



# The 20th Annual NASA Great Moonbuggy Race

Keeping the Wheels of Inspiration, Innovation Turning for Two Decades



Huntsville Center for Technology student racers gear up for the 18th annual NASA Great Moonbuggy Race in April 2011. (NASA/MSFC)

The 20th NASA Great Moonbuggy Race is set for April 26-27, 2013, at the U.S. Space & Rocket Center in Huntsville, Ala. More than 90 student teams — many representing schools that field competitors year after year — will demonstrate the same engineering skills and innovation that made NASA's Apollo-era lunar rover program a success four decades ago.

The event challenges high school, college and university students to design, build and race lightweight, human-powered rovers — "moonbuggies" — which address engineering problems similar to those faced by NASA's lunar rover developers in the late 1960s. The competition is designed to teach students to troubleshoot and solve problems, and demonstrates NASA's continuing commitment to inspiring new generations of scientists, engineers, technicians and astronauts.

Teams registered to compete in the 2013 race include students from 23 states and Puerto Rico; and international challengers representing Canada, India, Germany, Mexico and Russia. Roughly a third of the registered teams are new to the race in 2013.

The race honors the legacy of the first NASA Lunar Roving Vehicle (LRV), which made its inaugural excursion on the moon's surface July 31, 1971, driven by Apollo 15 astronauts David Scott and James Irwin. Two more rovers followed in 1972, enabling still greater scientific exploration during the Apollo 16 and Apollo 17 missions.

Four decades later, teams competing in the NASA Great Moonbuggy Race strive to uphold that engineering tradition. Scheduled around a typical school year, the project begins during the fall term, as teams organize, solicit sponsors,

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**The team from the University of Alabama in Huntsville won first place in the college division of the 19th annual NASA Great Moonbuggy Race in April 2012. (NASA/MSFC)**

design their racing machines, choose components and begin construction. Each team may include up to six students and a teacher/mentor. High school students square off in one division; college and university teams compete in another.

Their challenge each year is to deliver a two-person, human-powered buggy, and to achieve the fastest vehicle assembly and race times, while avoiding penalties on a grueling course — slightly more than half a mile of rock, gravel, sand and other materials, which simulate the craters, ridges and lava rilles found on the harsh lunar surface. Top prizes are awarded to the three teams in each division that finish fastest, with the fewest penalties.

Six college teams participated in the first NASA Great Moonbuggy Race, held in 1994 to commemorate the 25th anniversary of the Apollo 11 lunar landing. The race was expanded in 1996 to include high school teams, and student participation has swelled each year since. More than 70 teams fielded moonbuggies during the 19th annual race in 2012.

The NASA Great Moonbuggy Race is organized annually by the Academic Affairs Office at NASA's Marshall Space

Flight Center in Huntsville. It is sponsored by the Human Exploration & Operations Mission Directorate at NASA Headquarters in Washington. The U.S. Space & Rocket Center has been NASA's partner in the event since 1996.

Major corporate sponsors for the race are Lockheed Martin Corporation, The Boeing Company, Northrop Grumman Corporation, Aerojet and Jacobs Engineering ESSSA Group, all with operations in Huntsville. Other corporate and institutional contributors include Science Applications International Corporation (SAIC) of Huntsville; ATK Aerospace Systems of Salt Lake City, Utah; Davidson Technologies Inc. of Huntsville; the Universities Space Research Association (USRA), headquartered in Columbia, Md.; the U.S. Army Aviation and Missile Research, Development and Engineering Center (AMRDEC) at Redstone Arsenal in Huntsville; Naval Mobile Construction Battalion Two-Four; Teledyne Brown Engineering and MSB Analytics Inc., both of Huntsville; the American Institute of Aeronautics and Astronautics (AIAA), headquartered in Reston, Va.; the National Space Club, headquartered in Washington; AI Signal Research Inc. of Huntsville; National Defense Industrial Association (NDIA) of Arlington, Va.; Infotech Enterprises; Industrial Fabrication Co., both of Huntsville; and the Tennessee Valley chapter of the International System Safety Society, headquartered in Unionville, Va.

The NASA Great Moonbuggy Race is one of dozens of educational programs and initiatives implemented by NASA each year to inspire and engage America's next generation of scientists, technicians, engineers and mathematicians — the explorers who will carry on the nation's mission of discovery in the decades to come.

