Robotic Mining Competition Questions & Answers (new Q&As in red)

Competition Questions

Q. Can more than one team register from a single university?

A. Yes, more than one team can register from a university provided the dean of engineering approves both teams.

Technical Questions

Q. Rule 17 states "The walls may not be used for the purposes of mapping autonomous navigation and collision avoidance." If we cannot use the walls for collision avoidance, how would we stop our robot from crashing into the walls? We intend to create a map of the ground and avoid obstacles that are in the way, and were thinking that we should treat the walls like any other obstacle and simply avoid it, but not follow it. Is this acceptable to keep autonomous status?

A. In the potential World Finals competition in Hawaii there will be no walls on the volcano competition site and on Mars we will not have walls. Therefore the walls cannot be treated as an obstacle and used for autonomous collision avoidance with the walls. The arena may be mapped to the limits of the walls, but no active sensors are allowed to use the walls for navigation during the competition run. Collision with the wall can be avoided by placing a virtual boundary on the map created.

Q. Also regarding Rule 17, you state that "touching or having a switch sensor springwire that may brush on a wall as a collision avoidance sensor is not allowed. Are we allowed to use these types of sensors for collision avoidance with the obstacles? If so, we will be penalized if we accidentally touch the walls with them? Is that dependent on us proving we're not using it for mapping purposes?

A. Tactile sensors may be used to detect and avoid obstacles, but cannot be used to establish the boundary for mapping purposes or wall collision avoidance.

Q. Can you provide more clarification regarding how walls can and can't be used during autonomous operation? Our confusion stems from the fact that every sensor that "sees" the environment will "see" the walls. Most of the more advanced navigation sensors likely have a range that extends beyond the dimensions of the arena therefore "seeing" the walls by default. Even if a sensor has a limited range, as the robot moves, walls will be brought into the field of view. The FAQ says that collision with the walls can be avoided by placing a virtual boundary on the map created. However, to place a virtual boundary, the sensors would have to "see" the walls and recognize them as walls. So, even to ignore the walls, the walls have to be first sensed and recognized and then used to map the arena boundaries. Can a robot update these boundaries during the run? If so, then the robot will be repeatedly sensing and detecting the walls to update its map. While we understand the spirit of the rules (i.e. not using the walls to define robot navigation), the exact implementation of the rules remains confusing, and we would need to see a more detailed explanation of exactly what is and is not allowed in order to properly design an autonomous approach to fit within those rules.

A. On Mars there will be no walls. The rules intend to make the competition as realistic as possible in the constraints of the KSC regolith simulant arena. Please detect the walls initially, to determine the physical boundaries and then use a method that does not rely on scanning the walls repeatedly. The boundaries shall not be updated repeatedly by using the walls during the run. If the sensor sees the walls repeatedly

during the competition run then that is not a problem – as long as the robot does not rely on this data to navigate.

Q. Is the front of the deposition bin considered a wall? If so, then beacons that are placed on the bin would allow the robot to "see" the bin/wall for navigation purposes thus violating the "wall rule". Similarly, no tactile sensors would be allowed to touch the front of the bin during docking. Is this the correct interpretation of the new navigation rules?

A. The front of the deposition bin is not considered a wall. Tactile sensors may be used at the bin to detect it.

Q. Is it allowable for robots to contact the back wall in front of the bin for alignment while maintaining autonomy points?

A. A lander on another planetary surface would not have a back wall, so contacting the back wall is not realistic and is not allowed for autonomy. The bin itself may be contacted.

Q. The autonomy scoring is described as:

"1. Successfully crossing the obstacle field autonomously: 50 pts (two times only – outbound and back, point and shoot does not count for partial autonomy points)
2. Successful partial autonomy: crossing the obstacle field, excavating & returning to the collection bin. 150 pts
3. Successful partial autonomy: crossing the obstacle field, excavating & depositing regolith, 2 times. 250 pts
4. Successful fully autonomous run for 10 minutes: Successfully crossing the obstacle field, excavating and depositing regolith, a minimum of 3 times. 500 pts"

Does "2 times" in #3 mean that the robot must complete two complete cycles (Cycle 1: navigate, dig, navigate, dump; Cycle 2: navigate, dig, navigate, dump) to be awarded these 250 points? What if the robot doesn't complete 2 full cycles within the 10 minutes, but operates with full autonomy? For example, the robot is slow and completes one full cycle only in 10 minutes but does so autonomously?

