



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

Autonomy Questions

- Q. If we are going for fully autonomous, get the minimum 10 kg but try to keep mining because we still have time on the clock and get stuck or the bot breaks down, do we still get the points for fully autonomous?**
- A. Reference Rule 3G, as long as you mine 10 kg and no tele-operation occurs, then you will be awarded 500 points for autonomy. The operators may not touch the controls once the Lunabot starts autonomous operations. If the Judges see any deliberate strategy to “game” the rules by implementing autonomy without also trying to dig and deposit as much regolith simulant as possible, then the team is at risk of disqualification at the Judge’s discretion.
- Q. During the webinar the speaker said that we are allowed to input information into the computer during the 10 minute setup time. We were wondering if this was true because if so, couldn't you just map out the area if you right a good enough software program and then doesn't that take from the autonomy?**
- A. Lunabotics teams may initiate the Lunabot computer during the setup time, but the actual Lunabot may not start running the program until the competition attempt starts. Judges will be monitoring teams as they set up to ensure the Lunabot is not mapping out the area before the attempt starts. Full autonomy entails only a go command with no orientation data included. The Lunabot must determine its orientation autonomously without extra data or external inputs.
- Q. Our team is considering multiple autonomous systems but before we choose which one I wanted to confirm one thing. For one of our systems we would have 4 different go commands... each one telling the robot its initial orientation. The robot would then take this information and operate autonomously until it receives the stop command. Note that only one go command will be sent per competition attempt. Is this allowed, or does full autonomy entail only a go command with no orientation data included?**
- A. Full autonomy entails only a go command with no orientation data included. The Lunabot must determine its orientation autonomously without extra data or external inputs.

Communications Questions

- Q. On the January 16 Lunabotics Tips Webcast, we asked if we could have our calculations be on our laptop instead of the board and we could just take a hit on the bandwidth and Mr. Mueller said that was fine at first but then he made it sound like we would get penalized in other ways as well since in a real lunar situation there wouldn't really be a bandwidth. Is this true?**
- A. It is your choice. If you use more bandwidth you will lose more points in that category of the competition. On the moon there will be a communications time delay and a mission bandwidth limitation. Rule 3C: During each competition attempt, the team will lose 1 LunaPoint for each 50 kilobits/second (kb/sec) of average data used throughout each competition attempt.
- Q. In Rule 23-A-3, can you elaborate on what this means? “The teams must use the USA IEEE 802.11 b/g standard for their wireless connection (WAP and rover client). Teams cannot use multiple channels for data transmission. Encryption is not required, but it is highly encouraged to prevent unexpected problems with team links.”**
- A. Hint 1: Some modern wireless access points and routers are configured by default to bond wireless channels together using the 802.11n standard. Most, but not all, of these systems can be configured to operate on one channel using 802.11 b/g as required by the rules. Please test your wireless access point or router to assure that it is capable of being configured in this manner. Teams will not pass the Communications Check unless your robot and access point operate on a single channel. A

free open source Wi-Fi scanning tool is available on the Internet for testing your equipment at <http://www.metageek.net/products/inssider/>. Using a wireless notebook, this tool can easily show you if you are setup on a single channel.

Hint 2: Some modern wireless access points and routers are dual band and able to transmit on 2.4 GHz and 5 GHz. In order to pass the Communications Check, the 5 GHz transmitter will need to be turned off, only 2.4 GHz transmissions are allowed. If your laptop and wireless network card are fairly new, it likely supports 5 GHz and will allow you to verify that 5 GHz transmissions are turned off using the tool mentioned previously from Metageek at <http://www.metageek.net/products/inssider/>.

Scoring Questions

Q. Provide clarification on how to get regolith-dust-free operation LunaPoints.

- A. Reference Rule 3F, the 70 points for regolith-dust-free operation will be broken down in the following way:
1. Driving without dusting up regolith – 20 points
 2. Digging without dusting up regolith – 30 points
 3. Transferring regolith without dumping regolith on your own Lunabot – 20 points

Q. Provide clarification on how to get regolith-dust-tolerant design features LunaPoints.

- A. Reference Rule 3F, the 30 points for regolith-dust-tolerant design will be broken down in the following way:
1. Drive train components enclosed/protected and other component selection – 10 points
 2. Custom dust sealing features (bellows, seals, etc.) – 10 points
 3. Active dust control (brushing, electrostatics, etc.) – 10 points

Technical Questions

Q. What should be operating temperature for our devices? Should we design instruments for earth temperature (0 C to 40 C)? Or do we have to take lunar temperature in consideration? (-20 C to 70 C) Is anything ranging from 0 C to 40 C is fine? Because we are worried about Florida's hot and humid weather and we may need to change model of our instrument to accommodate more than 40C temperature. Is the competition arena environment going to be controlled?

