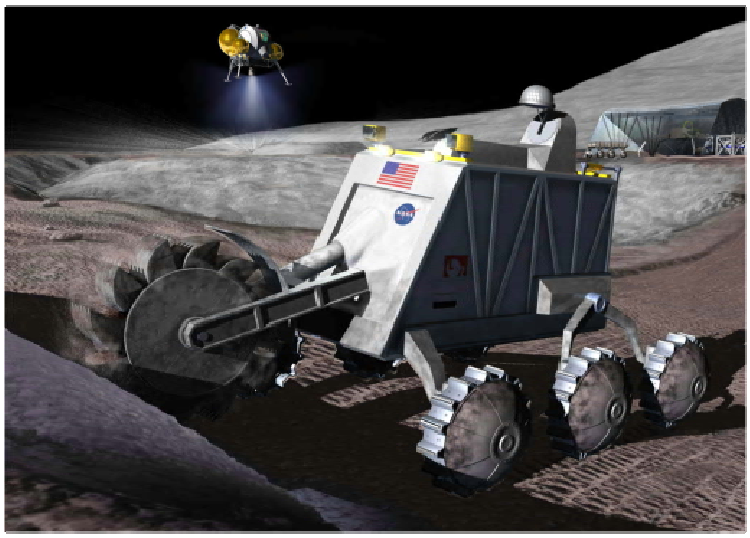
Lunabotics Mining Competition Rules

May 25-28, 2010

Kennedy Space Center

Astronaut Hall of Fame



Introduction

NASA's Lunabotics Mining Competition is designed to promote the development of interest in space activities and STEM (Science, Technology, Engineering, and Mathematics) fields. The competition uses excavation, a necessary first step towards extracting resources from the regolith and building bases on the moon. The unique physical properties of lunar regolith and the reduced 1/6th gravity, vacuum environment make excavation a difficult technical challenge. Advances in lunar regolith mining have the potential to significantly contribute to our nation's space vision and NASA space exploration operations.

The competition will be conducted by NASA at Kennedy Space Center. The prize funding for the Lunabotics Student Mining Competition is provided by NASA. The teams that can use telerobotic or autonomous operation to excavate the most lunar regolith simulant within a 15-minute time limit will win the competition. The minimum excavation requirement is 10.0 kg, and the excavation hardware mass limit is 80.0 kg. Winners are eligible to receive first, second, or third prize of $5,000, $2,500, and $1,000, respectively.

Undergraduate and graduate student teams enrolled in a U.S. college or university are eligible to enter the Lunabotics Mining Competition. Design teams must include: at least one faculty or industry advisor with a college or university affiliation and two or more undergraduate or graduate students. Teams will compete in up to five categories including: on-site mining, systems engineering paper, outreach project, slide presentation (optional), and team spirit (optional). Additionally, collaboration between a majority and minority serving institutions, digital video footage, and multidisciplinary teams earn teams additional points toward the Joe Kosmo Award for Excellence.

Prizes include monetary scholarships, a school trophy or plaque, individual certificates, KSC VIP launch invitations, and up to $1,500 travel expenses for each team member and one faculty advisor to participate with the NASA Desert RATS as the winners of the Joe Kosmo Award for Excellence.

Scoring rubrics and prize details are available at www.nasa.gov/lunabotics.

Game Play Rules

1) These rules and specifications may be subject to future updates by NASA at its sole discretion.

2) Teams will be required to perform 1 official competition attempt using lunar regolith simulant, sandbox and collector provided by NASA. NASA will fill the sandbox with compacted lunar regolith simulant that matches as closely as possible to the lunar regolith described in the Lunar Sourcebook: A User's Guide to the Moon, edited by G. H. Heiken, D. T. Vaniman, and B. M. French, copyright 1991, Cambridge University Press. NASA will randomly place 3 obstacles and create 2 craters on each side of the sandbox. Each competition attempt will occur with 2 teams competing at the same time in opposite directions, 1 on each side of the sandbox. After each competition attempt, the obstacles will be removed, the lunar regolith simulant will be returned to a compacted state, and the obstacles will be returned to the sandbox. See the Sandbox Diagrams on page 6.

3) In the official competition attempt, the teams that acquire (and deliver into the collector container) the first, second, and third most mass by excavating lunar regolith simulant over the minimum excavation requirement (10 kg) within the time limit (15 minutes) will respectively win first, second, and third place prizes. In the case of a tie, the teams will compete in a head-to-head round, where the team that acquires the most lunar regolith simulant in that round wins.