### **The rules**

First-, second- and third-place winning teams in the high school and college divisions are selected based on the shortest total time to reconfigure their collapsed moonbuggies and complete the lunar obstacle course with a minimum of time penalties for various vehicle and course violations. Each team is permitted two runs of the course. The shortest total buggy assembly and course completion time, plus penalties, comprises each team's final score.

Each vehicle must be solely human powered and propelled by two students — one female and one male — over the course. Every vehicle is required to have a specific set of lunar rover-style accessories: fenders, a flag and simulated batteries, communications antenna, radio and TV camera.

To reach the starting line, teams first must demonstrate that their folded or collapsed moonbuggies will fit into a 4-foot-by-4-foot-by-4-foot cubic container, similar to transport

### Registered 2013 high school teams

Academy of Arts, Careers & Technology, Reno, Nev.  
Academy of Engineering & Green Technology/Hartford Public High School, Hartford, Conn.  
Broad Run High School, Ashburn, Va.  
Cape Girardeau Career & Technology Center (two teams), Cape Girardeau, Mo.  
Carlisle County High School, Bardwell, Ky.  
Central Magnet High School, Murfreesboro, Tenn.  
Columbia Basin High School, Pasco, Wash.  
Cookeville High School, Cookeville, Tenn.  
East Central High School, Hurley, Miss.  
Elk Valley High School, Longton, Kan.  
Escuela Pedro Falu, Rio Grande, Puerto Rico  
Escuela Superior Rafaelina E. Lebron Flores, Patillas, Puerto Rico  
Fairhope High School (two teams), Fairhope, Ala.  
Franklin County High School, Winchester, Tenn.  
Greenfield Central High School, Greenfield, Ind.  
Huntsville Center for Technology (two teams), Huntsville, Ala.  
International Space Education Institute, Leipzig, Germany  
Jupiter High School (two teams), Jupiter, Fla.  
Lima Senior High School, Lima, Ohio  
Mayfield High School, Las Cruces, N.M.  
Mount Juliet High School, Mount Juliet, Tenn.  
New Britain High School, New Britain, Conn.  
Oxford High School (two teams), Oxford, Miss.  
Pana High School, Pana, Ill.  
Pelham High School (two teams), Pelham, Ala.  
Petra Mercado High School, Humacao, Puerto Rico  
Riverside Christian Academy, Fayetteville, Tenn.  
San Andres High School, Las Cruces, N.M.  
Scotlandville Magnet High School, Baton Rouge, La.  
Teodoro Aguilar Mora Vocational High School (two teams), Yabucoa, Puerto Rico  
University Gardens High School, San Juan, Puerto Rico  
Virginia City High School (two teams), Virginia City, Nev.

### Registered 2013 college/university teams

Accurate Institute of Management & Technology, Uttar Pradesh, India  
Alabama A&M University, Huntsville, Ala.  
Auburn University, Auburn, Ala.  
Bevill State Community College (two teams), Sumiton, Ala.  
Cameron University, Lawton, Okla.  
Carleton University, Ottawa, Canada  
Central Connecticut State University, New Britain, Conn.  
Chandigarh Group of Colleges, Punjab, India  
Christian Brothers University (two teams), Memphis, Tenn.  
Colegio Nuestra Senora del Perpetuo Socorro (two teams), Humacao, Puerto Rico  
Colorado School of Mines, Golden, Colo.  
Drake State Technical College, Huntsville, Ala.  
Galgotias College of Engineering & Technology (two teams), Uttar Pradesh, India  
International Space Education Institute "Team Russia," Moscow, Russia  
Mahakal Institute of Technology, Ujjain, India  
Manipal University of Jaipur, Jaipur Rajasthan, India  
Marc Garneau Collegiate Institute, Toronto, Canada  
Middle Tennessee State University (two teams), Murfreesboro, Tenn.  
Mukesh Patel School of Technology Management & Engineering, Maharashtra, India  
North Dakota State University, Fargo, N.D.  
Ohio State University, Columbus, Ohio  
PEC University of Technology, Chandigarh, India  
Pittsburg State University (two teams), Pittsburg, Kan.  
Purdue University Calumet (two teams), Hammond, Ind.  
Rhodes College (two teams), Memphis, Tenn.  
Samford University, Birmingham, Ala.  
Shri Shankaracharya Group of Institutes, Chhattisgarh, India  
South Texas College, McAllen, Texas  
Southern Illinois University at Carbondale, Carbondale, Ill.  
Southwestern Oklahoma State University (two teams), Weatherford, Okla.  
Sri Ramaswamy Memorial (SRM) University, Chennai, Tamil Nadu, India  
Surya World College, Patiala, India  
Tecnologico de Monterrey Campus Cuernavaca, Xochitepec, Mexico  
Tennessee Technological University, Cookeville, Tenn.  
Texas A&M University-Kingsville, Kingsville, Texas  
Thapar University, Punjab, India  
University Institute of Engineering & Technology at Kurukshetra, Haryana, India  
University Institute of Engineering & Technology at Panjab, Chandigarh, India  
University of Alabama in Huntsville, Huntsville, Ala.  
University of Puerto Rico at Humacao, Humacao, Puerto Rico  
Universidad del Puerto Rico-Mayaguez, Mayaguez, Puerto Rico