- A. Reference Rule #26. The tents for the LunArena and the LunaPits are air conditioned. Teams will have to cart their Lunabots on the sidewalk from the LunaPits to the LunArena so the Lunabots will be outside in the heat for a while which could cause condensation. Reference the Definition of LunArena in the Rules. The average high in May at Kennedy Space Center is 30°C.

Q. Are lunabot weights rounded to the nearest whole number of kilograms (i.e. 49.5 = 50 and 49.4 = 49)?

- A. Lunabots will be weighed to one decimal accuracy i.e 79.5 kg. The weights will not be rounded to the nearest kg.

Q. A little question about technical documentation. Can we use International System of Units, or we should use US Imperial system?

- A. We prefer the metric system.

Q. Can we use ISO threads, etc.?

- A. There are no restrictions on ISO threads.

Q. Can closed pneumatics such as a rear tailgate support cylinder on a car be used to assist in dumping of the regolith?

- A. If the pneumatic system is closed then it is acceptable.

Q. According to the competition rules, specifically Rule #22, the competition allows for laptops to remain powered after the stop button has been placed. We were wondering if this means that we are specifically allowed to power the laptop from a separate battery, such as the integrated battery of the laptop.

A. Yes, you are allowed to have your laptop powered by its internal battery.

Q. Are class 1 lasers allowed?

A. Yes, Class 1 lasers are allowed.

Q. As we are working on our lunabot, I had a question regarding the beacon (p4 Field Rule 15) It states that "The target/beacon may send a signal or light beam, but for safety reasons, only ANSI Z136, Class II, 2 or 2M lasers will be allowed." My question is, if we want use some light source such as LED, which has power density much less than a laser, will it be allowed? Or is only Laser sources allowed for the beacon? Just for the record, visible LED lights are completely harmless.

A. Yes, LEDs are allowed.

Q. Are we allowed to have a microcontroller on the LunaBin that will solely control the frequency of the lights for our beacon system?

A. The micro-controller is allowed, but the whole beacon system mass will count against the total mass of the Lunabot. A low power source must be self-contained in the beacon.

Q. According to the competition rules, specifically rule #22, the competition allows for laptops to remain powered after the stop button has been placed. We were wondering if this means that we are specifically allowed to power the laptop from a separate battery, such as the integrated battery of the laptop.

A. Yes, you are allowed to have your laptop powered by its internal battery. Thank you!

Q. We had a quick follow up question to this- we are planning to use microcontrollers in addition to our laptop for motor control. However, these devices will be powered via USB from the laptop, and will not turn off unless the laptop also turns off. We were wondering if it is alright if these devices can remained powered by the laptop, or if we need to build some sort of control to disconnect these devices when the robot needs to be turned off.

A. Any component that is not part of the laptop (i.e. added on) must have a separate kill switch control. It cannot remain powered on with the laptop.

