



2019 GUIDEBOOK



Note:

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Table of Contents

Timeline	1
Acronym Dictionary and Definitions	2

General Information

1. International Teams Information.....	3
2. Registration and Required Documentation	5
3. Mission Operations Rules and Requirements	6
4. Mission Readiness Review (MRR)	6

Safety

5. Excursion Readiness Review (ERR)	8
6. Safety	8

Competition Requirements

7. Course Information and Rules	9
8. Post-Excursion Review (PER)	10
9. Vehicle Rules	11
10. Crew Rules.....	12
11. Task Rules.....	12
12. General Information Rules	13
13. Point Breakdown	14
14. Obstacle and Task Descriptions	17
15. Pit Crew Description.....	34

Related Documents

Awards	35
STEM Engagement Form	46
Returning Vehicle Report and Verification	48
Media Release Forms	50

Timeline

Thurs., Oct. 11, 2018	Registration open dates for U.S. Teams
Fri., Jan, 17, 2019	Registration closes for U.S. Teams
Fri., Feb. 15, 2019	Student Data Feedback and Media Release Forms due for all teams. Final list of team members must be complete. Vehicle reuse report due to MSFC-RoverChallenge2019@mail.nasa.gov .
Fri., March 8, 2019	Team photos are due to MSFC-RoverChallenge2019@mail.nasa.gov .
Fri., March 29, 2019	Photos of completed Rover for verification of readiness are due to MSFC-RoverChallenge2019@mail.nasa.gov .
Thurs., April 11, 2019	All teams must arrive in Huntsville, Alabama, at the USSRC by 3:00 p.m. 12:00 – 4:00 p.m.: Team check-In 4:00 – 4:45 p.m.: Teams walk the course 5:00 – 6:00 p.m.: MANDATORY Safety Meeting
Fri., April 12, 2019	HERC Competition Day 1 Events: 7:00 a.m. – 4:00 p.m.: Rover excursion readiness check 11:00 a.m. – 1:00 p.m.: Lunch provided for teams in AstroTrek building 3:30 p.m.: Gates close for Day 1 excursion 4:00 p.m.: All surveys due (online or paper copy) to be eligible to compete on Day 2.
Sat., April 13, 2019	HERC Competition Day 2 Events: 7:00 a.m.: Rover Challenge continues 11:00 a.m. – 1:00 p.m.: Lunch provided for teams in the AstroTrek building 3:30 p.m.: Gates close for Day 2 excursion 5:00 – 7:00 p.m.: Awards ceremony in the Marriott Ballroom 7:00 p.m. – until: Rover dismantling and packing

Acronym Dictionary and Definitions

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 tasks. These assembly tools may be left in the designated tool area as part of the timed assembly process.

Excursion Readiness Review (ERR): The ERR events occur both days prior to course excursion and include safety, flag, and task material inspection.

HEO: Human Exploration and Operations

HERC: Human Exploration Rover Challenge

kg: Kilograms

Mission Readiness Review (MRR): The MRR events occur on Day 1 of the competition. All teams must complete the MRR event to be eligible for awards. This includes the volume constraint, weighing the vehicle and unfolding/assembling the vehicle.

mL: milliliter

NASA: National Aeronautics and Space Administration

Post-Excursion Review (PER): The PER occurs after course completion and includes ask completion inspection.

STEM: Science, Technology, Engineering and Mathematics

Task Materials: Task materials include all equipment needed for completing the tasks on the course. This may include items such as cameras, instrument deployment equipment, collection tools, storage containers, etc. These materials are allowed for use only at task areas.

TS: Task Site

USSRC: United States Space & Rocket Center

International Teams Information

Timeline:

Thurs., Oct. 11, 2018	Registration opens for international teams
Fri., Dec. 13, 2018	Registration closes for international teams
Fri., March 8, 2019	Deadline for cancelling with refund to international teams. (No cancellations will be refunded after this date.)

1. Registration and Required Documentation

- 1.1 International teams may register only four teams per country. The automated registration process will not allow additional registrants.
- 1.2 A registration fee is required for all international teams in an effort to reconcile increasing Rover International teams will be charged a registration fee of \$225.00 (U.S. dollars) per team which includes a nonrefundable \$150.00 handling fee per team. Upon check-in at the challenge \$75 of the fee will be reimbursed with proper paperwork submission. Teams that cancel their registration by the registration deadline of March 8, 2019 will be reimbursed. The registration fee WILL NOT be reimbursed to teams that do not cancel their registration by March 8, 2019. Payment instructions will be provided in the registration confirmation notice. Your registration is not confirmed until the \$225 registration/handling fee is paid.

1.3 Jesco von Puttkamer International Team Award

Jesco von Puttkamer Awards	One High School and One College	Optional for International Teams (submission due March 8)
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The Jesco von Puttkamer International Team Award will be awarded to the international (non-U.S.) high school or college/university teams with the highest score competing in the NASA Human Exploration Rover Challenge.

Description:

Beginning in 2007, Professor Dr. Jesco von Puttkamer was instrumental in encouraging international participation in NASA's Great Moonbuggy Race, now renamed the NASA Human Exploration Rover Challenge. He successfully initiated the International Team Award in 2009. After his death in 2012, friends and colleagues founded the Jesco von Puttkamer Society to keep his spirit alive. It is in memory of this ingenious engineer, author and visionary that the Jesco von Puttkamer Society provides the Jesco von Puttkamer International Team Award.

Rules:

1. At check-in, a written report will be submitted that includes a description of the transportation method used, copies of bills or tickets received for method of transportation and a photograph of the transportation box(es), container and/or vehicle.
2. The report can be no longer than two typed, double-spaced pages. It must include the name of the school and the name and phone number of the primary point of contact.

Criteria for Judging:

The award will be presented to the international team that earns the highest cumulative score during the NASA Human Exploration Rover Challenge.

Contact:

Jesco von Puttkamer Society, MSFC-RoverChallenge2019@mail.nasa.gov

NASA Human Exploration Rover Challenge Website: www.nasa.gov/roverchallenge

Challenge Dates for High Schools and Colleges: Fri. and Sat., April 12-13, 2019

Challenge Location: U.S. Space & Rocket Center
1 Tranquility Base
Huntsville, AL 35805

Shipping and Facility Information

All rovers may be shipped to the following address:
The U.S. Space & Rocket Center
Attn: Warehouse Manager
1 Tranquility Drive
Huntsville, AL 35805

The U.S. Space & Rocket Center will not receive any rovers that do not have pre-paid shipping documents with their rover shipment. All rovers must be crated by the team for return shipping pickup. The U.S. Space & Rocket Center does not provide a facility, tools or equipment for assembling or disassembling rovers and/or crates.

2. Registration and Required Documentation

Registration Dates: U.S. Teams: Oct. 11, 2018 – Jan. 17, 2019

- 2.1 Registration for the Human Exploration Rover Challenge is automated and electronically monitored. All teams must register via the site provided.
- 2.2 Entries will be accepted for up to two rovers/teams per school or institution. (Exception: international teams may register only one rover per school or institution). The automated registration process will not allow additional registrants. However, if more teams register for the challenge than can be accommodated in a given day of competition, schools or institutions with more than one rover must choose only one rover to compete.
- 2.3 Each team must fill out a registration form. All information must be completed for the registration to be considered valid.
- 2.4 All teams are required to submit the Student Data Feedback and Media Release forms no later than Feb. 16, 2019. Teams must have a finalized list of team members by this date. The Student Data Feedback form can be found online where registration information is located. The Media Release forms will be sent to all registered teams to complete.
- 2.5 Student teams are expected to design, construct and test their own rovers. Vehicles not constructed by the entering team are NOT acceptable. A rover may be used in more than one Rover Challenge; however, the reuse of the rover requires a minimum of 50 percent of the combined total structure and systems (content) to have been modified or replaced. Any team entering a vehicle that has been registered previously and attempted the course is required to have a minimum of 50 percent new content to compete in the current year. Rovers found to have been used in the Rover Challenge previously without substantial change will be

disqualified. The Returning/Reused Vehicle Report and Certification must be submitted to MSFC-RoverChallenge2019@mail.nasa.gov no later than Feb. 15, 2019.

- 2.6 Team photos should be emailed to MSFC-RoverChallenge2019@mail.nasa.gov by March 8, 2019. Team photos will be displayed at the challenge. For the best resolution, photos should be a minimum 1024 x 768 pixels in a JPEG format.
- 2.7 All teams must submit photos (front, side and back) of the finished/completed rover by Fri., March 29, 2019, to be eligible to participate in the challenge. This new requirement helps to ensure team readiness for the competition and assists in determining the reusable rover rules. The photo must be of the entire rover and must be clear for judges to see any changes. Multiple photos may be submitted. These photos should be emailed to MSFC-RoverChallenge2019@mail.nasa.gov.
- 2.8 The Technology Challenge is a required component of the 2019 competition. Rules and specifications of the challenge is located at requirement 8.2.
- 2.9 Additional awards that are required or optional are located in the related documents section. Awards are subject to change based on sponsor discretion.
- 2.10 Any team not providing the proper paperwork by the deadlines may be disqualified.