4) All excavated mass deposited in the collector during the official competition attempt will be weighed after completion of the competition attempt. Any obstacles deposited in the collector will be removed from the lunar regolith simulant collected.

5) The excavation hardware shall be placed in the randomly designated starting zones. The order of teams will be randomly chosen throughout the competition.

6) A team's excavation hardware shall only excavate lunar regolith simulant located in that team's respective mining zone at the opposite end of the sandbox from the team's starting zone. The team's exact starting point and transversal direction will be randomly selected immediately before the competition attempt.

7) The excavation hardware is required to move across the obstacle zone to the mining zone and then move back to the collector box to deliver the simulant into the collector box. See the Sandbox Diagrams on page 6.

8) Each team is responsible for placement and removal of their excavation hardware onto the lunar regolith simulant surface without the use of a ramp. There must be 1 person per 23 kg of mass of the excavation hardware, requiring 4 people to carry the maximum allowed mass. Assistance will be provided if needed.

9) Each team is allotted a maximum of 10 minutes to place the excavation hardware in its designated starting position within the sandbox and 5 minutes to remove the excavation hardware from the sandbox after the 15-minute competition attempt has concluded.

10) The excavation hardware operates during the 15-minute time limit of the competition attempt. The 15-minute time limit will be reduced if a team is not ready at the team's competition attempt start time. Time will start even if a team is still setting up their excavator after the 10 minute setup time period has elapsed. The competition attempt for both teams in the sandbox will end at the same time.

11) The excavation hardware will end operation immediately when the power-off command is sent, as instructed by the competition judges.

12) The excavation hardware cannot be anchored to the lunar regolith simulant surface prior to the beginning of the competition attempt.

13) Each team will be permitted to repair or otherwise modify the excavation hardware after the team's practice time. The excavation hardware will be inspected the evening before the competition takes place and quarantined until just before the team's competition attempt.

Field Rules

14) At the start of the competition attempt, the excavation hardware may not occupy any location outside the defined starting zone. At the start of each competition attempt the starting location and direction will be randomly determined.

15) The collector box top edge will be placed so that it is adjacent to the side walls of the sandbox without a gap and the height will be 1 meter from the top of the simulant surface directly below it. The collector top opening will be 1.65 meters long and .48 meters wide. See the Sandbox Diagrams in the Definitions. A target may be attached to the collector for navigation purposes only. This navigational aid must be attached during the setup time and removed afterwards during the removal time period. The mass of the navigational aid is included in the maximum excavation hardware mass limit of 80.0 kg and must be self-powered.

16) There will be 3 obstacles placed on top of the compressed lunar regolith simulant surface within the obstacle zone before the competition attempt is made. The placement of the obstacles will be randomly selected before the start of the competition attempt. No obstacles will be buried in the simulant. Each obstacle will have a diameter of approximately 20 to 30 cm and an approximate mass of 7 to 10 kg. Obstacles placed in the collector will not be counted as part of the excavated mass. There will be 2 craters of varying depth and width, being no wider or deeper than 30cm.

17) Excavation hardware must operate within the sandbox: it is not permitted to pass beyond the confines of the outside wall of the sandbox and the collector during the competition attempt. The regolith simulant must be collected in the mining zone allocated to each team and deposited in the collector. The team may only dig in its own mining zone. The simulant must be carried from the mining zone to the collector by any means. The excavator can separate intentionally, if desired, but all parts of the excavator must be under the team's control at all times. Any ramming of the wall may result in a safety disqualification at the discretion of the judges. A judge may disable the excavator by pushing the red emergency stop button at any time.

18) The excavation hardware must not push lunar regolith simulant up against the wall to accumulate lunar regolith simulant.

19) If the excavation hardware exposes the sandbox bottom due to excavation, touching the bottom is permitted, but contact with the sandbox bottom or walls cannot be used at any time as a required support to the excavation hardware. Teams should be prepared for airborne dust raised by either team during the competition attempt.

Technical Rules

20) During the competition attempt, excavation hardware is limited to autonomous and telerobotic operations only. No physical access to the excavation hardware will be allowed during the competition attempt. In addition, telerobotic operators are only allowed to use data and video originating from the excavation hardware. Visual and auditory isolation of the telerobotic operators from the excavation hardware in the Mission Control Room is required during the competition attempt. The Mission Control Room is approximately 60 meters from the sandbox. Telerobotic operators will be able to observe the sandbox through 2 fixed overhead cameras in 2 opposing corners of the sandbox through monitors that will be provided by NASA in the Mission Control Room. These monitors should be used for situational awareness only. The walls of the Mission Control Rooms are metal framed with 5/8" wall board on both sides of the framing. The sandbox will be outside the Astronaut Hall of Fame metal frame building in an enclosed tent.