LunArena Questions

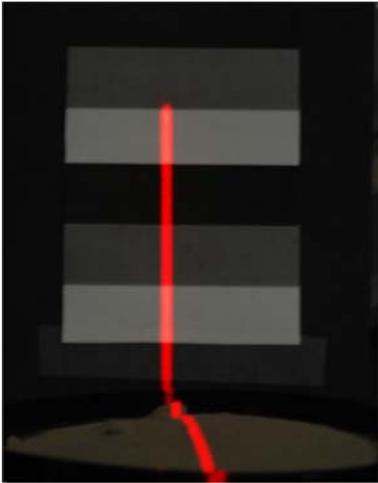
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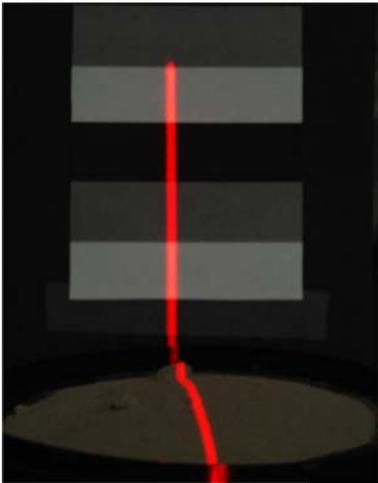
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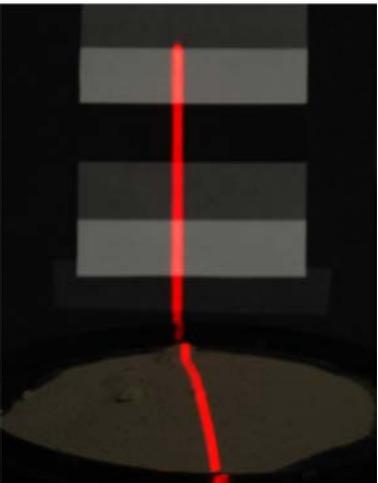
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- Q. We are exploring the concept of using a Lunabin mounted navigation system that would possibly map the arena, locate our Lunabot and send instructions to it. The idea is that on the moon it would be better to have a central control station that autonomously directs the Lunabot/s so that the control part of the system is isolated from potential damage due to navigation on the lunar surface. Additional Lunabots could be directed by the control station rather than trying to coordinate individually. Also, individual Lunabots would be less complex and expensive and therefore easier to replace so that the system never ceases production. We let our imaginations run into the future with this idea.**
- A. A central control station that autonomously directs the Lunabots from a lander platform is not recommended by the Lunabotics Judges since there would be significant line of sight issues with Radio Frequency (RF) communication if the Lunabots drove behind a hill, crater or other topographic feature that interrupts the line of sight.
- Q. The top edge of the LunaBin will be placed so that it is next to the side walls of the LunArena, without a gap, and the height will be approximately 0.5 meter from the top of the BP-1 surface directly below it. The top opening of the LunaBin will be 1.65 meters long and 0.48 meters wide. See Diagrams 1 through 3. However on the FAQ for 2011, the given height was 1 meter. May I please receive a clarification on the height of the LunaBin at your earliest convenience?**
- A. The LunaBin will be 0.5 meter above the top of the BP-1 surface as it was for 2012. The 1 meter above is a reference to the 2010 or 2011 competitions.
- Q. What is the maximum height of the navigation system on the LunaBin?**
- A. Only to 0.75 m above the regolith surface
- Q. Can we extend a mast from the LunaBin?**
- A. Only to 0.75 m height above the regolith surface.
- Q. Are there any limitations on what instruments can be placed on the LunaBin? e.g. cameras, processors and actuators.**
- A. Yes, see Rule #15. Targets and beacons only may be placed on the LunaBin. There are restrictions on Lasers. The target/beacon may send a signal or light beam, but for safety reasons, only ANSI Z136, Class II, 2 or 2M lasers will be allowed. The judges will inspect all laser devices and verify that they comply with the ANSI Z136, Class II, 2 or 2M standard and that they have not been modified (for optics or power). Original supporting documentation from the laser instrumentation vendor must be given to the inspection judge. Navigational aids may be deployed from the Lunabot after the official start time of the competition attempt. Navigational aids must comply with all RF constraints as stated in rule 23.
- Q. Is there any specific information regarding the actual mounting of a navigation system on the Lunabin? For instance, clamps or other devices for fixing the navigation system to the Lunabin.**
- A. No permanent attach hardware is allowed and the LunaBin may not be altered. (ie. No drilling, nails, etc)
- Q. Is it possible for us to hang two beacons on the two pit-side edges of the LunaBin?**
- A. Yes, you may use multiple beacons.
- Q. Is it possible if we can get a 3D model of LunaPit? It would be easier to create a geometry of our project, and would be useful in publicity.**
- A. If you are referring to the LunArena sandbox where you will compete, Diagram 1 on page 9 of the rules referenced above is the only 3D model available at this time. If you are referring to the LunaPits, that will be a 10 feet x 10 feet square open space in a tent where your team will be able to work on your Lunabot during the week of the competition.
- Q. How rigid is the LunaBin?**
- A. It is made of plywood and fairly rigid.