3. Mission Operations Rules and Requirements

- 3.1 Teams will have an assigned Mission Readiness Review (MRR) (Day 1 only) and excursion window (both days). Teams are required to participate in these activities during their assigned time window. Excursion order and time window will be communicated to teams no later than March 20, 2019. Teams arriving late to their time window or having arrived on time but not being ready to participate when called will result in a 5-point penalty for that day. Making changes to the vehicle before the first excursion will incur a 5-point penalty. This will be assessed between the time a rover finishes MRR and the start of their excursion.
- 3.2 Each team is expected to submit their participation survey by the end of Day 1. A team will not be allowed to start their Day 2 excursion until they have completed their participation survey. A team that is late to start their Day 2 excursion as a result of late participation survey submission will incur the 5-point late penalty for that day. There is a maximum of one late start penalty per team, per day.

4. Mission Readiness Review: All MRR activities occur only on Day 1 of the event.

- 4.1 All MRR activities must be completed on the first day of the competition. Teams that do not participate in these activities will not be eligible for awards. MRR activities include the volume constraint, weighing the vehicle, unfolding/assembling and measuring the size constraint. See items 4.2 - 4.5.
- 4.2 Volume Constraint: The vehicle will be tested for the 5 x 5 x 5-foot volume constraint (a cubical space that is 5 feet wide on each side) in the collapsed condition. Judging is conducted prior to the first excursion on the course. Once the team declares they are ready for the test, no modifications are allowed until the test is complete. A frame of this dimension will be placed over the collapsed vehicle for verification. No contact with the vehicle by the team is permitted while it is being measured. Tape, straps or other devices can be used to hold the rover together in the collapsed configuration; however, all such devices must be part of what is included in weighing the vehicle. Teams may or may not include task materials (i.e., instrument panel, tools for collecting samples, storage containers and camera) in the vehicle volume requirement. Teams will receive 4 points for fitting in the volume constraint or 0 points for being outside the volume constraint.

- 4.3 Weight: The vehicle will be weighed in the collapsed condition with all components needed for the mission. All task materials must be included when weighing the vehicle.
- 4.3.1 Vehicles that weigh less than 130 pounds receive 5 points.
 - 4.3.2 Vehicles that weigh 131 to 170 pounds receive 3 points.
 - 4.3.3 Vehicles that weigh 171 to 210 pounds receive 1 point.
 - 4.3.4 Vehicles weighing more than 210 pounds receive 0 points.



- 4.4 Unfold/Assembly: A signal is given to the two rover drivers to unfold/assemble their vehicle, and the clock is started. The clock stops when the vehicle is completely assembled; all assembly tools and implements are placed in a designated area and both team members are seated in the rover with seat belts fastened and hands up. Any component not part of the rover used for traversing the course must be left in the tool area before the assembly is considered to be complete. The tool area is a rectangular area marked with duct tape that is next to the assembly judging location. The rover drivers must have their helmets on, seat belts attached and feet on the pedals in a start-ready position. All task materials must be attached to the vehicle. Additional work is NOT allowed on the vehicle before the first excursion, nor can additional task materials be added to the vehicle. Making changes to the vehicle before the first excursion will incur a 5-point penalty (see 2.1). Teams with a complete/assembled vehicle within two minutes receive 2 points. Teams with a complete/assembled vehicle from 2:01 to 4:00 minutes receive 1 point. Teams requiring longer than four minutes receive 0 points.
- 4.5 Size Constraint: Assembled vehicles must be no wider than 5 feet (1.524 meters), as measured from the outside of a wheel to the outside of the wheel on the opposite side. There are no constraints for height and length of the assembled vehicle; however, a rover considered at serious risk of tipping over on the course may be considered unsafe and not allowed to

compete. All parts of the vehicle, including the seat, steering controls and pedals turned to their lowest position, with which the rover drivers have normal contact must be designed such that their lowest surface must be at least 15 inches (38.1 centimeters) above the ground when the vehicle is assembled on a level surface and with riders aboard. Any rover with a wheel base broader than 5 feet or with less than a 15-inch clearance is not eligible for competition prizes.

5. Excursion Readiness Review (ERR): The vehicle is inspected for ERR and Safety requirements (U.S., national or institutional flag, and task materials).

- 5.1 A U.S., national or institutional flag must be visible from the front, the side or the rear. This flag may be used in Task 4 should the team choose to complete this task. Vehicles with these requirements will receive 1 point for the flag.
- 5.2 All task materials will be inspected prior to excursion. Task materials must be unique to each rover and have the team number marked on each item. Task materials may not be shared with other teams including those from the same institution.

6. Safety: The vehicle is inspected for safety for the following requirements. Any requirement not met may result in disqualification.

- 6.1 Appropriate personal protective equipment and clothing are required when performing construction activities, such as welding, handling metal components and using tools anywhere on the U.S. Space & Rocket Center property or neighboring areas. A team performing work using unsafe conditions will be stopped and is subject to disqualification.
- 6.2 Seat Restraints: Each rover must have seat restraints for each of the two rover drivers. **Failing to provide robust, practical seat restraints can result in not being allowed to compete on the course.** The restraints must be worn at all times when the vehicle is moving on or off the course. A vehicle can be stopped by an official or judge if either passenger is not secured by a seat restraint and held stopped until the required restraint or restraints are firmly in place, except when rover drivers are freeing their rover from being stuck on an obstacle or performing a task where exiting the vehicle is necessary. The restraints must be capable of preventing the riders from being thrown from their seats should the vehicle be forced to a sudden stop. **The preferred method of restraint is a motor vehicle seat belt.** If the safety judge determines the restraints are inadequate to perform that function, the team will not be allowed to compete on the course until modifications or substitutions are made to the satisfaction of the safety judge.
- 6.3 Vehicle Dynamics: For safety reasons, it is recommended that the center of gravity of the vehicle plus rover drivers be low enough to safely handle slopes of 30 degrees front-to-back and side-to-side. Any vehicle exhibiting handling characteristics or other vehicle dynamics that are deemed unsafe or unstable by the judges will be disqualified from the competition and not allowed to compete on the course. This determination will be made by inspection of the assembled vehicle prior to traversing the course. Vehicles that are judged to have become unsafe while traversing the course can be disqualified from that attempt and removed from the course.

- 6.4 Protrusions: All sharp edges and protrusions must be eliminated (i.e., padded) or guarded, as necessary, to the satisfaction of the safety judge. No appendages, such as stilts, may be used on the feet of the drivers.
- 6.5 Passenger Attire: Specific personal protective equipment is required prior to any team being allowed to compete on the course. Eye protection (e.g., safety glasses, goggles or face shield), commercially manufactured head protection (a bicycle helmet), full fingered gloves, long-sleeved and long-torso shirts, long pants and socks must be worn during operation of the vehicle. Shoes are required. Shoelaces and dangling pants legs should be wrapped or taped down. **NOTE:** All drivers must wear a helmet the entire time they are racing. There are no exceptions. Homemade protective headgear is strictly prohibited.
- 6.6 Injury and Signals: Rover drivers who are injured, bleeding, or incapacitated must be removed from that attempt to receive medical attention. Injuries can occur in adjusting vehicle components, such as a chain, while on the course. Each team will be required to develop a signal system between the two drivers to ensure hands are clear before proceeding. Rover drivers will be asked to describe their communication plan to the Marshall Safety Action Team, or MSAT, member and/or the Starter before the excursion.
- 6.7 Individuals (team members and supporters) may NOT follow the vehicle around the course during an excursion. We suggest teams post their members at locations along the route, if desired. *Course judges have the authority to disqualify any team that violates this rule.*

7. Course Information and Rules

- 7.1 Two excursions of the course are permitted. The rover drivers for the first excursion must be the same who unfold/assemble the rover before the first excursion at the MRR area. Substitutes from the rover team may be made for either or both drivers for the second excursion of the course.
- 7.2 Teams not able to make the first excursion or otherwise disqualified from the first excursion of the course may make the second excursion of the course, provided they have successfully completed the MRR requirements.
- 7.3 Teams may not begin their excursions in the exact order of their team numbers. The intent is to follow the order of the assigned team numbers and their windows. However, competition readiness by the teams will determine the ultimate order in which they begin.
- 7.4 The course comprises 14 obstacles and five tasks. Nine of the obstacles have bypasses, where teams can choose to attempt the obstacle for points or bypass it for 0 points. Teams should be strategic in choosing the obstacles and tasks to complete to maximize point value.

- 7.5 Teams have a total of seven minutes to complete the mission. The first six minutes of the mission uses primary oxygen and the final minute uses reserve oxygen. During the first six minutes, teams are able to accumulate points by traversing obstacles and completing tasks. Teams on the course after six minutes will be notified that their excursion is aborted, that they must proceed with all haste to the end and can no longer accrue additional points. Teams on the course after six minutes must use all bypasses to return to home base. The team must return to home base in seven minutes or less to be eligible for competition prizes. The event clock stops when the rover crosses the finish line.