21) Mass of the excavation hardware shall not exceed 80.0 kg. Subsystems on the excavator used to transmit commands/data and video to the telerobotic operators are counted towards the 80.0 kg mass limit. Equipment not on the excavator used to receive commands from and send commands to the excavation hardware for telerobotic operations is excluded from the 80.0 kg mass limit.

22) The excavation hardware must be equipped with an easily accessible red emergency stop button (kill switch) of minimum diameter 5 cm on the surface of the excavator requiring no steps to access. The emergency stop button must stop excavator motion and disable all power to the excavator with 1 push motion on the button.

23) The communications link used for telerobotic operations is required to have a total bandwidth of no more than 5.0 megabits/second. Teams will be required to demonstrate compliance prior to starting the competition attempt. Wi-Fi infrastructures will be provided and monitored by NASA: 1 for practice and 1 for the competition attempt. IP addresses will be provided and managed by NASA. Each team must request anticipated IP address requirements by March 15, 2010 by e-mailing Susan Sawyer at Susan.G.Sawyer@nasa.gov. IP address requests will be processed on January 15 and March 15, 2010. NASA anticipates a minimum of 2 IP addresses for each team. NASA technical experts will offer feedback on real-time networking performance during practice attempts. There will be no lunar latency time delay imposed on teams by NASA this year.

24) The excavation hardware must be contained within 1.5m width x .75m length x 2m height. The hardware may deploy beyond the 1.5 m x .75 m footprint after the start of the competition attempt, but may not exceed a 2 meter height. The excavation hardware may not pass beyond the confines of the outside wall of the sandbox and the collector during the competition attempt to avoid potential interference with the surrounding tent. The team must declare the orientation of length and width to the inspection judge. Because of actual lunar hardware requirements, no ramps of any kind will be provided or allowed.

25) To ensure that the excavation hardware is usable for an actual lunar mission, the excavation hardware cannot employ any fundamental physical processes (e.g., suction or water cooling in the open lunar environment), gases, fluids or consumables that would not work in the lunar environment. For example, any dust removal from a lens or sensor must employ a physical process that would be suitable for the lunar surface. Teams may use processes that require an Earth-like environment (e.g., oxygen, water) only if the system using the processes is designed to work in a lunar environment and if such resources used by the excavation hardware are included in the mass of the excavation hardware.

26) Components (i.e. electronic and mechanical) are not required to be space qualified for the lunar vacuum, electromagnetic, and thermal environments.

27) The excavation hardware may not use any process that causes the physical or chemical properties of the lunar regolith simulant to be changed or otherwise endangers the uniformity between competition attempts.

28) The excavation hardware may not penetrate the lunar regolith simulant surface with more force than the weight of the excavation hardware before the start of the competition attempt.

29) No ordnance, projectile, far-reaching mechanism, etc. may be used (excavator must move on the lunar regolith simulant).

30) No excavation hardware can intentionally harm another team's hardware. This includes radio jamming, denial of service to network, regolith simulant manipulation, ramming, flipping, pinning, conveyance of current, or other forms of damage as decided upon by the judges. Immediate disqualification will result if judges deem any maneuvers by a team as being offensive in nature. Erratic behavior or loss of control of the excavation hardware as determined by the judges will be cause for immediate disqualification.

31) Teams must submit documentation containing a description of the excavation hardware, its operation, potential safety hazards, a diagram, and basic parts list. Each team will deliver the team's written documentation in .pdf by May 10, 2010 to Susan.G.Sawyer@nasa.gov.

