AWARDS

The Judges Innovation Award

Awarded to the team with the best design based on creative construction, innovative technology and overall architecture.

NASA's Solar System Exploration Research Virtual Institute (SSERVI) Regolith Mechanics Award

Awarded for the best example of a granular materials related innovation that identified a specific mechanics problem (e.g. regolith flowing around the grousers, angle of repose too high in the dump bucket) and improved their design to deal with it. From the NASA Solar System Exploration Research Virtual Institute (SSERVI's) Center for Lunar and Asteroid Surface Science (CLASS).

The Caterpillar Autonomy Award

Awarded to the teams with the first, second, third, fourth, fifth, and sixth most autonomous points averaged from both mining attempts. In the event of a tie, the team that deposits the most simulated icy regolith (rock/gravel) will win. If no simulated icy regolith is deposited, the Mining Judges will choose the winner. The fourth, fifth, and sixth places are new to the Caterpillar Autonomy Award. The intent is to incentivize more teams in attempting autonomy. It should be noted that the 50-point level in autonomy does not required depositing of material into the collection bin.

Robotic On-Site Mining Award

Awarded to the teams with the first, second and third most mining points averaged from both mining attempts. In the event of a tie, the team that deposits the most simulated icy regolith (rock/gravel) will win.

Category	Award
The Judge's Innovation Award	Trophy/Plaque
The SSERVI Regolith Mechanics Award	Trophy/Plaque
Caterpillar Autonomy Award	1st - $2000
	2nd - $1250
	3rd - $750
	4th - $500
	5th - $250
	6th - $250
Mining Award	1st - $2000
	2nd - $1500
	3rd - $750

ON-SITE MINING

A minimum amount of 1.0 kg of rock/gravel must be mined and deposited during either of the two competition attempts to qualify to win in this category. If the minimum amount of 1.0 kg gravel is not met for an attempt, then the total score for that attempt will be 0. In the case of a tie, the teams will compete in a tie-breaking competition attempt. All decisions by the judges are final.

Mining Points Calculator				
Mining Category Elements	**Specific Points**	**Actual Points**	**Units**	**Mining Points**
Pass Inspections	0 or 1,000	0.00	1=Achieved	1,000.00
			0=Not Achieved	
Gravel (icy-regolith) over 1.0 kg:	15/kg	11.00	Kg	150.00
Mining Robot Mass	-8/kg	62.55	Kg	-500.40
Report Energy Consumed	-1/watt-hour	9.00	Watt-hour	-9.00
Dust Tolerant Design (30%) & Dust Free Operation (70%)	0 to +100	30 design 10 operation	Judges Decision (JD)	49.00
Autonomy	50,150,250 or 500	150.00	(JD)	150.00
Total Points				810.60

Table 1. Example Mining Score Sheet.

UA Mining Arena
Competition Arena Dimensions and Characteristics

Inside dimensions of the arena:
Length Total: 7.38 m
Width Total: 3.78 m
Gravel approximate depth: 30.5 cm
UA-1 (crushed limestone) approximate depth over gravel: 30.5 cm

The mining arena will not have a level surface, since planetary surfaces are random and chaotic. Be prepared for slopes, irregularities and small rocks in the regolith simulant surface.

The competition arena is constructed using masonry block walls. One wall is floor to ceiling, and the others are approximately 86 cm (34”) high from the floor. The UA-1 (~30.5 cm (12”) deep on top) and gravel (~30.5 cm (12”) deep on bottom) are approximately 61 cm (24”) deep combined, and the masonry walls extend approximately 25.4 – 30.5 cm (10-12”) above the surface of the UA-1 on three sides of the arena. On the fourth side, the masonry wall extends to the ceiling. From the 86 cm (34”) line to the floor, the inside surface of all four masonry walls is painted matte black. Above the 86 cm (34”) line on the fourth wall, the wall is painted tan/beige. The glass enclosure is supported with a matte black anodized aluminum frame mounted to the top of two of the short masonry walls. There is a glass sliding door at the top of the ramp to access the arena. (See the additional diagrams for more details.)

The original dimensions for the 2019 NASA competition arena were specified as 3.691 m x 5.756 m. The UA arena was built to 2018 NASA specs measuring 3.78 m x 7.38 m. So, the width is nearly identical, but the UA arena is longer. While the overall dimensions of the 2019 NASA arena were posted, the sizes of the starting, obstacle, and mining zones were never defined. Therefore, the dimensions from the 2018 NASA arenas are used as a basis for each of the zones for the 2019 Challenge.

