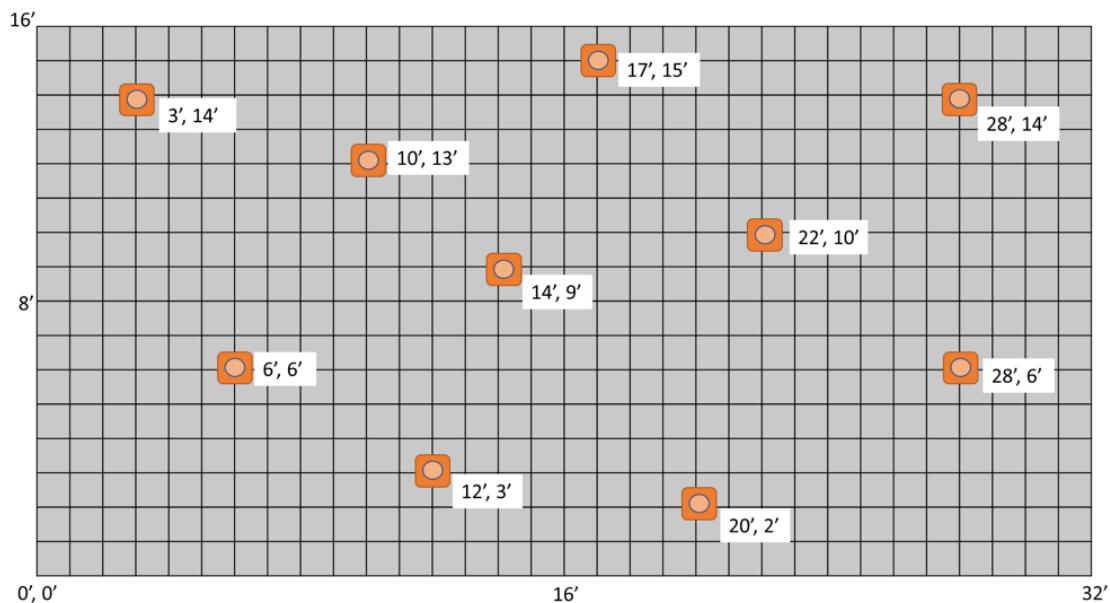


Figure 8. Obstacle 7—Ice Geyser Slalom (4 Points)

A series of simulated ice geysers impede the path. This obstacle requires that teams carefully navigate without encountering any of the geysers. The approximate places of the ice geysers and approximate total length and width of obstacles are shown in Figure 10. Steering systems will be of utmost importance to do this. There will be a marked exit lane through which rovers shall pass without touching its boundaries.

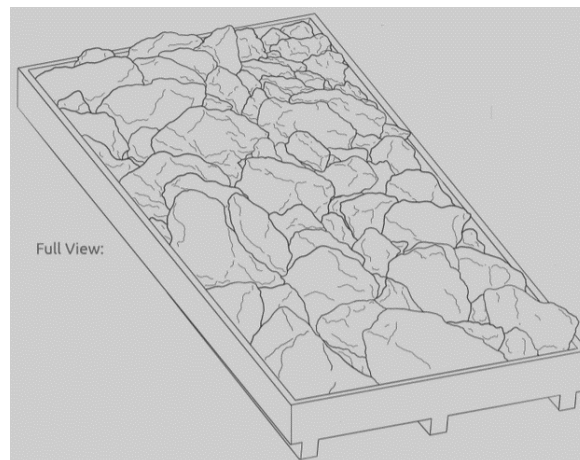
OBSTACLE
8**Bouldering Rocks**

Figure 9. Obstacle 8—Bouldering Rocks (4 Points)

Rovers shall navigate over this field of simulated asteroid debris (boulders) while not avoiding the debris. The asteroid fragments range in size from three to 12 in. and are situated close together. The total length of the obstacle is around 10 ft., and the width is around 6 ft. Proceed with caution.

OBSTACLE**9****Loose Regolith**

Figure 10. Obstacle 9—Loose Regolith (4 Points)

Meteoroid collisions with extraterrestrial surfaces produce fine-grain material, which is difficult to traverse. Beach sand (rounded grains) simulates this material, which allows wheel penetration. The depth of this simulant is 6 – 8 in. The total length of the obstacle is 10 ft. and the width is around 6 ft.