conditions experienced by the original lunar rovers during their journeys to the moon's surface in the Lunar Excursion Module. Folded moonbuggies next are lifted by the two drivers and carried 20 feet without touching the ground, demonstrating lightweight portability. The buggies then are timed during assembly, readied for the course by the drivers and evaluated for safety by the judges.

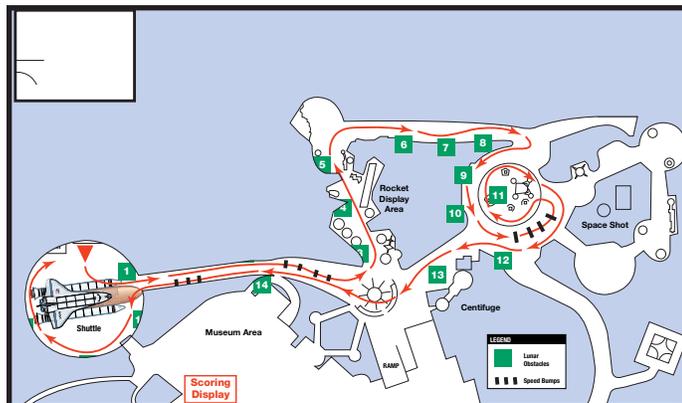
Many of these enduring vehicle requirements — the design constraints, the folded configuration, human pedaling power, transportability by hand and the onboard accessories — were the creation of Dr. Gerald Karr, a professor of mechanical engineering at the University of Alabama in Huntsville.

Buggies race against the clock, rather than side-by-side. Judges mark their progress, assessing time penalties if

the drivers touch the ground, leave the course or lose required onboard equipment. Moonbuggies having extreme difficulty on the course are subject to removal. Struggling racers receive a time warning at 4 minutes, and may be removed at the 6-minute mark if no further progress can be

made. Racers continuing to make forward progress will be permitted to continue, however — up to the official 8-minute course time limit.

Some 350 Marshall Center workforce volunteers to assist with the moonbuggy race each year, maintaining safety at numerous busy spots on the race course and serving as timekeepers, vehicle inspectors, obstacle judges and crossing guards.



### Course map

The NASA Great Moonbuggy Race course and specific obstacles vary slightly in detail from year to year. This outline gives participants a general idea of the course layout.

- The starting line is located under the space shuttle, near the “Pits” Area where moonbuggies are inspected and repaired. Obstacle 1 is under the space shuttle.
- Next, the course slopes up slightly on a paved path that leads to Obstacle 2, travels over a hill and then slopes downward to Obstacle 3.
- A sharp turn to the left leads through the U.S. Space & Rocket Center’s rocket display area to Obstacle 4 and Obstacle 5.
- The course turns sharply to the right, remaining on asphalt and moving uphill through Obstacle 6, Obstacle 7, Obstacle 8 and Obstacle 9.
- At the end of this straight section, a sharp turn brings participants to Obstacle 10, Obstacle 11 and Obstacle 12, on the circular downhill path leading to the lunar crater area.
- The course veers left into the permanent crater area and Obstacle 13. Racers must take a 360-degree, clockwise turn around this simulated lunar surface. Its largest interior crater includes a challenging, 15-inch change in surface roughness.
- Exiting the crater area, moonbuggies turn right toward Obstacle 14, Obstacle 15 and Obstacle 16, on a path that starts flat, then slopes uphill. The course slopes downward again to Obstacle 17.
- Finally, the course takes a left turn as racers enter the shuttle area and tackle Obstacle 18, Obstacle 19 and Obstacle 20 before reaching the finish line.

### The course

The U.S. Space & Rocket Center’s maintenance and grounds crew spends two weeks prior to each year’s competition preparing the simulated lunar course. It covers slightly more than a half-mile of cement patios and pathways that wind around the exterior of the popular Huntsville space museum and NASA Visitor Center, twining through an atmospheric backdrop of famous American rockets and space vehicles.