Starting Zone:
The 2018 NASA starting zone measured 3.78 m x 1.5 m. NASA divided this zone into two equal halves measuring 1.89 m x 1.5 m. The 2019 UA starting zone measures 3.78 m x 1.90 m. The extra depth is to accommodate the collector trough which is 1.65 m long plus an extra access area (0.25 m) to allow access to the trough along one side. The primary difference for 2019 is that NASA placed the collector trough on the side of the starting zone on the inside of the arena. So now, the collector trough is consuming some of the real estate inside the starting zone. In the UA arena, the 2019 right/left starting zones were created by taking the 3.78 m dimension minus the 0.48 m required for the trough and dividing it into two equal halves, starting zones A and B. The resulting dimensions of each starting zone are 1.65 m x 1.90 m. These are slightly larger than the starting zones from the 2018 RMC due to the added depth for the Collector Bin. (See the additional diagrams for the details.)

Obstacle Zone:
The 2018 NASA obstacle zone measured 3.78 m x 2.94 m. The 2019 UA obstacle zone measures 3.78 m x 2.74 m.

Mining Zone:
The 2018 NASA mining zone measured 3.78 m x 2.94 m. The 2019 UA mining zone measures 3.78 m x 2.74 m.

Competition Arena Environment
The arena will be indoors and the atmosphere will be an air-conditioned facility without significant air currents and cooled to approximately 73° F (23° C).

Competition Arena Lighting Conditions
The competition arena is inside a lab with regular fluorescent lighting. There are several windows that allow additional natural light into the arena as well.

SDS for Crushed Limestone (UA-1)
See separate SDS document.

Specs on gravel (icy regolith simulant)
The icy regolith simulant is a #5 washed gravel purchased from a local quarry. Its size ranges from < 1.27 cm (0.5") to just over 3.81 cm (1.5"). It has a similar mean size (~ 2 cm (0.78")) as that used by NASA at KSC, however, it is more dense. Last year, the KSC gravel was very "light" almost like a volcanic pumice. The gravel in the UA arena is much more like the typical gravel one would see on a gravel road. It is estimated that the UA gravel is approximately 2x the density of the NASA gravel based upon testing results and the masses collected during the 2018 RMC.

The #5 gravel is sort of a "standard" and you should be able to find it anywhere.

Collector Trough
The collector trough is the same design from 2018. In 2019, the sieve back edge will be placed on a wall of the mining arena with the trough hanging over into the arena as shown in the drawings. The top opening inner dimensions for both the trough and the sieve screen placed above it are: 1.5 m long by 0.457 m deep with slope angles of 44 degrees long sides and 51 degrees at the ends.

With the addition of the sieve screen, the effective height of the collector trough lip is raised by 3.8 cm above the trough alone. The sieve screen is 6.4 cm below the sieve frame top.

The outside dimensions of the collector trough and sieve frame are 1.65 m long and .48 m wide.

The top edge of the sieve will be approximately 0.55m +/- 0.05m from the top of the regolith surface directly below it. The sieve screen frame will have the same opening dimensions and internal slope angles as the trough but will be suspended above it.

The mesh is standard hardware mesh with the center to center distance of 12.7 mm and wire diameter of 1.58 mm with square openings 11.1 mm on a side.

These are the specs directly from the NASA rules document. We will attempt to build the collector trough as close as possible to these specs. Note, the position of the collector trough within the arena was never specified by NASA for 2019. Its position is based upon the preliminary NASA diagrams.

Also, we plan to build the trough so that its front side (against which robots will dock to offload) and the two short sides will extend down to the top of the regolith. This will eliminate access to

the area directly beneath the trough and prevent robots from potentially getting stuck under the trough. No final design for this is available yet. Photos and/or diagrams will be posted as soon as possible.

Finally, the collector trough will be in the same location for all competition runs. It is not feasible to move it between competition runs. Thus, we cannot mimic the 2019 NASA plan where the two competition arenas were mirror images of each other and the trough was on the right or left depending upon the arena.

Mission Control Center (MCC)
As shown in the additional diagrams, the MCC is in the same lab as the competition arena. The control team will have access to time and current gravel weight throughout their competition run. They will also have access to at least one camera view within the arena. The control team will be separated from the competition arena by partitions so they can't physically see the robot.