**OBSTACLE
10****Pea Gravel**

Figure 11. Obstacle 10—Pea Gravel (3 Points)

This ancient stream bed consists of fine rounded pebbles deposited to a depth of about 6 in. Rover wheels might sink in this smooth obstacle material. The total length of the obstacle is 10 ft. and the width is around 6 ft.

10. AWARDS

Award	Description of Award
Overall Winner	Awarded to the top overall team. Design reviews, educational STEM engagement, safety, and a successful excursion will all factor into the Overall Winner.
STEM Engagement	Awarded to the team that is determined to have best inspired the study of STEM-related topics in their community to include collaboration with middle school students for the Task Challenge. This team not only presented a high number of activities to a large number of people, but also delivered quality activities to a wide range of audiences.
Project Review	Awarded to the team that is deemed to have the best combination of written reviews and formal presentations.
Phoenix	Awarded to the team that demonstrates the greatest improvement between Design Review and Operational Readiness Review.
Social Media	Awarded to the team that has the most active and creative social media presence throughout the project year.
Task Challenge	Awarded to the team that best demonstrates a multi-tool design for the liquid sample retrieval tasks.
Featherweight	Awarded to the team that best addressed the ongoing space exploration challenge of weight management, delivering an innovative approach to safe minimization of rover weight. (Only awarded to one team overall.)
Ingenuity	Awarded to the team that approaches any complex project or engineering problem in unique and creative ways.
Pit Crew	Awarded to the team as judged by the pit crew that best demonstrates resourcefulness, motivation, good sportsmanship, and team spirit in repairing or working on their rover while the teams are in the pit area.
Safety	Awarded to the team that best demonstrates a comprehensive approach to system safety as it relates to their vehicle, personnel, and operations.
Team Spirit	Awarded to the team that is judged by their peers that display the “Best Team Spirit” during the on-site events.
Crash and Burn	Awarded to the team that embraces failure as a learning lesson for future success. (Only awarded to one team overall).
Rookie of the Year	Awarded to the top overall newcomer team. (Same judging criteria as overall award. If rookie team is awarded an overall award, the 2nd place standing rookie team will receive the award, and so forth. Only awarded to one team overall)
Pay It Forward Award	This Artemis Student Challenge (ASC) award is given to the team that best conducts impactful educational engagement events in their community or further. Educational engagement includes instructional, hands-on activities where participants engage in learning a STEM-related concept by actively participating in an activity. Each challenge activity lead will choose the top teams from each challenge for consideration of final awardees.
Innovation Award	This Artemis Student Challenge (ASC) award is given to teams that best create new, innovative ideas and/or solutions within the scope of their respective challenge. Ingenuity, creativity, and inventiveness in either technology or non-technology focused ideas are awarded for their original ideas, creating efficiency, effective results, and/or solving a problem. Each challenge activity lead will choose the top teams from each challenge for consideration of final awardees.
Artemis Educator Award	This Artemis Student Challenge (ASC) award is given to educators/faculty/mentors in each challenge as nominated by student team members. Student team members will recognize their faculty/mentor(s) who inspire learners and motivate them to work hard, achieving more than the team members thought possible. The award acknowledges the time and dedication educators/faculty/mentors take to be exceptional teachers. Educators/faculty/mentors are noted for their commitment to learning and their valuable efforts for motivating and inspiring others.
Other Awards	Other awards will be given based on components of the competition, such as discussions within Design Review and Operational Readiness Review reports or the in-person competition.

Note: Awards are given to a qualified team in each category (middle school, high school and college/university) unless otherwise noted. Awards are subject to change without notice

11. RC DIVISION DIFFERENCES

Mission Readiness Review

Item	Description	Possible Points	Summary of Points Breakdown
MRR Late Penalty	Teams arriving outside their time window for MRR, or not being ready for the MRR.	5-point penalty (-5 Points)	Penalty can be assessed once at MRR and will carry over in the MRR score for both excursions.
MRR Readiness Penalty	Teams not able to demonstrate the vehicle is ready to proceed to ERR, not being ready to compete.	5-point penalty (-5 Points)	Penalty can be assessed once at MRR and will carry over in the MRR score for both excursions.
Volume Constraint (This point total is carried over both excursions).	Vehicle measured to fit inside 2.5 x 2.5 x 2.5-ft. volume constraint.	5	5 points for success 0 points for failure
Weight (This point total is carried over both excursions).	Vehicle will be weighed.	5	5 points for less than 20 lbs. 3 points for 20 – 30 lbs. 1 point for 30 – 60 lbs. 0 points for more than 60 lbs.