Note: Although judges will make team members aware of their course time periodically, teams are encouraged to have timing devices on their vehicle. A team's timing device will not be used for the official time. The judging officials will maintain the official time used on the course.

- 7.6 Both Rover drivers must be on the rover prior to the obstacle to be considered attempting the obstacle. Teams not on the vehicle (pushing, pulling) will receive 0 points for the obstacle. Teams attempting an obstacle but not successfully completing it will earn no more than 1 point for that obstacle. A team that does not directly approach the obstacle, gets off the rover or veers off is considered having an unsuccessful attempt. A successful completion refers to a team that approaches the obstacle straight on, completes the entire obstacle without touching the ground and finishes without veering off the obstacle. Exception: If the obstacle is associated with a task, the task requires the driver to get off the rover (Tasks 2 & 4) and the team attempts the task, teams will not be penalized for an unsuccessful attempt.
- 7.7 Judges have the authority to remove a disabled vehicle from the course when they feel it will affect the course time of the next successive vehicle. The course time for the disabled vehicle ends at this point. Failure to yield to the judge's request will result in disqualification of the rover for the challenge.

8. Post-Excursion Review (PER): The vehicle is inspected for final condition.

- 8.1 Teams may use the U.S., national or institutional flag for Task 4; therefore, this item is not required for final condition.
- 8.2 Teams conducting one or more tasks will demonstrate task collections and completions for judging. For example, if the team collected soil samples in Task 1, the judge will inspect for the number of samples collected for cross-contamination, and to see if samples were put in proper storage. See the point breakdown for each task for clarification.
- 8.3 The team with the highest number of points in each category (high school and college) will be the winner. In the case of a tie, the team with the fastest excursion completion time will be the winner.

9. Vehicle Rules

- 9.1 Propulsion System: Rovers must be human-powered. Energy storage devices, such as springs, flywheels, batteries or others are not allowed.
- 9.2 Rover performance: Teams should expect their rover to be capable of traversing hills up to 5 feet (~1.5 meter) high and pathways inclined up to 30 degrees in their direction of travel and transverse to the direction of travel. Wheels and drivetrains should be designed for both speed and the ability to perform on the difficult terrain. A 15-foot or less turning radius is also necessary.
- 9.3 We encourage you to avoid using bike chains, which have proven to be inadequate in past races.
- 9.4 Each team is required to compete for the Technology Challenge Award. The 2019 Technology Challenge Award Competition will concentrate on wheel design and fabrication. Rover wheels will encounter hard and regolith-like surfaces. Soft surfaces may include sand and small pebbles. Hard surfaces may include simulated rock outcroppings, fissures or cracks up to 5 inches (~13 cm) wide, and be included up to 30 degrees.
 - 9.4.1 Wheel Technology – Typically a wheeled vehicle makes contact with the ground through wheels and tires, where tires provide the traction and the wheels provide the mechanical strength to hold the vehicle above the surface against gravity. The surfaces of planetary bodies other than Earth are most often without substantial exposure, covered in regolith and sometimes have very low temperatures. Wheeled vehicles enable wide-ranging exploration if their wheels and tires are suitable. Wheel/tire technology is, therefore, a critical element of exploration in space and, consequently, an important part of the Rover Challenge. The wheel mounting plate, hub, rims, spokes, dish and tire are hereafter referred to as a wheel. To be successful, the wheels of an exploration rover must be designed and fabricated against specific constraints. Commercial tires, whether of pneumatic or solid type, are excluded from the competition. Rover wheels should be designed, constructed and tested as new NASA Rover Challenge team creations. The wheels include the outer surface (treads) making contact with the terrain and supporting structure (rims, spokes, etc.).
 - 9.4.2 The only commercial items that may be used in the fabrication of the rover wheels are the hubs containing bearings or bushings.
 - 9.4.3 Strips or other portions of commercial tires may not be used on rovers competing in the Challenge.
 - 9.4.4 Commercially available wheel rims and spokes may not be used on rovers competing in the Challenge.
- 9.5 Vehicles not constructed by the entering team are not acceptable. Student teams are expected to design, construct and test their own rovers. **Rovers found to have been used in the Rover Challenge previously by the current team or any other team without substantial change will be disqualified.** Reuse of vehicle is permitted only when a minimum of 50 percent of the combined total structure and systems (content) has been modified or replaced. Reused is defined as a vehicle that has been registered by any team and attempted to compete in a previous year. New content is defined as changes to a vehicle that include any combination of the following:
 - 9.5.1 New or modified wheels equals 40 percent.

- 9.5.2 A 10 percent or greater change in length, width or weight of the vehicle frame equals 25 percent.
 - 9.5.3 Changes to crew restraints equals 10 percent.
 - 9.5.4 Adding a working telemetry or camera system equals 20 percent.
 - 9.5.5 Changes to the storage/deployment systems equals 20 percent.
 - 9.5.6 A 20 percent decrease in overall vehicle weight equals 20 percent.
 - 9.5.7 Changes to vehicle steering equals 20 percent.
 - 9.5.8 Changes to vehicle braking equals 10 percent.
 - 9.5.9 All such changes are to be documented in the Returning/Reused Vehicle Report and Certification, which is due by Fri., Feb 15, as well as verified in the photo requirement for verification of readiness are due to MSFC-RoverChallenge2019@mail.nasa.gov by Fri., March 30.
- 9.6 Officials will continue to provide rover team numbers on two printed 8.5- by 11-inch sheets of waterproof paper that are provided in each team's registration packet. Team numbers must be clearly displayed on rovers, and the provided sheets can be affixed to the vehicle for this purpose. Teams have the option to design an alternative approach to display their assigned number on their vehicles. The method must allow the number to be displayed on the front and left side (port side, as for a boat) of the rover. The number display must use a font size that is at least 5.5 inches (14 centimeters) in height and 4 inches (10.2 centimeters) in width. Numbers must be black on a white background, be easily readable and conform to all safety requirements. However it is attached, the rover number is part of the vehicle and subject to all rules pertaining to the vehicle. **Note that the "order number" and the "assigned number" for a rover are the *same* but will not be assigned until March 20. The "assigned number" will not be changed once assigned. The "order" is subject to change any time before a rover begins traversing the course.

10. Crew Rules

- 10.1 Rover drivers are two student team members (one female and one male) that propel the vehicle over the course.
- 10.2 Pushing the rover with a pole or other implement is not allowed. A driver's use of his or her hands on the wheels (as with a wheelchair) to rock or otherwise facilitate moving the vehicle is permitted.
- 10.3 Communication devices are allowed as long as one driver can still hear ambient sounds/instructions from judges.

11. Task Rules

- 11.1 All tools associated with tasks must be carried on the rover throughout the excursion except for the flag and instrumentation package, which are left at the task site.
- 11.2 All tools must be on the rover by ERR.
- 11.3 Tools cannot be shared between teams.
- 11.4 All tools will be inspected at ERR.
- 11.5 If teams fail to have tools for a particular task at ERR and PER, points will not be awarded for that task.

12. General Information Rules

- 12.1 Each team is responsible for building its own rover, and the two rover drivers must be chosen from the team. Students shall do 100 percent of the work.
- 12.2 Each rover must be the work of the current student team from a high school or an accredited institution of higher learning.
- 12.3 The school or institution may enter up to two teams. (Exception: International teams may only enter one team per school/institution). Only U.S. high schools or colleges may collaborate in building a rover for entry.
- 12.4 An entity that promotes education, such as a museum, science center, planetarium or youth-serving organization, may also enter up to two rover teams in each division. International country and team limitations apply.
- 12.5 High school teams are considered those that are predominantly composed of students ages 14 through 19. All team members must be enrolled in a high school as per U.S. standards. Age verification may be requested.
- 12.6 College/university teams are considered those that are predominantly composed of students ages 19 and older. All team members must be enrolled in a college/university. Age and enrollment verification may be requested.
- 12.7 Each team, regardless of division, must be accompanied by an adult age 21 or older to serve as a mentor and/or advisor.
- 12.8 The team shall engage a minimum of 200 participants in educational, hands-on science, technology, engineering and mathematics (STEM) activities, as defined in the STEM Engagement Activity Report, by March 29, 2019. The STEM Engagement Activity Report shall be completed and submitted within two weeks after completion of the team's STEM engagement event. A sample of the STEM Engagement Activity Report can be found on page 47 of the handbook. Teams will be judged on the overall experience, quality and quantity of the STEM engagement experiences they provide.
- 12.9 Only vehicles registered for the competition will be allowed in the pit area. All other vehicles and trailers must be parked outside of the pit area. Parking passes must be displayed in the front windshield of the registered vehicle. Others are subject to be towed, with the exception of the time required to quickly load and unload your vehicle and equipment. DO NOT block other rover parking spaces. Each team is provided two parking spaces and must fit all equipment in the spaces provided.
- 12.10 Driving the rover on the course or in the parking lot in a reckless or unsafe manner is not acceptable.
- 12.11 The consumption of alcoholic beverages or controlled substances by any team member at any time during the event is strictly prohibited and is grounds for disqualification of the team.
- 12.12 U.S.A. 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 U.S. Space & Rocket Center property.
- 12.13 In accordance with Federal Aviation Administration regulations, the use of drones (unmanned or manned flying vehicles) during any Rover Challenge activity is strictly prohibited.
- 12.14 Scoring appeals: The scoring decisions of the judges are considered to be final. Only in extraordinary circumstances can an appeal of a score be proposed. If the appeal process is chosen, the advisor/instructor or the team leader must submit the appeal of the penalty in writing to the Scorekeeping Lead in the scoring area within 30 minutes of the posting of the score in question. The final decision of the Competition Director shall prevail.