RULES

1. Teams will be required to perform two official competition attempts (10 minutes each) to mine the rock/gravel in the arena. The mining area will contain UA-1 (crushed limestone) to a depth of approximately 30.5 cm. Below the UA-1 lies the rock/gravel (icy-regolith simulant) with a mean particle size diameter of ~ 2 cm. Larger rocks may also be mixed in with the UA-1 and rock/gravel in a random manner. Note that rock/gravel may be mixed in with the UA-1, but the bulk of it will lie under the UA-1 in the mining area only. Surface features will consist of craters on each side of the arena with three, randomly placed obstacles. The mining robot will be placed in the arena in a randomly selected starting position. Each competition attempt will occur with one team competing at a time. After each competition attempt, the obstacles and craters will be returned to their starting state.

2. Scoring for the Mining Category will require teams to consider a number of design and operation factors such as dust tolerance and projection, communications, vehicle mass, energy/power required, and autonomy. In each of the two official competition attempts, the teams will score cumulative mining points.

3. See Table 1 for the Mining Points Calculator. The teams' mining points will be the average of their two competition attempts.

   a. Each team will earn 1000 Mining points after passing the safety inspection and communications check.

   b. During each competition attempt, the team will earn 15 Mining points for each kilogram in excess of 1.0 kg of rock/gravel deposited in the Collector Bin. (For example, 11 kg of gravel mined will earn 150 Mining points.) The rock/gravel will be sieved out at the Collector Bin and weighed separately from the UA-1.

c. There will be no bandwidth penalty and no penalty for use of the situational awareness camera(s).

d. During each competition attempt, the team will lose 8 Mining points for each kilogram of total mining robot mass. (For example, a mining robot that weighs 80 kg will lose 640 Mining points).

e. During each competition attempt, the team will lose one (1) Mining point for each watt-hour of energy consumed. The electrical energy consumed must be displayed by an (commercial-off-the-shelf or "COTS") electronic data logger and verified by a judge.

f. During each competition attempt, teams can earn up to 100 Mining points for dust tolerant design features on the mining robot (up to 30 Mining points) and dust free operation (up to 70 Mining points). If the mining robot has exposed mechanisms where dust could accumulate during a Martian mission and degrade the performance or lifetime of the mechanisms, then fewer Mining points will be earned in this category. If the mining robot raises a substantial amount of airborne dust or projects it due to its operations, then, fewer Mining points will be earned. Ideally, the mining robot will operate in a clean manner without dust projection, and all mechanisms and moving parts will be protected from dust intrusion. The mining robot will not be penalized for airborne dust while dumping into the Collector Bin. All decisions by the judges regarding dust tolerance and dust projection are final.

g. DUST-TOLERANT DESIGN - The 30 points for dust-tolerant design will be broken down as follows:

i. Drivetrain components enclosed/protected and other component selections	10 points
ii. Custom dust sealing features (bellows, seals, etc.)	10 points
iii. Active dust control (brushing, electrostatics, etc.)	10 points

h. DUST-FREE OPERATION - The 70 points for dust-free operation will be broken down as follows:

i. Driving without dusting up crushed limestone	20 points
ii. Digging without dusting up crushed limestone	30 points
iii. Transferring crushed limestone without dumping the crushed basalt on your own Robot	20 points

i. AUTONOMOUS OPERATION - During each competition attempt, the team will earn up to 500 Mining points for autonomous operation. Mining points will be awarded for successfully completing the following activities autonomously:

   i. Crossing the obstacle field (one time only):
      Starting from time zero in the starting area and successfully traversing the obstacle field and fully entering the mining area. (50 points)

ii. Crossing the obstacle field, excavate and returning to the collection bin: Starting from time zero in the starting area and successfully traversing the obstacle field and fully entering the mining area. Excavating material and returning to the collection bin and depositing material. (150 points)

iii. Crossing the obstacle field, excavate and depositing regolith (two times): Starting from time zero in the starting area and successfully traversing the obstacle field and fully entering the mining area. Excavating material and returning to the collection bin and depositing material. Successfully completing two times. (250 points)

iv. Fully autonomous run for 10 minutes with a minimum of 2 complete dig/dump cycles (500 points)

j. The points earned for autonomy are not cumulative. Levels 1 through 4 points will be incrementally achieved. For example if level 2 is achieved then the points for level 1 are not counted. If the robot fails to achieve autonomy during the competition attempt, and manual control is regained, then only autonomy points achieved to that point in time will be allowed.