Q. What areas of the bin can we mount on? Specifically, could we have a device mounted on the front of the LunaBin such that it is on the inside of the LunArena, sitting against the wall, close to the ground?

A. It may attach to the top edge of the LunaBin only. Targets or beacons may be attached to the LunaBin for navigation purposes only, but cannot be placed on the excavating end of the LunArena. This navigational aid system must be attached during the setup time and removed during the removal time. If a navigational aid system is attached to the LunaBin, it must not exceed the width of the LunaBin and it must not weigh over 9 kg. The navigational aid system must be self-powered and its mass will be included in the Lunabot mass limit of 80.0 kg.

Q. Have there been any light intensity readings in the Lunarena? If so could you pass on any lux measurements?

A. The lighting conditions in the Lunarena are not quite as bright as outdoors daylight. We use 400 Watt Halide Lights (5 or 6 of them) in that tent, and because it has clear/glass wall, the light from outside comes in as well. See the photos below.

Q. Is it possible to confirm whether or not an indoor LIDAR will be able to function in the Lunarena? Indoor LIDARs are rated to work in lighting up to 6000 lux. Unfortunately we can't use an outdoor LIDAR unless it is donated to us as they are several times more expensive than the indoor variety which are already priced in the thousands.

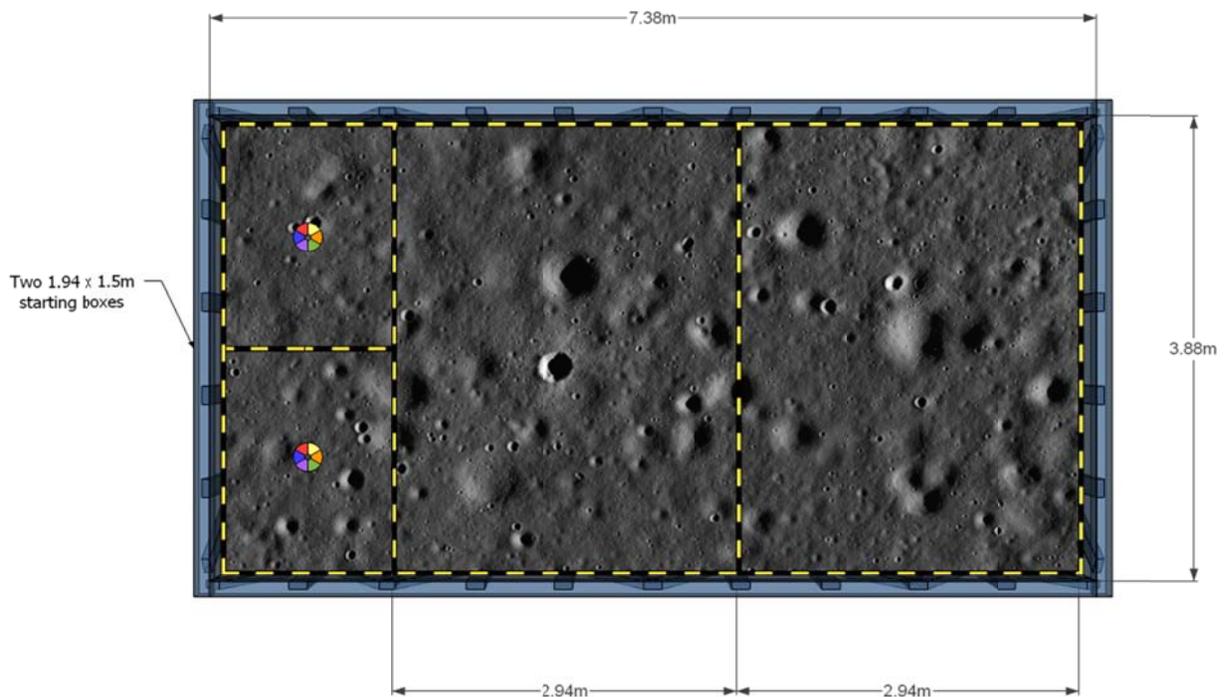
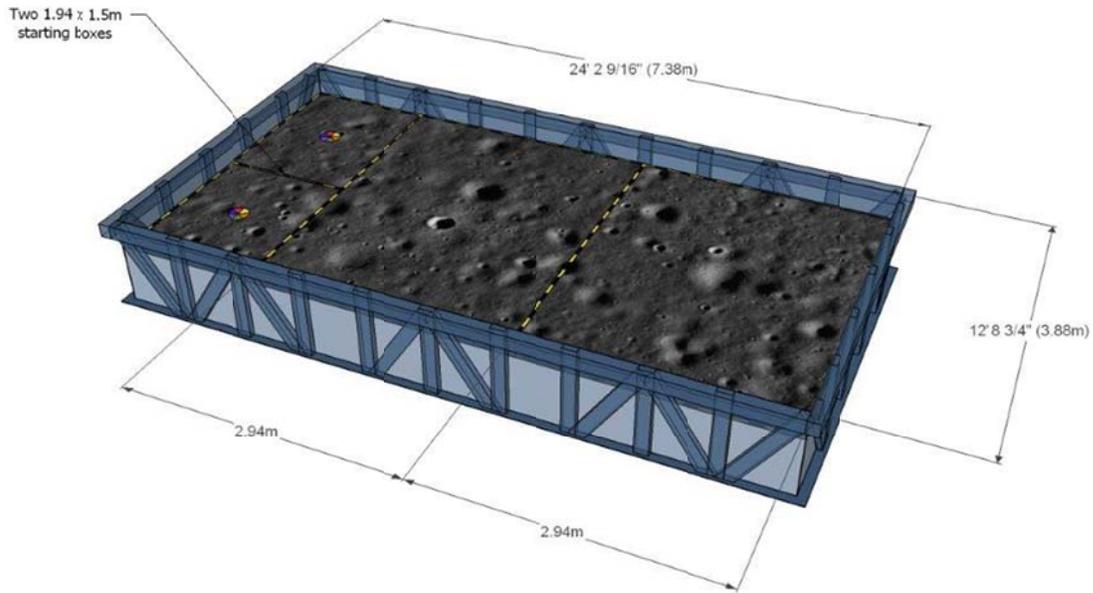
A. The LIDAR will not work if it is too bright. See the photos below.