12.15 Code of conduct: Committee members who administer the planning and operation of the NASA Human Exploration Rover Challenge strive to conduct themselves in a professional manner. We ask the same from each participant. All faculty members, team members, team supporters, judges and officials are to conduct themselves responsibly, respectfully and in a safe manner throughout the challenge. All participants also must conform to the laws of the State of Alabama and the United States of America. Anyone not doing so will be requested to leave the U.S. Space & Rocket Center grounds.

13. Point Breakdown

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

Item	Description	Bypass Available	Possible Points	Summary of Point Breakdown
Late Penalty	Teams arriving outside their time window, not being ready to compete or making changes to the rover before excursion during assigned time.	N/A	5-point penalty (– 5 Points)	Penalty can be assessed per occurrence/per day.
Mission Readiness Review				
Volume Constraint (This point total is carried over to Day 2.)	Vehicles must fit in 5 x 5 x 5-foot volume constraint	N/A	4	4 points for entire vehicle fit 0 points for not fitting
Weight (This point total is carried over to Day 2.)	Vehicle and task materials will be weighed.	N/A	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 to Day 2.)	Teams will be assessed on the amount of time it takes to unfold/assemble and ready the vehicle for course excursion.	N/A	2	2 points for 0:00 – 2:00 minutes 1 point for 2:01 – 4:00 minutes 0 points for more than 4:00 minutes
Excursion Readiness Review (ERR)	Teams will be inspected for having one U.S., national or institutional flag, safety requirements and task material requirements.	N/A	1	1 point for U.S., national, or institutional flag
Obstacle/Task Number	Description	Bypass	Possible Points	Point Breakdown
1	Undulating Terrain	Y	2	2 points for successful completion 1 point for attempt 0 points for bypass

Obstacle/Task Number	Description	Bypass	Possible Points	Point Breakdown
Task 1	Solid Soil Sample Retrieval	Y	10	<u>3 separate soil sample collections</u> 2 points for each successful collection, baggage, storage (6 points) (TS) 1 point for return of each sample, uncontaminated before 7:00 (3 points) (PER) 1 point for using appropriate storage bin/container (PER)
2	Serpentine Chicane	N	3	3 points for successful completion 1 point for attempt 0 points for failure to attempt
Task 5 may be completed during Obstacle 2 or after Obstacle 11.				
3	Crater with Ejecta	N	2	2 points for successful completion 1 point for attempt 0 points for failure to attempt
4	High Butte	Y	6	6 points for successful completion 1 point for attempt 0 points for bypass
5	Large Ravine	Y	4	4 points for successful completion 1 point for attempt 0 points for bypass
Task 2 (Obstacle 5 must be attempted to attempt Task 2.)	Spectrographic Analysis	Y	10	<u>Four photographs</u> 1 point for each photograph taken at the site (4 points) (TS) 1 point for safe storage of filters (PER) 1 point for safe storage of photographing device (PER) 1 point for each photograph returned before 7:00 (4 points) (PER)
6	Martian Sand Dunes	Y	5	5 points for successful completion 1 point for attempt 0 points for bypass
Task 3 (Bypass cannot be used to complete the task.)	Instrument Deployment	Y	11	<u>Deploy solar power cell</u> 3 points for providing scientific instrumentation (TS) 3 points for deploying and correctly orienting instrumentation (TS) 2 points for demonstrating instrumentation properly functions (turn switch, light illuminates) (TS) 1 point for safe storage of photographing device (PER) 2 points for photograph of functioning device if returned before 7:00 minutes (PER)

7	Crevasses	Y	3	3 points for successful completion 1 point for attempt 0 points for bypass
8	Side Incline	N	3	3 points for successful completion 1 point for attempt 0 points for failure to attempt
9	Lunar Crater	Y	4	4 points for successful completion 1 point for attempt 0 points for bypass
Task 4 (Obstacle 9 must be attempted to attempt Task 4.)	Flag Plant and Photo	Y	7	<u>Flag Plant and Photo</u> 2 points for successfully planting flag at landing site (TS) 1 point for safe storage of photographing device (PER) 4 points for 1 photograph if returned before 7:00 minutes (1 point for photograph, 1 point for including the flag in the photograph, 1 point for Rover in the photograph, 1 point for at least 1 driver in the photograph). (PER)
10	Bouldering Rocks (large rocks)	Y	4	4 points for successful completion 1 point for attempt 0 points for bypass
11	Tilted Craters	N	2	2 points for successful completion 1 point for attempt 0 points for failure to attempt
Task 5 (This task may be attempted at Obstacle 2 or after Obstacle 11)	Liquid Sample Retrieval	Y	10	<u>3 separate liquid sample collections</u> 2 points for each successful collection, baggage, storage (6 points) (TS) 1 point for return of each sample, uncontaminated before 7:00 (3 points) (PER) 1 point for using appropriate storage bin/container (PER)
12	Loose Regolith	Y	4	4 points for successful completion 1 point for attempt 0 points for bypass
13	Pea Gravel	Y	4	4 points for successful completion 1 point for attempt 0 points for bypass
14	Undulating Hills	N	2	2 points for successful completion 1 point for attempt 0 points for failure to attempt
Return to Home Base	Teams must reach the end of the course in the specified time.	N/A	5	5 points for returning to home base by 6:00 minutes 0 points for returning to home base from 6:01 minutes to 7:00

				Not eligible for awards after 7:00 minutes.
Post Excursion Review	Inspection	N/A		
Total Possible Points			113	

14. Obstacle and Task Descriptions

Note: The course obstacles and tasks outlined below are subject to change. Please check periodically for updates. Photos are provided as examples of the obstacle from a previous year and may or may not be the same. Obstacle 1 – Undulating Terrain (2 Points)

This gently uneven surface is replicated by wooden ramps 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. The ramps range from 6 to 12 inches in height with gradual ingress and egress slopes, all covered with gravel.





14.1 Task 1 – Solid Soil Sample Retrieval (10 Points)

Teams will need to collect three separate soil samples of different sizes and consistencies while remaining on the rover. To collect the samples, teams will need to use a sample retrieval tool designed and created by the team. Teams need to design/procure a tool or tools that can collect solid samples and must provide methods for preventing cross-contamination. Teams are not limited to the number of sample retrieval devices. Each sample must be stored in a sealed, isolated, uncontaminated container, which is also provided by the team. The collection of samples must be contained in a storage area or vessel on the rover. If the tool is used repeatedly, it must be cleaned between each collection. Cross-contaminated samples will not receive points.

- 14.1.1 Teams will receive 2 points for each sample that is successfully retrieved and placed in the sample container. Each sample must be at least 50 ml. Individual sample containers are required for each collected sample to prevent cross-contamination. The sample container must be sealable.
- 14.1.2 Sample containers shall be stored in the sample storage bin. The sample storage bin must be located on the rover and able to hold all sample containers. All items must be properly stored before continuing to traverse the course. Teams will receive 1 point for storing all sample containers in the sample storage bin at the task site.
- 14.1.3 Teams will receive 1 point for each sample that is successfully returned uncontaminated and provided to the PER judge. Teams must finish before the 7:00 minute reserve oxygen expires to receive these points.

Obstacle 2 – Serpentine Chicane (3 Points)

The Serpentine Chicane is new to the Human Exploration Rover Challenge and features downhill, narrow, S-shaped turns requiring teams to turn right and left to stay on the path.

**Note: Task 5 may be attempted at Obstacle 2 or during the return after Obstacle 11.*



14.2 Obstacle 3 – Crater with Ejecta (2 Points)

This large crater is about 3 feet in diameter with a vertical height of 8 inches. Rays of ejecta, the material thrown out of the crater on impact, are fashioned out of 2-by-4- and 2-by-6-inch lumber. The whole assembly is covered by gravel. Boulders are added to direct the rovers to traverse the large crater.



14.3 Obstacle 4 – Martian Terrain – High Butte (6 Points)

This feature is a test of the rover's climbing ability. This butte is 4 feet high with a 20-degree incline.



14.4 Obstacle 5 – Martian Terrain – Large Ravine (4 Points)

A remnant of an ancient erosion channel, this 2-foot depression, about 8 feet wide, provided a conduit for liquid runoff on the Martian surface.