k. For a team to earn mining points in the autonomous category, the team cannot touch the controls during the autonomous period. If the team touches the controls, then the autonomy period for that run is over; however, the team may revert to manual control to complete that run. Start and stop commands are allowed at the beginning and end of the autonomous period. Orientation data cannot be transmitted to the mining robot in the autonomous period. Telemetry to monitor the health of the mining robot is allowed during the autonomous period. The mining robot must continue to operate for the entire 10 minutes to qualify for a fully autonomous run.

l. The walls of the UA Mining Arena shall not be used for sensing by the robot to achieve autonomy. The team must explain to the inspection judges how their autonomous systems work and prove that the autonomy sensors do not use the walls. There are no walls on off-world locations and teams shall operate as closely as possible on that scenario of operations. Integrity is expected of all team members and their faculty advisors. Failure to divulge the method of autonomy sensing shall result in disqualification from the competition.

4. All excavated mass deposited in the Collector Bin during each official competition attempt will be weighed after the completion of each competition attempt. All rock/gravel will be sieved out from the UA-1 at the Collector Bin and weighed separately.

5. The mining robot will be placed in a randomly selected starting position.

6. A team's mining robot may only excavate UA-1 and gravel located in the mining area at the opposite end of the UA Mining Arena from the team's starting area. The team's starting direction will be randomly selected immediately before the competition attempt. Mining is allowed as soon as the mining line is crossed by the front end of the robot.

7. The mining robot is required to move across the obstacle area to the mining area and then move back to the Collector Bin to deposit the UA-1 and rock/gravel into the Collector Bin.

8. Each team is responsible for placement and removal of their mining robot onto the UA-1 surface. There must be one person per 20 kg of mass of the mining robot, requiring four 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 mining robot in its designated starting position within the UA Mining Arena; and remove the mining robot from the Mining arena after the 10-minute competition attempt has concluded and as directed by the Mining Judge.

10. The mining robot operates during the 10-minute time limit of each competition attempt.

11. The mining robot will end operation immediately when the power-off command is sent, and as instructed by the Mining Judge.

12. The mining robot cannot be anchored to the UA-1 and or rock/gravel surface prior to the beginning of each competition attempt.

13. The mining robot will be inspected during the practice days and right before each competition attempt. Teams will be permitted to repair or otherwise modify their mining robots while the RoboPits are open.

14. At the start of each competition attempt, the mining robot may not occupy any location outside the defined starting position in the mining arena.

15. Navigation
    a. Targets or beacons may be attached to the collector trough (not the sieve frame) for navigation purposes only. This navigational aid system must be attached during the setup time and removed afterwards during the removal time period. If attached to the collector trough, it must not exceed the length of the trough and not weigh over 9 kg.

    b. The navigational aid system may not be higher than 0.25 m above the Collector Trough, and cannot be permanently attached or cause alterations (ex: no drilling, nails, etc.).
    c. The mass of the navigational aid system is included in the maximum mining robot mass limit of 80.0 kg and must be self-powered.

d. The target/beacon may send a signal or light beam or use a laser based detection system. Only Class I or Class II laser or low powered lasers (< 5mW) are allowed. Supporting documentation from the laser instrumentation vendor must be provided to the inspection judges for “eye-safe” lasers.

e. The judges will inspect and verify that all laser devices are Class I or II lasers or low powered lasers (< 5mW) and laser based detection system products which have not been modified (optics or power).

f. Inertial measurement units (IMU) are allowed on the mining robot. Teams have to explain to the judges how the compass feature will be switched off or the compass data is subtracted to ensure the internal calculations do not make use of the compass (from any magnetic field surrounding the robot).

g. Compasses (analog, digital, etc.) are not allowed on the mining robot.

h. Global Positioning Satellite (GPS) or IMU-enabled GPS devices are not allowed. Teams have to explain to the judges how the device will be switched off or the data is subtracted and ensure the internal calculations do not make use of the GPS or IMU-enabled GPS device.