Q. I have a question about the random starting positions and orientation of the Lunabot. What is illustrated is that there are 4 start positions, and a conclusion that I jumped to was that the orientation would be that the forward arrow reference would be parallel to a wall pointing north, east, south, or west and that the center of the robot is over one of the start positions. Is this the case? Because a few "what if" questions came to mind. What if the robot has a length of 1.5 m? Based on my assumption of orientation, two orientations would result in the robot length being in parallel with the start area's length, which are equal. Meaning that for those orientations there could not be four independent positions at which the robot could be placed, instead there would be only two. The other "what if" that came to mind was, what if my assumptions are wrong? Are there more than four starting positions, does the center of the

Lunabot sit directly over the start position, and are the angles of orientation only 0, 90, 180, and 270 degrees or are there more angles in between?

- Q. In Rule number 6, does 'randomly selected direction' mean that rover can be rotated by any angle (0-360 degrees)? Is it possible, that one team can start with front in driving direction, and other rover start rotated by 180 degrees for example? It is important issue in our autonomy simulations.
- A. Yes, that is what that rule means. Basically, each team will spin a wheel that determines their starting direction. **NASA has determined to only have two starting blocks so that when rotated the Lunabot will still be in a starting block. See figures below.**



Simulant Questions

Q. We have come up with some simple simulant that may mimic the very basic properties of lunar regolith like density and particle size. We wanted to possibly get some advice from NASA employees who have worked with BP-1 who can tell us if we are on the right track so to speak.

A. Yes, it is probably a good approach. The most important properties are:

1. Wide range of compactibility from fluffy to dense
2. Becomes strong when compacted

To get the first of these properties, having lots of fine powder is probably the most important thing. You will just have to experiment to see if it becomes strong (difficult to excavate) when it is very compacted. JPL uses a similar technique to make Mars simulant. They use 50% sand and 50% diatomaceous earth. That gives it the right mechanical behavior compared to what they've seen with the rovers on Mars. As long as it behaves the right way, it doesn't really matter what it's made of.