- 14.5 *Task 2 – Spectrographic Analysis (10 points)* For this task, a simulated terrain or analysis site shall be photographed utilizing primary color filters. The camera should be able to display the photographs quickly for the PER judge. Teams will provide the photographic device and the appropriate filters. The primary colors that shall be used in Task 2 are red, blue and yellow. Teams must photograph the site once unfiltered and once with each filter such that the filtered photographs' composite encompasses the full spectrum of the unfiltered photo. Internal filters that are optical/mechanical and part of the camera/device are acceptable; however, the use of software that applies a filter to the camera will not be accepted. Drivers may get off the rover to make the appropriate photographs. All photos must be taken with equipment properly stored before continuing to traverse the course.
- 14.5.1 Teams will receive 1 point for each of the four total photographs taken at the analysis site, for a possible 4 points.
- 14.5.2 Teams will receive 1 point for safe storage of the color filters on the rover. To receive the point, teams must have all filters stored and use the storage container at the task site.
- 14.5.3 Teams will receive 1 point for safe storage of the photographing device. To receive the point, teams must store the device and use the storage container at the task site.
- 14.5.4 Teams will receive 1 point for each photograph returned and successfully demonstrated to the PER judge. Teams must finish before the seven-minute reserve oxygen expires to receive these points, for a possible total of 4 points.



14.6 *Obstacle 6 – Martian Terrain – Sand Dunes (5 Points)*

Images from NASA's Mars Reconnaissance Orbiter show sandy slopes composed of fine-grain (soft) material. Best passage is achieved by navigating to pass between the dunes to avoid traversing them. Individual dunes are about 2 feet high and 3 feet wide at the base, randomly scattered on the Martian surface. Rovers benefit from flotation (large wheel footprints) on soft surfaces.



14.7 Task 3 – Instrument Deployment (11 points)

A simulated remote location needs instrumentation deployed and correctly calibrated for future missions. For this task, the instrumentation will be a solar-powered instrument that the teams must deploy in the proper compass orientation. The device must be built by the teams and will require the following components: A solar cell, a functioning on/off switch and a power-indication light that illuminates when the switch is on and operates on solar power. (A light source will be provided to simulate the Sun and accommodate for the possibility of inconsistent Sun coverage.) Teams will need to provide their own compasses. Teams will be required to deploy the instrument in a designated compass orientation and demonstrate successful operation by turning switch to the “on” position and have indicator light be illuminated by the solar power. At the task site, teams will be given a compass orientation (relative to north) in which to deploy the instrument. Teams will need a marker or fiducial on the instrument in order to properly orient and for judges to verify orientation. The instrument will also need to be open on the bottom such that it can be inspected to verify that no stored energy power sources are present. All the components to build the instrument package can be purchased.

14.7.1 Teams will receive 3 points for providing the scientific instrumentation. To receive the points, teams must use the instrumentation at the task site.

14.7.2 Teams will receive 3 points for deploying and successfully orienting the instrumentation at the task site.

14.7.3 Teams will receive 3 points if the instrumentation functions properly after orientation and deployment, i.e., the switch is turned on and light illuminates with judge verification.

14.7.4 Teams will receive 2 points for demonstration of photograph of functioning device to the PER judge. Teams must finish before the seven-minute reserve oxygen expires to receive these points.

14.8 Obstacle 7 – Crevasses (3 Points)

Crevasses result from cracks in the surface regolith or from erosion by liquid and/or molten material forming ruts in underlying material. The crevasses vary in width between 1 and 4 inches. Avoid having the rover wheels stuck in these cracks, which are 4 to 6 inches deep.



14.9 Obstacle 8 – Side Incline (3 Points)

The slope of this obstacle is perpendicular to the direction of rover traverse. The simulated lava or rock outcropping surface is smooth. The angle of elevation of the incline is about 20 degrees. Avoid tipping over by lowering the center of gravity and by leaning to the high side of the incline. Traction will assist on this smooth surface (no gravel). The steep incline will be followed by a marked exit lane within which the rovers remain.



14.10 Obstacle 9 – Lunar Crater (4 Points)

This area surrounding the Lunar Excursion Module replica consists of asphalt lava with craters of various sizes and strewn boulders. The large crater will test the 15-inch clearance of the rovers. A turn of 360 degrees is traversed within this large crater.





14.11 Task 4 – Flag Plant and Photo (7 points)

Teams are staking claim on the Martian terrain. They will need to provide a team flag (see requirement 4.2) and a photographing device. In the *Lava Flow with Craters*, teams must depart the rover, plant their team's flag and take a photograph containing the flag, rover and at least one driver. Drivers may get off the rover to make the appropriate photographs. Teams are encouraged to post this photo on social media and use the hashtag: #roverchallenge2019.

14.11.1 Teams will receive 2 points for successfully planting the flag at the task site. The flag will be mounted in a holder. The holder has a one-inch (2.54 cm) inner diameter and is approximately 2 feet (61 cm) tall.

14.11.2 Teams will receive 1 point for safe storage of the photographing device. To receive the point, teams must store the device and use the storage container at the task site.

14.11.3 Teams will receive 1 point for demonstrating to the PER judge the photograph, 1 point for the photograph containing the flag, 1 point for the photograph containing the entire rover and 1 point for at least one driver in the photograph. All items must be included in a single photo to receive points. Teams must finish before the seven-minute reserve oxygen expires to receive these points for a possible total of 4 points.

14.12 Obstacle 10 – Bouldering Rocks (4 Points)

Rovers must navigate over this field of simulated asteroid debris (boulders) while *not* avoiding the debris. The asteroid fragments range in size from 3 to 12 inches and are situated close together, touching each other. Proceed with caution.



Obstacle 11 – Tilted Craters (2 Points) [No photo available]

Rovers travel up a slope and then encounter medium craters on the descending side. The slope is gentle, about 15 degrees. Boulders force the rovers to traverse the two craters. The whole obstacle is covered by gravel.





14.13 *Task 5 – Liquid Sample Retrieval (10 points)*

Teams must collect three separate liquid samples in a diorama of different colors while remaining on the rover. To collect the samples, teams will need to use a sample retrieval tool designed and created by the team. Teams must design/procure a tool or tools that can collect liquid samples and must provide methods for preventing cross-contamination. Teams are not limited to the number of sample retrieval devices. Each sample must be stored in a sealed, isolated, uncontaminated container, which is also provided by the team. The collection of samples must be contained in a storage area or vessel on the rover. If the tool is used repeatedly, teams must clean the tool between collections. Cross-contaminated samples will not receive points.

14.13.1 Teams will receive 2 points for each sample that is successfully retrieved and placed in the sample container. Each sample must be at least 50 ml. Individual sample containers are required for each collected sample to prevent cross-contamination. The sample container must be sealable.

14.13.2 Sample containers shall be stored in the sample storage bin. The sample storage bin must be located on the rover and able to hold all sample containers. All items must be properly stored before continuing to traverse the course. Teams will receive 1 point for storing all sample containers in the sample storage bin at the task site.

14.13.3 Teams will receive 1 point for each sample that is successfully returned uncontaminated and provided to the PER judge. Teams must finish before the seven-minute reserve oxygen expires to receive these points.

14.14 Obstacle 12 – 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 to 8 inches. Traction and support (flotation) will assist in traversing this obstacle.



14.15 Obstacle 13 – Pea Gravel (4 Points)

This ancient stream bed consists of small rounded pebbles deposited to a depth of about 6 inches. Rover wheels might sink in this smooth obstacle material. Wheel flotation (support) will assist in traversing this obstacle.



14.16 *Obstacle 14 – Undulating Hills (2 Points)*

Similar to Obstacle 1, this obstacle consists of uneven terrain characterized by humps randomly positioned so that they occur first on one side of the rover, then on the other. Navigating the humps produces twisting forces on the rover chassis. Wooden ramps covered with gravel simulate this landform.



15. Pit Crew

The Pit Area is a mobile machine and welding shop staffed by volunteer pit crew technicians and engineers. The Pit Area is available to teams for repairs and light modifications on previously fully assembled Rovers. The Pit Area is not intended to assist teams with extensive work in the final assembly of their rovers. Priority will be given to those repairs and light modifications that can be completed in a timely manner over more extensive work that may consume an inordinate amount of pit crew resources.

Hand tools, small power tools and welding machines are available for use by the teams inside the Pit Area. A vertical milling machine and lathe are available for precision machining operations, and are performed by trained machinists based on drawings provided by the team. All teams must check in with a Pit Crew Director to remove tools from the trailer or to request a task to be performed. A work order form must be filled out to request a task to be performed. The Pit Area is open to the teams on Thursday 12:00 - 4:45 p.m., Friday 7:00 a.m. - 5:00 p.m., and Saturday 7:00 a.m. - 4:45 p.m.



Awards

Awards are subject to change without notification.