16. There will be at least three obstacles placed on top of the compressed UA-1 surface within the obstacle area before each competition attempt is made. The placement of the obstacles will be randomly selected before the start of the competition. Each obstacle will have a diameter of approximately 10 to 30 cm and an approximate mass of 3 to 10 kg. There will be two craters of varying depth and width, being no wider or deeper than 30 cm. No obstacles will be intentionally buried in the UA-1 by the Challenge, however, UA-1 includes naturally occurring rocks.

17. The mining robot must operate within the UA Mining Arena: it is not permitted to pass beyond the confines of the outside wall of the Arena and the Collector Bin during each competition attempt. The gravel must be mined in the mining area and deposited in the Collector Bin. A team that excavates any material from the starting or obstacle areas will be disqualified. The gravel must be carried from the mining area to the Collector Bin by any means and be deposited in the Collector Bin in its raw state. A secondary container like a bag or box may not be deposited inside the Collector Bin. Depositing a container in the Collector Bin will result in disqualification of the team. The mining robot can separate intentionally, if desired, but all parts of the mining robot 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. The walls may not be used for the purposes of mapping autonomous navigation and collision avoidance (there are no walls on off world locations). Touching or having a switch sensor spring wire that may brush on a wall as a collision avoidance sensor is not allowed.

18. The mining robot must not use the wall as support or push/scoop the rock/gravel up against the wall to accumulate the excavated mass. If the mining robot exposes the mining arena bottom due to excavation, touching the bottom is permitted, but contact with the mining arena bottom or walls cannot be used at any time as a required support to the mining robot.

19. During each competition attempt, the mining robot is limited to autonomous and telerobotic operations only.

    a. No physical access to the mining robot will be allowed during each competition attempt.

    b. Arena team members are not allowed to point out obstacles/arena surface conditions to the Mission Control Center team members. In addition, telerobotic operators are only allowed to use data and video originating from the mining robot and the Challenge video monitors.

    c. Visual isolation of the telerobotic operators from the mining robot in the Mission Control Center is required during each competition attempt. Telerobotic operators will be able to observe the mining arena through at least one overhead camera in the mining arena via monitors that will be provided by the Challenge in the Mission Control Center. These color monitors should be used for situational awareness only.

    d. No other outside communication via cell phones, radios, other team members, etc. is allowed in the Mission Control Center once each competition attempt begins. During the 10 minute setup period, a handheld radio link will be provided between the Mission Control Center team members and team members setting up the mining robot in the mining arena to facilitate voice communications during the setup phase only.

    e. Team operators are not permitted to update or alter the autonomy program to account / detect or upload information about obstacle locations.

    f. During autonomous operation, teams are allowed to interact with an interface that allows different pieces of telemetry data to be viewed as long as there is no real time or other interaction to control or influence the robot. Teams must explain to the attending judge before each competition run how they are interacting with the telemetry system and the judge will observe to ensure compliance with all RMC rules.

20. The mining robot mass is limited to a maximum of 80.0 kg. Subsystems on the mining robot used to transmit commands/data and video to the telerobotic operators are counted toward the 80.0 kg mass limit. Equipment not on the mining robot used to receive data from and send commands to the mining robot for telerobotic operations is excluded from the 80.0 kg mass limit.
21. The mining robot must provide its own onboard power. No facility power will be provided to the mining robot during the competition runs. There are no power limitations except that the mining robot must be self-powered and included in the maximum mining robot mass limit of

80.0 kg. The energy consumed must be recorded with a commercial off-the-shelf (COTS) electronic data logger device. Actual energy consumed during each competition run must be shown to the judges on the data logger immediately after the competition attempt.

22. The mining robot must be equipped with an easily accessible red emergency stop button or ""Kill Switch"". The emergency stop button or ""Kill Switch"" shall have a minimum diameter of 40 mm on the surface of the mining robot requiring no steps to access. The ""Kill Switch"" shall not cut power to the data-logger installed. There can be more than one ""Kill Switch"" on the robot. The spirit and intent of the ""Kill Switch"" is that it is easily accessible and can be safely activated by anyone in an easy and quick manner. Use good engineering practices and principles in placing the "Kill Switch" on your robot, failure to do so may result in a safety disqualification. The "Kill Switch" is required to be on the robot and enabled at all times during the competition week. Disabling the "Kill Switch" without authorization from the Competition Staff shall result in a safety disqualification. The emergency stop button must stop the mining robot's motion and disable all power to the mining robot with one push motion on the button. It must be highly reliable and instantaneous. For these reasons an unmodified commercial off-the-shelf (COTS) red button is required. A closed control signal to a mechanical relay is allowed as long as it stays open to disable the mining robot. This rule is to safe the mining robot in the event of a fire or other mishap. The button should disconnect the batteries from all controllers (high current, forklift type button) and it should isolate the batteries from the rest of the active sub-systems as well. Only laptop computers may stay powered on if powered by its internal battery.