32) Teams must submit video documentation containing no less than 30 seconds of excavation hardware operation and at least 1 full cycle of operation. One full cycle of operations includes excavation and depositing material. Each team will deliver their video documentation by May 10, 2010 to Susan.G.Sawyer@nasa.gov. This video documentation is solely for technical evaluation of the team's excavation hardware. It is not for the video category in the overall Lunabotics Mining Competition. Video specifications:

Formats/Containers: .avi, .mpg, .mpeg, .ogg, .mp4, .mkv, .m2t, .mov; Codecs: MPEG-1, MPEG-2, MPEG-4 (including AVC/h.264), ogg theora; Minimum frame rate: 24 fps; Minimum resolution: 320 x 240 pixels

Definitions

Collector – A device provided by NASA for the competition attempt into which each team will deposit excavated regolith simulant. The collector will be large enough to accommodate each team's excavated regolith simulant. The collector will be stationary and located adjacent to the sandbox. Excavated regolith simulant mass will be measured after completion of the competition attempt. The collector mass will not be counted towards the excavated mass or the mass of the excavation hardware. The collector will be 1.65 meters long and .48 meters wide. The collector walls will rise to an elevation of 1 meter above the regolith simulant surface directly below the collector. See the Sandbox Diagrams on page 6.

Competition attempt – The operation of a team's excavation hardware intended to meet all the requirements for winning the competition by performing the functional task. The duration of the competition attempt is 15-minutes.

Excavated mass – Mass of the excavated lunar regolith simulant delivered to the collector by the team's excavation hardware during the competition attempt, measured in kilograms (kg) with official result recorded to the nearest one tenth of a kilogram (0.1 kg).

Excavation hardware – Mechanical and electrical equipment, including any batteries, gases, fluids and consumables delivered by a team to compete in the competition.

Functional task – The excavation of regolith simulant from the sandbox by the excavation hardware and deposit from the excavation hardware into the collector box.

Lunar regolith simulant – Specific lunar regolith simulant provided by NASA during the competition attempt is to be determined. The simulant will have a particle size and distribution similar to the lunar regolith as stated in the Lunar Sourcebook: A User's Guide to the Moon, edited by G. H. Heiken, D. T. Vaniman, and B. M. French, copyright 1991, Cambridge University Press. Teams are encouraged to develop or procure simulants based on lunar type of minerals and lunar regolith particle size, shape, and distribution.

Minimum excavation requirement – 10.0 kg is the minimum excavated mass which must be met in order to qualify to win the competition.

Power – All power shall be provided by a system onboard the excavator. No facility power will be provided to the excavator. There are no power limitations except that the excavator must be self-powered and included in the maximum excavation hardware mass limit of 80.0 kg.

Practice time – Teams will be allowed to practice with their excavators in the sandbox on May 25 and 26, 2010. NASA technical experts will offer feedback on real-time networking performance during practice attempts.

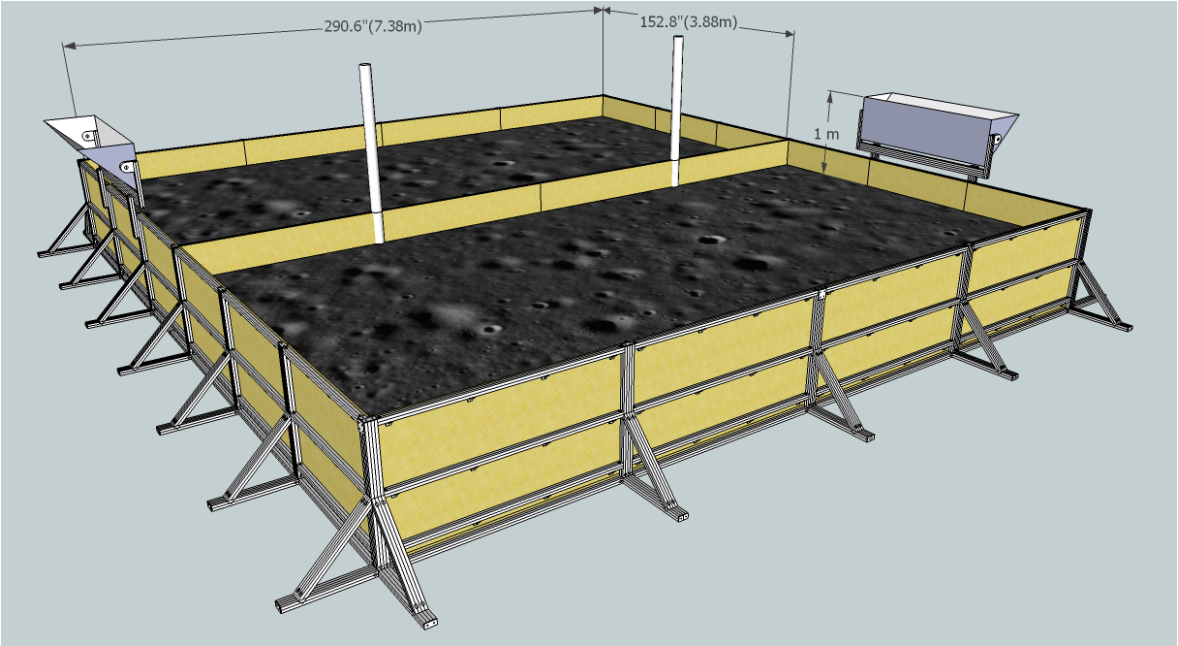
Reference point – A fixed location on the excavation hardware that will serve to verify the starting location and traversal of the excavation hardware within the sandbox. An arrow on the reference point must mark the forward direction of the excavator in the starting position configuration. The judges will use this reference point and arrow to orient the excavator in the randomly selected direction and position.