Award	Categories	Criteria
STEM Engagement Awards	One High School and One College	Required (outlined in rules section) submission due: March 8
Technology Challenge Award for Wheel Design and Fabrication	Best Overall either High School or College	Required (submission due March 8)
Drive Train Technology Challenge	Best Overall either High School or College	Optional (submission due March 8)
System Safety Awards	One High School and One College	Optional (submission due March 8)
Featherweight Awards	One1 High School and One College	No submission required
Best Report Awards	One High School and One College	Optional (submission due March 8)
Telemetry/Electronics Award	Best Overall either High School or College	Optional (submission due March 8)
Neil Armstrong Best Design Awards	One High School and One College	Optional (submission due March 8)
Crash and Burn Award	Best Overall either High School or College	No submission required
Frank Joe Sexton Memorial Pit Crew Awards	One High School and One College	No submission required
Team Spirit Award	Best Overall either High School or College	No submission required
Rookie Award	One High School and One College	No submission required
3 rd Place	One High School and One College	No submission required
2 nd Place	One High School and One College	No submission required
1 st Place	One High School and One College	No submission required

Technology Challenge Award (Required)

The NASA Human Exploration Rover Challenge Technology Challenge Award invites participants to apply their engineering skills to develop mobility devices. The goal of the Technology Challenge Award is to involve students in hands-on engineering experiences related to NASA's mission of exploration and discovery. Mobility devices, such as rovers, simulate the extension to astronauts' range and carrying capabilities as they explore other worlds.

Teams will focus on creativity, ingenuity and effectiveness as they design and build a particular component technology of a rover. This technology is built to aid navigation of the extraterrestrial-like surfaces of the NASA Human Exploration Rover Challenge course.

In the 2019 NASA Human Exploration Rover Challenge, the Technology Challenge will concentrate on wheel design and fabrication.

Definitions

Wheel refers to the rover components that provide contact with the surface. Those components might consist of wheels, belts, tracks, treads, skids, rails, rollers, etc. Through these components, force is exerted on the surfaces being navigated to provide propulsion (thrust) and steering.

2019 Wheel Design and Fabrication

The design should take into account the following criteria:

- Safety
- Adaptability to different surfaces
- Durability and strength
- Traction
- Stability
- Performance
- Maneuverability
- Ground Contact Area (wheel footprint)
- Flotation (less sinkage)

Judging

A team of judges will determine, based on the written report, material presented and visual inspection which entries produced, documented and explained the technology challenge solution to best meet the performance requirements.

Note: This judgment is based on the professional opinion of the judges and challenge results.

Judging will take place in three parts and is evaluated as:

- Technology Challenge Written Report – 40 percent of total score
- Oral Interview/Presentation/Wheel Inspection: *Interviews will take place from 7:30 a.m. - 3 p.m. CDT on April 12 - 13 outside Excursion Readiness Review.* – 30% of total score
- Overall Performance of Technical Solution During the Race – 30% of total score

Technology Challenge Report

1. Each team will supply documentation detailing its design and how that design meets the criteria listed above.
2. The teams' documentation should answer the "who, what, where, how and why" questions of the design. Questions to be answered shall include, but are not limited to, the following:
 - a. Who are the members of your team and the advisor?
 - b. Who was responsible for the wheel design solution?
 - c. Why did the team choose this particular solution?
 - d. How much did it cost?
 - e. Where was the work completed?
 - f. What materials did you use to fabricate the wheels?
 - g. What was the process used to design the solution?
 - h. How did you construct the solution?
 - i. How did you pay for it?
 - j. What design features enhance the robustness of the wheels to ensure survival on the race course?
 - k. What part is most likely to break? Why?
 - l. What can/should be done to minimize the effects of this failure?
 - m. What is the most important lesson learned on the project to date?
3. Documentation shall be limited to eight (8.5 x 11) pages (eight single-sided or four double-sided) or the equivalent. Drawings, pictures and figures are not considered in the page count.
4. Documentation may be sent by using one of the following options:
 - a. Regular Mail: postmarked no later than March 8, 2019 to:
Mr. Tom Hancock
79 Hartington Drive
Madison, AL 35758
ATTN: 2019 Technology Challenge Award
 - b. Email to: tom.hancock@knology.net
 - c. Web Page: Send Web page address to tom.hancock@knology.net.
5. Please request confirmation that your documentation has been received. All submissions will be confirmed by email. So that we may confirm your submission, confirmation of receipt must take place before the start of the race to signify your team entry in the Technology Challenge Award competition.

Technology Challenge Oral Interview/Presentation/Wheel Inspection

A team member will discuss the technology challenge solution with the judges. The team should be able to discuss, in detail, the design, manufacturing, testing, documentation and implementation of the technology challenge solution. A formal presentation (PowerPoint, etc.) is not required for the interview. Visual aids such as test components, spares and models (both hardware and computer-based) can be used to discuss the team's technology solution.

2019 Drive Train Technology Challenge (Optional)

Rover Challenge teams are invited to participate in an optional Drive Train Technology Challenge. High school and college Human Exploration Rover Challenge teams may participate. Over time, we anticipate that the drive train on exploration rovers will consist of reliable systems such as belts, drive shafts or direct drives, replacing chains that are currently often employed.

For the 2019 competition, this alternative will be optional but encouraged by offering separate technology awards for the best overall performance of the high school and college/university team that participates in the Drive Train Challenge.

To participate, teams are to email a report by March 8, 2019. Include Drive Train Challenge in the subject line to MSFC-RoverChallenge2019@mail.nasa.gov. Provide the name of the school.

Written Report:

Include a cover page with “Drive Train Technology Challenge” and team name. Items to be documented within the report must include, but are not limited, to the following:

- Describe the design of your rover drive train.
- What hurdles did you encounter that affected your design?
- What materials did your team use to make your drive train?
- Why did you use those specific materials?
- How did you build it?
- Which part of the drive train is most likely to fail? Why?
- Is there anything your team can do to minimize the likelihood or effects of the failure?
- What, during the entire process, would you do differently?
- What, during the entire process, worked so well you would repeat it?
- What is the most important thing your team learned throughout the process?

Oral Presentation:

- Students from the rover team must discuss their rover drive design and answer questions asked by the design judges. The team must be present for the presentation.
- Visual aids (one-page pamphlets, CAD animations, 3D printed models, etc.) may be used as part of the briefing.
- Only students may present and answer questions at the briefing. Translators will be allowed if needed.

Additional notes:

- Rovers that fail during operation on the course still qualify for Drive Train Technology Challenge award consideration.
- Teams who submit their written reports after the deadline will not be considered.

System Safety Challenge Award

The International System Safety Society
Professionals Dedicated to the Safety of Systems, Products and Services
Tennessee Valley Chapter
Alabama – Mississippi – Tennessee

Greetings to all competitors entering the NASA Human Exploration Rover Challenge!

This year, the Tennessee Valley Chapter of the International System Safety Society (ISSS-TVC) will once again be judging for the best use of system safety in the System Safety Challenge. Two awards will be made for the best application of system safety engineering—one to a college/university team and one to a high school team.

System safety is a formal discipline characterized by the application of engineering and management principles, criteria and techniques to optimize safety within the constraints of operational effectiveness, time and cost throughout the system life cycle. System safety has evolved as a distinct engineering discipline in the post-WWII era of increasingly complex systems in which accident risks are less and less tolerable to society. System safety has been effectively applied in numerous industries and programs, including spaceflight, military weapons, transportation, energy and chemical processing, to name but a few. More information on system safety is readily available on a variety of internet sites, including the International [System Safety Society's](#) website. Interested teams are encouraged to monitor the [ISSS-TVC](#) website for any helpful updates that may be posted concerning the System Safety Challenge Award.

System safety is most effective and economical when begun as early in system development as possible—before details of the design are firm and when there is the most opportunity to influence the design. Safety needs to be designed in, rather than added as an afterthought. One of the most important system safety activities is hazard analysis. A hazard is any real or potential condition that can result in death, injury or illness to personnel; damage to or loss of equipment or property; or damage to the environment. In a hazard analysis, the analyst identifies and characterizes the hazards posed by the system or its operation; assesses the risk associated with each hazard (in terms of severity of consequences and probability of occurrence); and identifies real or proposed means for eliminating the hazard or minimizing its risk. Results of the hazard analysis are usually compiled in a series of hazard reports or hazard logs, giving a thorough characterization of each hazard. These hazard data are used by the project team to manage risks and incorporate hazard-control measures in a prioritized fashion.

The preferred order for controlling hazards is to: (1) eliminate the hazard by designing it out, (2) implement safety devices such as guards, interlocks or redundant systems, (3) provide warning devices such as lights, alarms, displays or signs and (4) institute special procedures or training.

Participants in the NASA Rover Challenge may enter the System Safety Challenge by submitting a documentation package in a format of their choice that follows the submittal instructions on the next page. In addition to stating where and how your package should be submitted, the attached sheet also provides a suggested content outline and judging criteria. Entries in the System Safety Challenge must be received by 5 p.m. CST on March 8, 2019. NOTE: Please get a receipt for your application from Melissa Waters.

Good luck to all participants!

Submission Instructions

Entries must be submitted electronically, by U.S. Mail, or by other delivery service with confirmation requested to the following:

APT Research, Inc.
4950 Research Dr.
Huntsville, AL 35805
Attention: Melissa Waters
Phone: 256-955-6830
Email: mwaters@apt-research.com

Entries must be received by 5 p.m. CST on March 8, 2019.