23. The mining robot mass is limited to a maximum of 80.0 kg and must be contained within 1.5 m x 0.75 m x 0.75 m box/envelope. The mining robot may deploy or expand beyond the 1.5 m x 0.75 m footprint after the start of each competition attempt, but may not exceed a 1.5 meter height. The mining robot mass is limited to a maximum of 80.0 kg. During the excavated mass dumping operations only, the mining robot may deploy itself and exceed 1.5 m in height, but must be lower than the ceiling height which is less than 2.4 m above the surface of the regolith.

24. The mining robot may not pass beyond the confines of the outside wall of the UA Mining Arena and the Collector Bin during each competition. The team must declare the orientation of length and width to the inspection judge. Because of actual Lunar/Martian hardware requirements, no ramps of any kind will be provided or allowed. An arrow on the reference point (the reference location and arrow pointing forward can be any point and direction of the team's choosing, except up) must mark the forward direction of the mining robot in the starting position configuration. The judges will use this reference point and arrow to orient the mining robot in the randomly selected direction and position. One or multiple permanent-type marker(s) indicating the team's choice of forward direction on any location on the robot is acceptable as long as multiple arrows do not conflict. The arrow does not have to indicate the robot's preferred forward direction. The arrow is used only to orientate the robot prior to starting the robot run to face the robot arrow either north, east, south or west after spinning the direction wheel. Multiple mining robot(s) systems are allowed but the total mass and

starting dimensions of the whole system must comply with the volumetric dimensions given in this rule.

25. To ensure the mining robot is usable for an actual mission, the mining robot cannot employ any fundamental physical processes, gases, fluids or consumables that would not work in an off-world environment. For example, any dust removal from a lens or sensor must employ a physical process that would be suitable for the Lunar or Martian 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 or Martian environment and if such resources used by the mining robot are included in the mass of the mining robot. Closed pneumatic mining systems are allowed only if the gas is supplied by the mining robot itself. Pneumatic mining systems are permitted if the gas is supplied by the robot and self-contained.

26. Components (i.e. electronic and mechanical) are not required to be space qualified for Lunar or Martian atmospheric, electromagnetic, and thermal environments. Since budgets are limited, the competition rules are intended to require mining robots to show an off-world plausible system functionality but the components do not have to be traceable to an off-world qualified component version. Examples of allowable components are: Sealed Lead-Acid (SLA) or Nickel Metal Hydride (NiMH) batteries; composite materials; rubber or plastic parts; actively fan cooled electronics; motors with brushes; infrared sensors, inertial measurement units, and proximity detectors and/or Hall Effect sensors, but proceed at your own risk since the UA-1 is very dusty. Teams may use honeycomb structures as long as they are strong enough to be safe. Teams may not use GPS, rubber pneumatic tires; air/foam filled tires; open or closed cell foam, ultrasonic proximity sensors; or hydraulics because the Challenge does not anticipate the use of these on an off-world mission.