Q. On the Soil Test on the BP-1 article, Why in the Figure 3 of "Preliminary Geological Findings on the BP-1 Simulant" the curve of BP-1 warns "Wet Sieving"?

A. Wet sieving is the method we used to measure the particle size distribution. There are different methods that you can use. Wet sieving, laser diffraction, optical microscope methods, etc. Every method gives a slightly different result. Therefore, sometimes people will note which method was used. For our purposes it doesn't really matter. It only matters for people who are being extremely picky. For robotics driving and digging in the soil it makes no difference.

Q. We have a quick question: for testing and calibration, we were hoping to acquire some BP-1 lunar simulant - do you know which company(ies) produce(s) it? We would be willing to buy some from them.

A. BP-1 is not commercially available. However, JSC-1A is available from Orbital Technologies at <http://www.orbitec.com/store/simulant.html>, and NU-LHT is commercially available from Zybek Advanced Products (ZAP) at <http://www.zybekap.com/>.

Q. We have a question regarding the density of BP-1. We know that the density of the top-layer on the bed is .75g/cc. We were wondering, if we excavate this top-layer and deposit it in our temporary storage container, how will the bulk density change as the height of the deposited BP-1 pile changes due to self-compaction by gravity?

A. The density of bulk material (not mere upper layer fluff) varies from about 1.5 g/cc to 2.6 g/cc, plus or minus (those are rough estimates). It is hard to predict how dense soil will be after pouring and dumping. It depends on how it was dumped. Very energetic dumping will fluff up the soil and mix air in it so that it is fluidized. Slow, cautious dumping with mild vibration will compact the soil. Adding more overburden onto soil while providing moderate vibration will cause it to keep compacting to denser states. It is really impossible to provide more details without actually measuring the behavior inside your lunabot. The teams can assume that self-compaction will raise the density to 1.5 g/cc.

Social Media and Outreach Questions

Q. Are there restrictions on the use of Luna*Bot? For example, can we print stickers of the mascot for our outreach events? Or a postcard that contains both the mascot and our logo, to be mailed to friends and family around the world?

A. Teams are encouraged to use Luna*Bot for educational outreach and promotional purposes.

Q. Can we use NASA logo on our website? Can we use it in our outreach project?

A. No, but you may use the Lunabotics graphic.

Q. How we can prove our participation in lectures about moon (as organizers)? Photo will be enough? Timesheet?

A. There is no need for timesheets. If you asking about the Outreach project, you will submit a report about your outreach activities. Please see the rubric on page 12 in the rules at: www.nasa.gov/Lunabotics. The winning outreach project report from last year is posted as an example on the website.

Wait Listed Team Questions

Q. Can the wait listed teams bring their Lunabots to the competition?

A. Yes, it is encouraged.

Q. If the wait listed teams can bring their Lunabots to the competition, will they have available space in the pit area?

A. No, time and space are the major constraints on the competition. You can keep it at your hotel or in your vehicle and bring it to the competition for your presentation and demonstration if time allows.

Q. Will the wait listed Lunabots be checked out by the judges?

A. Possibly, if there is time.

Q. Can the wait listed teams test their Lunabots in the LunArena during the practice periods?

A. Possibly, if there is time.

Q. Will wait listed teams be able to attend the awards ceremony?

A. Yes

Q. When is the latest date that a standby team will be informed that it can fully compete?

A. Possibly at the competition itself, if teams do not show up.

Award Questions

Q. If team members won't be attending the event at KSC, will they be receiving any certificate of participating/winning at the event?

A. All student team members on the team will receive a certificate of participation. These are given to the team at the end of the competition. If your team wins an award, we will print enough team certificates for every member to have one and mail them to you after the competition.

Eligibility Questions

Q. We've got 3 students, who will get their Master degree before May 2013. Some of them won't continue their studies. Can they participate? If they cannot be team members, can they come with us on competition?

A. Yes, as long as the students are enrolled during the 2012-13 academic year, they may participate.

Q. What about PhD students. Are they considered as University employees or as students?

A. As long as the students are enrolled during the 2012-13 academic year, they may participate as students.