NASA Human Exploration Rover Challenge: Featherweight Award

Weight management continues to be a challenge for space exploration. Weight reduction is especially important for rover developers, and results in increased performance from the application of drive power for lighter weight rovers. Therefore, the Human Exploration Rover Challenge Featherweight Award has been established to reward rover teams that best meet the weight minimization challenge. Weighing the rovers will take place in the folded configuration. The Human Exploration Rover Challenge Featherweight Award will be presented to high school and college/university teams that have the highest value of cumulative course score divided by weight. Safety must not be compromised in rover design in order to achieve light weight. The team with the highest score divided by the lowest weight wins this award. Teams not completing the challenge in the allotted time are not eligible for awards.

AIAA Best Report Award (Optional)

The Greater Huntsville Section of the American Institute of Aeronautics and Astronautics (AIAA) will present an award titled “AIAA Best Report,” which recognizes the high school and college reports that best describe their technical design process for the Rover Challenge. This award is independent of the Neil Armstrong Best Design Award.

Submission: Written report (no more than 12 pages, not counting cover page)

Deadline: March 8, 2019

Method of Submission: Email with PDF attachment of written report sent to distribution@hsv-aiaa.org

Please include the award name as the subject line.

The report must include the following information:

1. **Cover Page** – Include “AIAA Best Report Award” and team name.
2. **Introduction** – Introduce your team’s system.
3. **Schedule** – Explain the schedule for which your team planned and describe what actually happened during the development process. Identify any major delays and setbacks to the schedule and why they occurred.
4. **Budget** – Compare your original budget to the actual costs of developing your team’s rover and identify any significant increases or decreases in development costs compared to your original budget.
5. **Process** – Describe how your team did the work to develop the vehicle and discuss any changes along the way. Highlight any resources used, including but not limited to, any prototyping performed, subject matter expert (SME) input and/or development tools your team might have used.
6. **Technical Challenge** – Detail the major technical challenges your team faced while developing your rover.
7. **Construction** – Describe how your team built your rover and highlight why you decided to build it in that particular way.
8. **Test** – Explain how your team tested the vehicle and why you designed your test plan that specific way.
9. **Conclusion** – Describe what your team learned throughout the process. Explain anything you would do differently and identify what (concepts, subsystems, processes, etc.) worked well.
10. **Personal** – Include team biographies and specifically identify assigned tasks for the development process.
11. **Advisor(s)** – Include biography/biographies for team advisor(s).

Additional Notes:

- Rovers that fail during operation on the course still qualify for AIAA Best Report award consideration.
- Teams who submit their written report after the deadline will not be considered for the AIAA Best Report award.
- Judges are able to exclude a team for consideration of an award if the team's written report exceeds the permitted number of pages as outlined above.

AIAA Telemetry/Electronics Award (Optional)

The Greater Huntsville Section of the AIAA will present an award titled “AIAA Telemetry,” which recognizes the development and operation of the most innovative and useful real-time telemetry system at the Rover Challenge.

Submission: Written report (no more than five pages, not including cover page) and oral presentation (no more than five minutes, not including judges’ questions and answers)

Deadline: March 8, 2019 (written report); oral presentation at the Rover Challenge

Method of Submission: Email with PDF attachment of written report sent to distribution@hsv-aiaa.org
Please include the award name as the subject line.

The telemetry system must do at least one of the following two options:

Transmit Real-Time Video

- Video must be broadcast and received by a central station, and video image must be available for viewing in real time by your team.
- Teams may use on-board data logging (recording) for later review.
- Report and presentation must justify the system design choices made by your team relative to weight, usefulness to crew, function, innovation and redundancy.

Transmit Real-Time Sensor Data

- Sensor data must be broadcast and received by a central station, and the raw data must be available for viewing in real time by your team.
- Teams may use on-board data logging (recording) for later review.
- A baseline for sensor data must be established prior to the excursion. Explain how your team will accomplish this.
- Report and presentation must justify the system design choices made by your team relative to weight, usefulness to crew, function, innovation and redundancy.

Additional notes:

- The report must include a cover page with the words “AIAA Telemetry Award” and the team name.
- The telemetry package may be designed and constructed by someone external to your team. If this method is used, your team must obtain permission to integrate the package from the developer. A PDF version of this permission must be included in your written report by the report submission deadline. This additional documentation will not count against your page limit.
- Telemetry systems that fail during operation on the course still qualify for award consideration.
- Functioning power system batteries and transmission antennae must be appropriately labeled as defined by the Rover Challenge rules.
- Teams who submit their written report after the deadline will not be considered for the AIAA Telemetry/Electronics Award.
- Judges are able to exclude a team for consideration of an award if the team's written report exceeds the permitted number of pages and/or if the oral presentation exceeds the time allowed.

Questions should be directed to: distribution@hsv-aiaa.org

Please include the award name as the subject line.

Neil Armstrong Best Design Award (Optional)

The Greater Huntsville Section of the AIAA will present an award titled “Neil Armstrong Best Design,” which recognizes the high school and college systems best designed to meet the Rover Challenge performance requirements. This award is independent of the Best Report Award.

A prize will also be awarded to the team whose rover design represents the best technical approach toward solving the engineering problem of navigating the extraterrestrial terrain. The award is based not on rover performance but upon the technical approach taken by teams in their design.

Submission: Written report (no more than 10 pages, not counting cover page) and oral presentation (no more than 10 minutes, not including judges’ questions and answers)

Deadline: March 8, 2019

Method of Submission: Email with PDF attachment of written report sent to distribution@hsv-aiaa.org.

Please include the award name as the subject line.

Written Report:

Include a cover page with “AIAA Neil Armstrong Best Design Award” and team name. Items to be documented within the report must include, but are not limited to, the following:

- Who are the members of your team? What were their specific roles in the rover development?
- What did it cost to develop your rover? How did your team pay for it?
- What did your team’s development schedule look like? What hurdles did you encounter that affected your project schedule?
- What is the design of your team’s rover? Why did you design your subsystems that way?
- Where did your team do the work?
- Which part is most likely to fail? Why? Is there anything your team can do to minimize the likelihood or effects of the failure?
- What materials did your team use to make your rover? Why did you use those specific materials?
- How did you build it?
- What, during the entire process, would you do differently? What, during the entire process, worked so well you would repeat it?
- What is the most important thing your team learned throughout the process?

Oral Presentation:

- Students from the rover team must discuss components of their rover design and answer questions asked by the design judges. The team must be present for the presentation.
- Visual aids (one-page pamphlets, CAD animations, 3D printed models, etc.) may be used as part of the briefing.
- Only students may present and answer questions at the briefing. Translators will be allowed if needed. However, answers by someone other than students will be penalized.
- Safety features and required equipment will be checked at the briefing. Note: This is not the only time during the Rover Challenge these items will be reviewed.

Additional notes:

- Rovers that fail during operation on the course still qualify for Neil Armstrong Best Design Award consideration.
- Teams who submit their written reports after the deadline will not be considered for the Neil Armstrong Best Design Award.
- Judges are able to exclude a team for consideration of an award if the team's written report exceeds the number of pages and/or if the oral presentation exceeds the time allowed.

Questions should be directed to: distribution@hsv-aiaa.org.

Please include the award name as the subject line.

STEM Engagement Form

Please complete and submit this form each time you host STEM engagement event.

(Return within 2 weeks of the event end date)

School/Organization name:

Date(s) of event:

Location of event:

Instructions for participant count

Direct Interactions: A count of participants in instructional, hands-on activities where participants engage in learning a STEM topic by actively participating in an activity. This includes instructor-led facilitation around an activity regardless of media (e.g., **face-to-face**). **Examples:** Students learn about Newton's laws through building and driving a rover. Teams deliver a presentation to students about their Rover Challenge project, bring their rover and components to the event and drive the rover at the end of the presentation.

Indirect Interactions: A count of participants engaged in learning a STEM topic through instructor-led facilitation or presentation. **Examples:** Students learn about Newton's laws through a PowerPoint presentation, WebEx or Skype. The team sets up a display at a local museum during Science Night.

Grade level and number of participants: (If you are able to break down the participants into grade levels: PreK-4, 5-9, 10-12, and 12+, this will be helpful.)

Participant's Grade Level	STEM Engagement	
	Direct Interactions	Indirect Interactions
K-4		
5-9		
10-12		
12+		
Educators (5-9)		
Educators (other)		

Are the participants with a special group/organization (i.e. Girl Scouts, 4-H, school)? Y N

If yes, what group/organization?

Briefly describe your activities with this group:

Did you conduct an evaluation? If so, what were the results?

Describe the comprehensive feedback received.