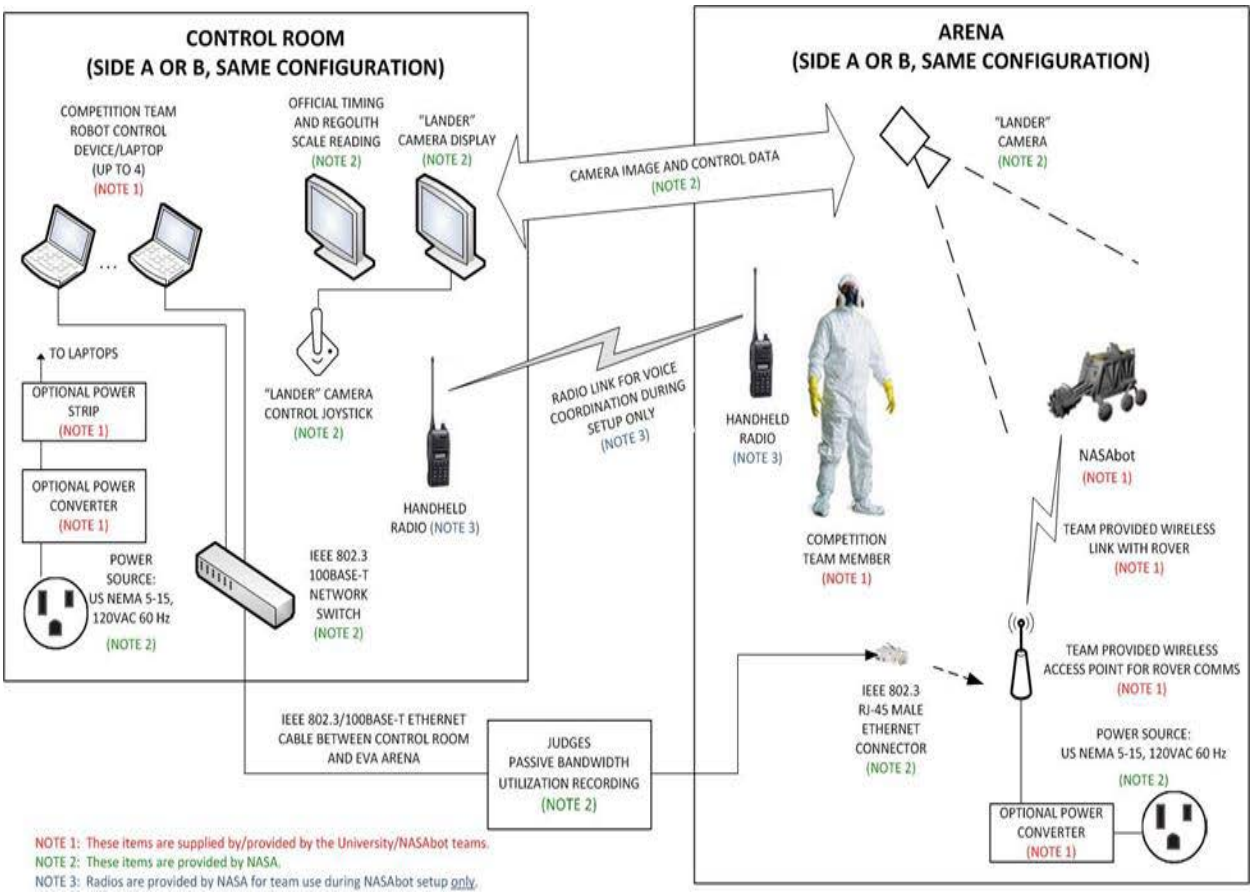
27. The mining robot may not use any process that cause the physical or chemical properties of the UA-1 or gravel to be changed or otherwise endangers the uniformity between competition attempts.

28. The mining robot may not penetrate the UA-1 surface with more force than the weight of the mining robot before the start of each competition attempt.

29. No ordnance, projectile, far-reaching mechanism, etc. may be used. The mining robot must move on the UA-1 surface.

30. No team can intentionally harm another team’s mining robot. This includes radio jamming, denial of service to network, gravel 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 mining robot as determined by the judges will be cause for immediate disqualification. A judge may disable the mining robot by pushing the red “Kill Switch” or emergency stop button at any time.

Mission Control Center and Communications



Note: There is only one arena and one MCC.

31. Mining Robot Wireless Systems Requirements

a. Each team is required to command and monitor their mining robot over the provided network infrastructure.

b. This configuration must be used for teams to communicate with their robot.

c. At least one “Lander” camera will be staged in the UA Mining Arena. The camera display will be located with the team in the Mission Control Center (MCC).

d. The MCC will have an official timing display and excavated mass display which would be weighed after the UA-1 is sifted through the sieve.

e. Handheld radios will be provided to each team to link their Mission Control Center team members with their corresponding team members in the mining arena during setup.