All obstacles are worth 1 point for successful completion and 0 points for unsuccessful or bypassed obstacles.

Points Breakdown

Points Breakdown	Points	Weight %
DR	20	20%
ORR	20	20%
MRR	10	10%
OBSTACLES	10	10%
TASKS	30	30%
STEM ENGAGEMENT	10	10%
TOTAL POSSIBLE POINTS	100	100%

11.1 Design Review (DR) – RC

The purpose of the DR is to demonstrate that the overall design meets all requirements with acceptable risk, within the cost, schedule, and technical performance constraints, and establish the basis for proceeding with fabrication, assembly, and integration. It should show that the correct design options have been selected, and interfaces have been identified. Full baseline cost and schedules, as well as all risk assessment, management systems, and metrics, should be presented.

- The Design Review Report accounts for 20% of the overall score for the competition.
- The Design Review Presentation will be worth 10% of the total Design Review points.

Teams shall submit their Design Review Report and Design Review Presentation via Box link. Submit by the deadline specified in the handbook. Design Review file name must follow the nomenclature *School Name_Year_Design Review*.

Format:

- Design Review must be submitted in a PDF format.
- Size 12 Times New Roman font or similar.
- 8.5 in. x 11 in. paper size with 1-in. margins.
- A cover page that includes:
 - The name of the middle school/high school, college/university, or institution along with full mailing address.
 - Division: Middle School or High School or College/University
 - Date.
 - Name, Title, Email Address of:
 - The team advisor.
 - The student team lead.
 - The student safety officer.
 - List of participating student team members (inclusive of the Student Team Lead and Student Safety Officer) who will be committed to the project and their proposed duties.

DR Presentation: It is expected that the team participants deliver the report in a professional manner and answer all questions to their best ability. The advisor may attend but shall not deliver the presentation or answer any questions pertaining to the project other than when directed. The entire presentation will be delivered in English and translators will not be permitted.

- There is a 20-minute time-limit for presentation. A 10-minute feedback discussion will follow the presentation.
- The presentation should include an overview of each section of DR report.

Design Review Report Outline

Page Limit: RC DRs will only be scored using the first 20 pages of the report (not including cover page, abstract, and table of contents). Any additional content will not be considered while scoring.

1. Table of Contents**2. Vehicle/Instrumentation Criteria – Selection, Design, and Rational of Design**

- 2.1. Review the design at a system level (i.e., wheel design, drivetrain design, suspension), going through each system's alternative designs, and evaluating the pros and cons of each alternative.
- 2.2. For each alternative, briefly present research on why the alternative should not be chosen.
- 2.3. After evaluating all alternatives, present the chosen vehicle/tool design.
- 2.4. Describe each subsystem and the components within those subsystems
- 2.5. Describe how the design meets size, weight, volume, assembly, and clearance constraints.

- 2.6. Provide dimensional drawings of the leading design.
- 2.7. Provide top level schematic diagrams for instrumentation electronics.

3. Analysis of Design

- 3.1 Provide analysis of the rover and any subsystems demonstrating design sufficiency for expected obstacle performance requirements. Include any simulated vehicle data and/or calculations.

4. Safety

- 4.1 Provide a preliminary Failure Modes and Effects Analysis (FMEA) of the proposed design of the vehicle and components.
- 4.2 The focus of the safety analyses at the design review is identification of hazards/failure modes, their causes, and resulting effects.
- 4.3 Preliminary mitigations and controls should be identified, but do not need to be implemented at this point unless they are specific to the construction of the vehicle or components. (i.e., cost, schedule, personnel availability). Rank the risk of all hazards and failure modes for both likelihood and severity.