2019 NASA HUMAN EXPLORATION ROVER CHALLENGE RETURNING VEHICLE REPORT AND VERIFICATION – INSTRUCTIONS

National Aeronautics and
Space Administration



INTRODUCTION
<p>Student teams are expected to design, construct, and test their own rovers. Vehicles not constructed by the entering team are not acceptable. A rover may be used in more than one Rover Challenge race; however, the reuse of a rover requires a minimum of 50 percent of the combined total structure and systems (content) to have been modified or replaced.</p> <p>Any team entering a vehicle that has been previously registered and attempted the course is required to have a minimum of 50 percent new content to race in the current year. Rovers found to have been used in the Rover Challenge previously without substantial change will be disqualified.</p>
DEFINITIONS
<p>Reused/Returning — a vehicle that has been registered and attempted to race in a previous year of the Great Moonbuggy Race or the Rover Challenge.</p> <p>New Content — changes to wheels; length, width, or weight of vehicle; crew restraints; steering; braking; the addition of a working telemetry system, camera system, or storage/deployment systems.</p>
REQUIREMENTS
<p>Every team entering a vehicle in the 2019 Rover Challenge must verify whether the vehicle is new or reused/returning and that it is the work of the student team registered for the race. If a team is entering a new vehicle, no report is necessary; however, the advisor is to email at MSFC-RoverChallenge2019@mail.nasa.gov no later than February 16, 2019, to verify that the team is using a new Rover vehicle.</p> <p>If a team is entering a reused vehicle in the 2019 Rover Challenge, the team must complete a report, and the advisor must return it to MSFC-RoverChallenge2019@mail.nasa.gov no later than February 16, 2019. Teams must describe in detail a minimum of 50 percent of changes using any combination of the following:</p> <ol style="list-style-type: none"> 1. New or modified wheels equal 40 percent 2. A 10 percent or greater change in length, width, or weight of the vehicle frame equals 25 percent 3. Changes to crew restraints equal 10 percent 4. Adding a working telemetry or camera system equals 20 percent 5. Changes to the storage/deployment systems equal 20 percent 6. A 20 percent decrease in overall vehicle weight equals 20 percent 7. Changes to vehicle steering equal 20 percent 8. Changes to vehicle braking equal 10 percent <p>This report will be used by Rover Challenge managers to ensure the team is complying with Rover Challenge rules. Rover Challenge managers will email the advisor after receiving the report to indicate the team's eligibility to compete.</p>
<p>PAPERWORK REDUCTION ACT STATEMENT</p> <p>This information collection meets the requirements of 44 U.S.C § 3507, as amended by section 2 of the Paperwork Reduction Act of 1995. You do not need to answer these questions unless we display a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 2700-0157 and this information collection expires on 07/31/2020. We estimate that it will take 49 minutes to read the instructions, gather the facts and answer the questions. Send only comments relating to our time estimate to: HQ-OEIDAdmin1@mail.nasa.gov.</p> <p>NASA PRIVACY STATEMENT</p> <p>This notice provides NASA's policy regarding the nature, purpose, use and sharing of any information collected via this form. The information you provide on a NASA-issued form will be used only for its intended purpose. NASA will protect your information consistent with the principles of the Privacy Act, the e-Government act of 2002, the Federal Records Act, and as applicable, the Freedom of Information Act. Submitting information is strictly voluntary. By doing so, you are giving NASA your permission to use the information for the intended purpose. If you do not want to give NASA permission to use your information, simply do not provide it. However, not providing certain information may result in NASA's inability to provide you with the information or services you desire. For additional information please visit NASA Privacy Policy and Important Notices at http://www.nasa.gov/about/highlights/HP_Privacy.html.</p>

MSFC Form 4687 (August 2018)

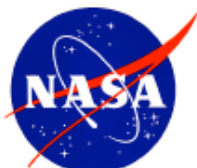
Previous Versions Obsolete

2019 NASA HUMAN EXPLORATION ROVER CHALLENGE RETURNING VEHICLE REPORT AND VERIFICATION

National Aeronautics and
Space Administration



PLEASE USE THE TEMPLATE BELOW AND LIMIT YOUR RESPONSE PER CATEGORY TO THE DESIGNATED NUMBER OF CHARACTERS AND SPACES INDICATED. BY SUBMITTING THE REPORT, THE ADVISOR CONFIRMS THE VALIDITY OF THE CONTENT.	
SCHOOL NAME:	
ADVISOR NAME:	TEAM NUMBER (If available):
IS YOUR SCHOOL NEW TO THE ROVER CHALLENGE? <input type="checkbox"/> YES <input type="checkbox"/> NO	
IF NOT, IN WHICH OF THE PAST FIVE YEARS DID YOUR SCHOOL RACE A TEAM(S) IN EITHER THE NASA GREAT MOONBUGGY RACE OR THE ROVER CHALLENGE?	
<input type="checkbox"/> 2014 <input type="checkbox"/> 2015 <input type="checkbox"/> 2016 <input type="checkbox"/> 2017 <input type="checkbox"/> 2018	
WHAT PARTS OF THE ROVER WERE REUSED FROM A PREVIOUS YEAR? (Maximum of 800 characters, including spaces)	
OF THE FOLLOWING EIGHT POSSIBLE OPTIONS, WHICH CHANGES WERE MADE TO MEET THE 50 PERCENT MINIMUM REQUIREMENT? CHECK ALL THAT APPLY. FOR EACH APPLICABLE ITEM, PLEASE DESCRIBE IN DETAIL WHAT IMPROVEMENTS WERE MADE OR WHAT NEW PARTS OF THE ROVER WERE DESIGNED AND FABRICATED BY THE TEAM.	
<input type="checkbox"/> 1. WHEELS (Maximum of 800 characters, including spaces)	
<input type="checkbox"/> 2. LENGTH, WIDTH, OR WEIGHT OF THE VEHICLE FRAME (Maximum of 800 characters, including spaces)	
<input type="checkbox"/> 3. CREW RESTRAINTS (Maximum of 800 characters, including spaces)	
<input type="checkbox"/> 4. WORKING TELEMETRY OR CAMERA SYSTEM (Maximum of 800 characters, including spaces)	
<input type="checkbox"/> 5. STORAGE/DEPLOYMENT SYSTEM (Maximum of 800 characters, including spaces)	
<input type="checkbox"/> 6. WEIGHT REDUCTION (Maximum of 800 characters, including spaces)	
<input type="checkbox"/> 7. VEHICLE STEERING (Maximum of 800 characters, including spaces)	
<input type="checkbox"/> 8. VEHICLE BRAKING (Maximum of 800 characters, including spaces)	



NASA Media Release for Parent and Minor

I, _____, am the parent/guardian/legal representative of
(Please print your name)

_____ and do hereby give permission
(Please print name of child)

for the above-named minor child (hereinafter "Minor") to be interviewed, photographed and/or videotaped by NASA or its representatives. I understand and agree that the text, photographs, and/or videotapes containing the words, image and/or voice of the Minor may be used in the production of instructional and/or promotional materials produced by or on behalf of NASA (hereinafter the "Program") and that such materials may be distributed or broadcast to the public and displayed publicly. I also understand that my permission to use the text, photographs and videotapes is for an unlimited duration and that neither I nor the Minor will receive any compensation for granting this permission or for the use, if any, by NASA of the Minor's words, image and/or voice.

I acknowledge that NASA has no obligation to use the Minor's words, image or voice in connection with the Program.

I hereby unconditionally release NASA and its representatives from any and all claims and demands arising out of the activities authorized under the terms of this agreement.

By signing below, I represent that I am at least 18 years of age and am the parent/guardian/legal representative of the above-named Minor. I have read the foregoing agreement and am familiar with all of the terms and conditions thereof and I consent to its execution by the Minor. I agree that neither I nor the Minor will revoke or disaffirm the this agreement at any time.

Signature of Parent/Guardian/Legal Representative of Minor: _____

Relationship to Minor: _____ Date: _____

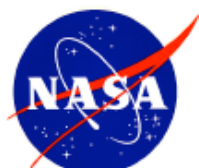
Signature of Minor: _____

Name and Location of Event: _____

Address: _____

Telephone: _____

Email: _____



**NASA Media Release for Adults
(Do Not Use for Minors)**

I, _____ do hereby give permission to be
(Please print name your name)

interviewed, photographed, and/or videotaped by NASA or its representatives in connection with a NASA production.

I understand and agree that the text, photographs, and/or videotapes thereof containing my name, likeness, and voice, including transcripts thereof, may be used in the production of instructional, promotional materials, and for other purposes that NASA deems appropriate and that such materials may be distributed to the public and displayed publicly one or more times and in different formats, including but not limited to, websites, cablecasting, broadcasting, and other forms of transmission to the public. I also understand that this permission to use the text, photographs, videotapes, and name in such material is not limited in time and that I will not receive any compensation for granting this permission.

I understand that NASA has no obligation to use my name, likeness, or voice in the materials it produces, but if NASA so decides to use them, I acknowledge that it may edit such materials. I hereby waive the right to inspect or approve any such use, either in advance or following distribution or display.

I hereby unconditionally release NASA and its representatives from any and all claims and demands arising out of the activities authorized under the terms of this agreement.

By signing below, I represent that I am of legal age, have full legal capacity, and agree that I will not revoke or deny this agreement at any time.

I have read the foregoing and fully understand its contents.

Accepted by:

Signature: _____ Date: _____

Name and Location of Event: _____

Address: _____

Telephone: _____

Email Address: _____