32. Each team will provide the wireless link (access point, bridge, or wireless device) to their mining robot, which means that each team will bring their own Wi-Fi equipment/router and any required power conversion devices. Teams must set their own network IP addresses to enable communication between their mining robot and their control computers, through their own wireless link hosted in the UA Mining Arena.

a. In the UA Mining Arena, the Challenge will provide an elevated network drop (male RJ-45 Ethernet plug) that extends to the Mission Control Center, where the Challenge will provide a network switch for the teams to plug in their laptops.

b. The network drop in the Mining arena will be elevated high enough above the edge of the regolith bed wall to provide adequate radio frequency visibility of the UA Mining Arena.

c. A table will be set up next to the network drop at a height 0 to 2 feet above the walls of the arena. This location is outside the mining arena protective walls. This table is where teams will place their Wireless Access Point (WAP) to communicate with their mining robot. (see additional diagram for details).

33. Power Interfaces

a. The Challenge will provide a standard US National Electrical Manufacturers Association (NEMA) 5-15 type, 110 VAC, 60 Hz electrical jack by the network drop. This will be no more than 5 feet from the table.

b. The Challenge will provide standard US NEMA 5-15 type, 110 VAC, 60 Hz electrical connections in the Mission Control Center for each team.

c. The team must provide any conversion devices needed to interface team access points or Mission Control Center computers or devices with the provided power sources.

34. During the setup phase, the teams will set up their access point and verify communication with their mining robot from the Mission Control Center.

35. The teams must use the USA IEEE 802.11b, 802.11g, or 802.11n standards for their wireless connection (WAP and rover client).

a. Teams cannot use multiple channels for data transmission, meeting this rule will require a spectral mask or “maximum spectral bandwidth setting” of 20MHz for all 2.4 GHz transmission equipment.

b. Encryption is not required, but it is highly encouraged to prevent unexpected problems with team links.

36. Each team will be assigned an SSID that they must use for the wireless equipment.

    a. SSID will be “Team_##”

    b. Teams are required to broadcast the SSID.

37. The use of specific low power (these power consumers are not part of the total power consumed COTS meter) Bluetooth transmission equipment in the 2.4 GHz range is allowed for sensors and other robot communications. Bluetooth is allowed only at power levels of Classes 2, 3, and are limited to a maximum transmit power of 2.5 mW EIRP. Class 1 Bluetooth devices are not allowed.

38. The use of 2.4 GHz ZigBee technology is prohibited because of the possibility of interference with the competition wireless transmissions.

39. Technology that uses other ISM non-licensed radio frequencies outside of the 2.4 GHz range, such as 900 MHz and 5 GHz, are allowed to be used for any robot or sensor systems, but these frequencies will not be monitored during the competition. Interference avoidance will be the responsibility of the Team and will not be grounds for protest by any team.

40. Radio Frequency Power:

    a. All Team provided wireless equipment shall operate legally within the power requirements power levels set by the FCC for Unlicensed Wireless equipment operating in the ISM radio band. The FCC Federal Regulations are specified in the Electronic Code of Federal Regulations, Title 47, Telecommunication, Part 15, and must be followed if any commercial equipment is modified. All unmodified commercial-off-the-shelf access point equipment and computers already meet this requirement.

    b. If a team inserts any type of power amplification device into the wireless transmission system, this will likely create a violation of FCC rules and is NOT allowed in the competition.

    c. This radio frequency power requirement applies to all wireless transmission devices at any ISM frequency.

41. Radio Frequencies and Communications Approval

    a. Each team will have approximately 15 minutes at the communication judges’ station.

b. To successfully pass the communication judges' station, a team must drive their mining robot by commanding it from their mining robot driving/control laptop through their wireless access point. The judges will verify the course of travel.

c. The teams must identify and show to the judges all the wireless emission equipment on the robot, including amplifiers and antennas. If the team has added an amplifier, written documentation shall be submitted to the judges demonstrating that the limits as designated in these rules for power transmission levels are not being exceeded.

d. If the team robot is transmitting low power Bluetooth, or is using any non-2.4 GHz frequency equipment, the following information must be provided to the judges during the communications checkout. Printed documentation from the manufacture with part numbers of all wireless transmission equipment. This printout must be from the manufacturer's data sheet or manual, and will designate the technology, frequency, and power levels in use by this type of equipment.

e. If a team cannot demonstrate the above tasks in the allotted time, the team will be disqualified from the competition.

f. On Monday of the competition week, on a first-come, first-serve basis, the teams will be able to show the communication judges their compliance with the rules.

g. The Challenge communications technical experts will be available to help teams make sure that they are ready for the communication judges' station on Monday and Tuesday of the competition week.

h. Once the team arrives at the communication judges' station, the team can no longer receive assistance from the communications technical experts.