A. #3 – two full cycles must be completed.
#4- The requirements of #3 must be completed and exceeded, before being awarded the full autonomy points. i.e. a minimum of three fully autonomous runs must be completed in 10 minutes

Q. Rule 15 states that the Collector Bin will be placed at 0.5 meter +/-0.2 m. Is this intended to be +/- 0.02 m, or do we need to build a robot capable of depositing at 0.7 m in height?

A. The bin height tolerance with respect to the regolith surface is +/- 20 cm, therefore your robot must be capable of depositing at any height between 0.3m and 0.7m..

Q. How does NASA plan to maintain the integrity of the separation of regolith from gravel in the mining area? As we understand the rules, the regolith layer will be approximately 12" deep. Below this layer, there is a layer of gravel for which bonus points are awarded for mining. At the start of the competition, I expect that there will be a clean separation (as much as possible) of gravel and regolith as the mining area has been prepared and undisturbed. However, as the competition progresses and teams penetrate into the gravel layer, it will become almost impossible to return the mining area to its pre-disturbed condition. Gravel will obviously mix with the upper layers of regolith resulting in easier extraction of the gravel. The teams that compete early in the competition will have a distinct disadvantage since all the gravel will be neatly tucked below the regolith (at depths of 12+ inches), while teams competing later in the round will have the benefit of mining loose gravel lifted and mixed into the upper regolith layers by previous mining robots. How will this situation be addressed to ensure that all teams encounter a consistent mining environment?

A. NASA does not plan to maintain the integrity of the separation plane between gravel and the regolith. On Mars there will be rocks mixed in with the regolith. The judges will make every attempt to return the gravel to the bottom layer, but some will be mixed in as the arena is excavated – so you should design for that possibility. The arenas will be used during the practice days – so it will already be in a disturbed state. Each team will get two competition attempts, and there should be no expectation of a clean separation of gravel from regolith dust. Please design your robots to be versatile and robust so that they

can accommodate gravel mixed in with the regolith. The majority of the gravel will still be at the bottom of the bin, so plan your strategy accordingly.

Communication Questions

Q. You use the term "bandwidth" in the rules several times referring to measurements of MHz, Kbps, and Mbps. These are completely different type of measurements and they're both different from my definition of bandwidth. There's no definition in the rules at the bottom for "bandwidth" either. In these rules, is "bandwidth" synonymous with frequency and data rates? If not, could we get the definition you're using for the competition?

A. 1. In the rules, the word “bandwidth” is used in both the context of network utilization and in the context of radiofrequency spectrum width.. This term is typically used in these manners interchangeably in the industry, but we agree, it can be confusing. “Spectral bandwidth” in megahertz (MHz) is indeed different than “network utilization bandwidth” in megabits/second (Mb/s). We will further clarify this distinction in the rules at a later date. These references will give you greater insight into the differences between spectral and network bandwidth, but the later comments in this answer will hopefully answer your questions.

a. http://en.wikipedia.org/wiki/Bandwidth_(computing)

b. http://en.wikipedia.org/wiki/Bandwidth_(signal_processing)

2. In Section Section 3 (H) on Table 1: Mining Category Scoring Example

a. In this table the context of “bandwidth” is for network utilization.

b. The mining category element of “Average Bandwidth” may be a bit misleading, a better way to refer to this element would be the Average Data Network Utilization. For this table, the units are in kilobits per second (kb/sec). This will be changed as in future versions of this table.

3. Section 23 (A) 5 (a) refers to the requirement for teams to configure their wireless systems to use a “maximum bandwidth setting” of 20 MHz.

a. In this section the context used for “bandwidth” is radiofrequency spectral bandwidth.

b. This rule requires teams to “spectrally limit” their emissions using a common setting on the wireless access point (AP) used by each team, because spectrum is limited. The requirement is to have a maximum frequency transmission width or span of 20 MHz. Some AP devices allow a wider setting of 40MHz, this is not allowed because it increases the risk of interference between teams.

4. Section 23 (B) BANDWIDTH CONSTRAINTS

a. In this section the context used for “bandwidth” is for network utilization.

b. This section refers to an award for the team that uses the lowest average data network utilization during the completion.

5. Definitions:

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

b. Bandwidth -- In this section the context used for “bandwidth” is for network data utilization