5. Project Plan

- 5.1 Requirements verification to demonstrate all applicable requirements in section 6 of this handbook are being met.
- 5.2 Provide a timeline update to demonstrate that the team is on schedule to meet the requirements of this project. Include deliverable dates, and planned fabrication and testing.
- 5.3 Provide a budget update to demonstrate that the team is within budget. Include funding updates since proposal.

11.2 OPERATIONAL READINESS REVIEW (ORR) – RC

The ORR examines construction, tests, demonstrations, and analyses to determine the overall rover and task tool readiness for a safe and successful excursion. The rover is expected to be complete and begin the testing phase. Performance data should be included validating the analyses from Design Review and that the team is ready to safely compete in the in-person competition.

- The Operational Readiness Review Report accounts for 20% of the overall score for the competition.
- The Operational Readiness Review Presentation will be worth 10% of the total ORR points.
- The ORR report and presentation should be given as a stand-alone deliverable. No information from the Design Review should be assumed as known by the scorers and panel participants. All relevant design information should be stated again.

Teams shall submit their ORR Report and ORR Presentation via Box link. Submit by the deadline specified in the handbook. Operational Readiness Review file name must follow the nomenclature *School Name_Year_Operational Readiness Review*.

Format:

- ORR Report must be submitted in a PDF format.
- Size 12 Times New Roman font or similar.
- 8.5 in. x 11 in. paper size with 1-inch margins.

- A cover page that includes:
 - The name of the middle school/high school, college/university, or institution along with full mailing address.
 - Division: Middle School or High School or College/University
 - Date.
 - Name, Title, Email Address of:
 - The team advisor.
 - The student team lead.
 - The student safety officer.
 - List of participating student team members (inclusive of the Student Team Lead and Student Safety Officer) who will be committed to the project and their proposed duties.

ORR Presentation: It is expected that the team participants deliver the report in a professional manner and answer all questions to their best ability. The advisor may attend but shall not deliver the presentation or answer any questions pertaining to the project other than when directed. The entire presentation will be delivered in English and translators will not be permitted.

- There is a 30-minute time-limit for presentation. A 15-minute feedback discussion will follow the presentation.
- The presentation shall include an overview of each section of the ORR Report.

Operational Readiness Review Report Outline

Page Limit: RC ORRs will only be scored using the first 20 pages of the report (not including cover page, abstract, and table of contents). Any additional content will not be considered while scoring.

1. Table of Contents

2. Vehicle Criteria – Design and construction of the vehicle

- 2.1 Provide a final design summary of the as-built rover and instrumentation. Include dimensions, materials, and masses of major subsystems.
- 2.2 Describe any major changes to the rover from the Design Review and explain why those changes are necessary.
- 2.3 Prove that the vehicle is fully constructed and explain the construction process for major subsystems.
- 2.4 Include schematics and/or images of the completed rover.

3. Excursion Performance Predictions

- 3.1. Describe a strategy for optimizing points earned by your team's excursion performance on the course.
- 3.2. Estimate how long it will take to complete each task and obstacle to be included in your excursion strategy.
- 3.3. Explain how the rover will overcome each obstacle your team plans to attempt. This should include

the physical aspect or parameter of each obstacle that is most important to complete it. Explain how your rover interfaces with those aspects or parameters.

- 3.4. Identify parts or subsystems of that rover that are most critical (i.e., greatest potential for failure). Provide data showing these systems will perform successfully under nominal conditions.
- 3.5. Include contingency planning. How and why might your rover team adjust your excursion strategy while on the course?

4. Safety

- 4.1. Update Failure Modes and Effects Analysis to include:
 - 4.1.1. Finalized hazard descriptions, causes, and effects of the vehicle and mission components the team has built.
 - 4.1.2. A completed list of mitigations addressing the hazards and/or their causes.
 - 4.1.3. A completed list of verifications for the identified mitigations. This should include methods of verifying the mitigations and controls are (or will be) in place, and how they will serve to ensure mitigation.
- 4.2. Include a list of procedures and checklists for competition days.

5. Project Plan

- 5.1. Update the requirements verification plan demonstrating that all applicable requirements from Section 6 in this handbook are met.
- 5.2. Discuss any remaining test plans. Estimate test dates.
- 5.3. Discuss the final budget and expense report.

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