The course includes 20 unique obstacles built of plywood, aluminum and discarded tires. These obstacles and other portions of the course are sculpted from approximately 20 tons of gravel and 5 tons of sand. The material is carefully shaped to resemble craters, basins, ancient lava “rilles” and other obstacles found in the harsh lunar landscape.

Initially, the race was run on a Redstone Arsenal obstacle course used by the military to test its off-road vehicles. The unearthly landscape of the current course was designed in 1996 by Dr. Larry Taylor, a lunar geologist and professor at the University of Tennessee at Knoxville; Dr. J.M. Wersinger, a physics professor at Auburn University in Auburn, Ala.; and the Marshall Center’s Dr. Frank Six, now Marshall’s university affairs officer.

Safety is paramount on the challenging course. Every driver is required to wear a seatbelt during the race, and more than 175 hay bales line the drive path to protect speeding drivers and spectators alike.

### The repairs tent

Student “pit crews” make use of NASA’s buggy repairs tent throughout the competition, welding snapped struts, replacing bent wheels and installing new chains and sprockets. The tent includes work tables and benches, equipment and material supplies for crews working on up to eight moonbuggies at a time.

Team members make their own repairs, with oversight and guidance provided by Marshall Center engineers and technicians. All pit crew members are required to wear safety glasses in the work area, and repair operations are supervised and assisted as necessary by trained professionals.

Repair tent equipment, provided by the Metals Engineering Division of Marshall’s Engineering Directorate, includes a variety of welding machines, hand tools, machining equipment, duct tape and epoxy — and a sizeable pile of salvaged scrap metal to replace or strengthen damaged vehicle parts.



The team from Petra Mercado High School in Humacao, Puerto Rico, won first place in the high school division of the 19th annual NASA Great Moonbuggy Race in April 2012 at the U.S. Space & Rocket Center in Huntsville, Ala. (NASA/MSFC)

### The prizes

Top prizes are awarded to the three teams in the high school division and three in the college division that post the shortest official times, which factor in pre- and post-race inspection results, assembly and course time, obstacle faults and any other assessed penalties.

In the high school division, the first-place team receives a trophy from the Marshall Center. In the college and university division, the first-place team receives a trophy from the Marshall Center. The first-place winning team in each division also receives \$3,000 in cash from Lockheed Martin Corporation.

Marshall also gives commemorative plaques to the second- and third-place teams in the high school and college divisions, and presents a medallion and certificate to each team member of the top three teams in both divisions.

The Marshall Center's Engineering Directorate presents the Frank Joe Sexton Memorial Pit Crew Award plaque to the team whose engineering ingenuity, resourcefulness and teamwork most successfully overcomes race-day obstacles. Sexton, a NASA welder who mentored numerous welders and engineers among the Marshall workforce, worked on the original lunar rover and

numerous other space vehicles until his death in 2000. NASA also presents plaques for “Best Team Spirit” and “Featherweight.” The latter award recognizes the team that designs the lightest, fastest buggy on the track.

The AIAA Telemetry/Electronics Award is presented by AIAA to the team that develops and operates the most innovative and useful telemetry system — an automated data-gathering and delivery system mounted on the buggy to return real-time information during the race. This award includes a \$250 cash prize.

Additional prizes for each division include a \$500 cash award from AIAA for the “Neil Armstrong Best Design” award. A “Most Improved Team” award from Jacobs Engineering, includes a check for \$250. An award for fastest rookie team is a plaque presented by Northrop Grumman. AIAA also awards a “Crash and Burn” plaque to the college or university team that faces and resolves the most dramatic vehicle breakdown of the day’s race. AIAA also provides a “Best Design Report” award of \$250 and a plaque. The “System Safety” award is presented by

the System Safety Society, Tennessee Valley Chapter, and includes a \$250 check. The “Lunatic” award is presented by AIAA to the team in each division that wins the Moon Bowl, a lunar science quiz, and carries a \$250 cash award. SAIC provides every participating moonbuggy team with a commemorative plaque.

For complete race rules and other official information, visit:

**<http://moonbuggy.msfc.nasa.gov>**

For high-resolution images and additional information about past races, visit:

**<http://www.nasa.gov/topics/moonmars/moonbuggy.html>**

For information about other NASA education programs, visit:

**<http://education.nasa.gov>**

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