Sandbox – An open-topped container (i.e., a box with a bottom and 4 side walls only), containing regolith simulant, within which the excavation hardware will perform the competition attempt. The inside dimensions of the each side of the sandbox will be 7.38 meters long and 3.88 meters wide, and 1 meter in depth. A dividing wall will be in the center of the sandbox. The sandbox for the official practice days and competition will be provided by NASA. See the Sandbox Diagrams on page 6.

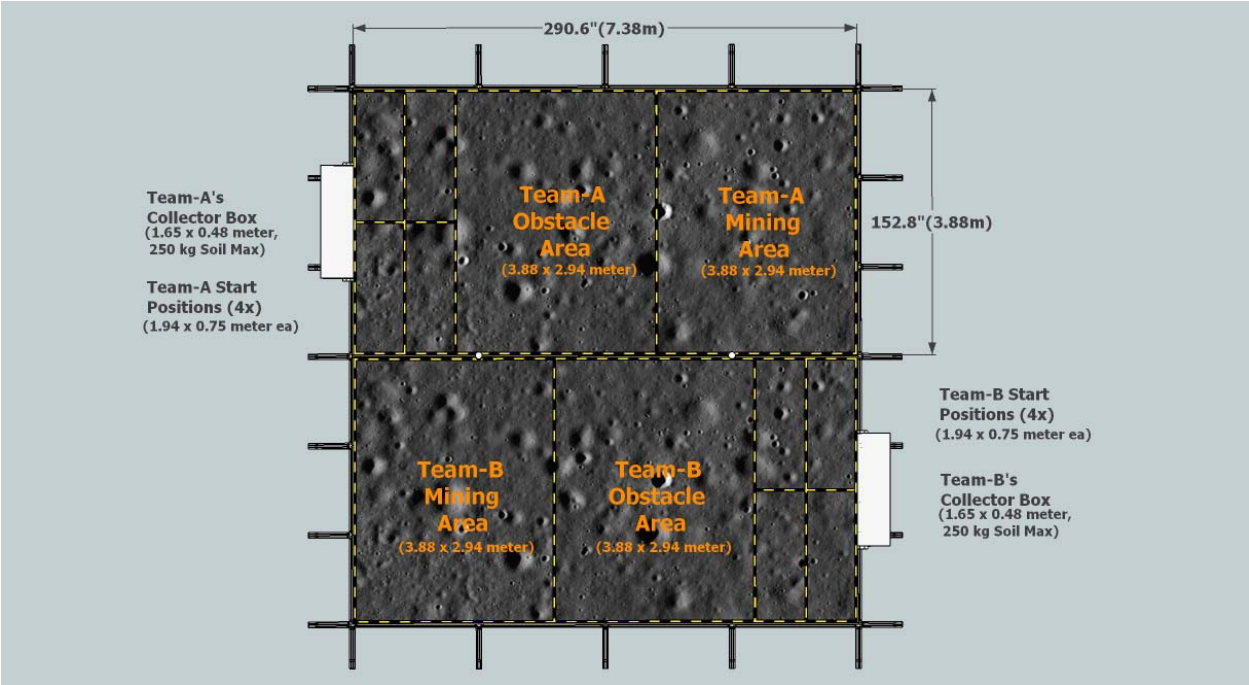
Telerobotic – Communication with and control of the excavation hardware during the competition attempt must be performed solely through the provided communications link which is required to have a total bandwidth of no more than 5.0 megabits/second on all data and video sent to and received from the excavation hardware.

Time Limit – The amount of time within which the excavation hardware must perform the functional task, set at 15 minutes; set up excavation hardware, set at 10 minutes; and removal of excavation hardware, set at 5 minutes.

Sandbox Diagrams



Sandbox Diagram (side view)



Sandbox Diagram (top view)