RASC-AL Special Edition:

MOON TO MARS ICE & PROSPECTING CHALLENGE

Q&A Session

October 17, 2019 2:00 – 3:30 PM EST

Add call-in phone number

RASC-AL Special Edition Program Team

Shelley Spears

Program Director

Shelley.spears@nianet.org

Stacy Dees

Program Manager

Stacy.dees@nianet.org

Victoria O'Leary

Program Coordinator

Victoria.oleary@nianet.org

RASC-AL Special Edition Steering Committee

Dean Bergman
Honeybee Robotics

Ben Galke
NASA LaRC

Steve Hoffman
Aerospace Corporation
(NASA JSC)

Sharon Jefferies
NASA LaRC

Chris Jones
NASA LaRC

Kevin Kempton
NASA LaRC

Bob Moses
NASA LaRC

Keith Nicewarner
SpaceX

Jerry Sanders
NASA JSC

Kris Zacny
Honeybee Robotics

Agenda

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- Questions from teams:
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About this year’s challenge:

For the 4th Moon to Mars Ice and Prospecting challenge, there are two main components:

1. Prospecting on the moon
2. Acquisition of water-ice from Mars

Along with that is a technology demonstration: designing a prototype of your system to be tested here in the Earth environment on the test stations that are described in all of this year’s competition documents.

First, we're interested in seeing what teams can do in designing a concept that could be useful for acquiring water on Mars and the moon. When we do eventually go to the moon or Mars, there is every indication that there will be ways to get water, and if we can do that robotically, that has a huge benefit to the way we would approach human missions to the surface.

We also want to understand exactly how teams would attempt to go through the dirt to get to the ice. We want to see what teams can come up with to manage different types of materials they might encounter on their way to the ice on either the moon or Mars.

With that, we get the two main components of this year’s challenge: prospecting on the moon and then, of course, the acquisition of ice from Mars.

General Technical Questions: Water Filtration

1: Are the pollutants in the ice water-soluble? If yes do we need to purify the water, or is the only measure of the water's "cleanliness" the sediment captured at the collection tank?

- Answer:
  - On earth test beds: The ice used in the earth test beds comes from an ice-sculpting company who utilizes a filtration process to get the clearest blocks of ice possible. There are no inherent pollutants in the ice itself. For the on-site portion of the competition, the only impurities that the teams must "purify" are those caused by sedimentary materials introduced into your water sample from the overburden. The water cleanliness will be measured by sediment captured, as well as by turbidity measurements.
  - Off-earth environment: Regarding the potentially toxic impurities (like perchlorate salts) though to be in Martian water and ice, this is something you may want to consider addressing in your system's path-to-flight for filtration.

2: Do we need to chemically filter the water or just mechanically filter it?

- Answer: It is up to each team to determine the best method of water filtration, but it must be filtered prior to entering the external collection bucket used to measure water volume.

General Technical Questions: Melting Ice

3: Can we use a cutting fluid?

- Answer: No. To be applicable to Mars or the Moon, fluids are not allowed. Compressed gas is allowed though but the mass of the pneumatic system needs to be included in the total system mass

4: Can we use a coagulant to melt the ice?

- Answer: While not restricted, it is not recommended for several reasons.
  1. There may be a safety/disposal issues that restrict which chemicals can be used, and
  2. Use of coagulants are probably not practical for Mars unless your team has a plan for manufacturing these chemicals with locally obtained materials (i.e., ISRU). If you do choose to propose use of a coagulant, the specific chemicals will need to be reviewed by the NASA Safety Office prior to approval. Additionally, you must separate the resulting water and only deliver that water to the collection bucket.

5: Does the team melt ice into water for water extraction?

- Answer: It is up to each team to develop a process for water extraction that works best for them

General Technical Questions: Hands-on/Hands-off

6: For the hands-off section, can the team control the system remotely after layers been identified, or does the system itself have to be autonomous from the beginning to the end?

- Answer: Hands-on and Hands-off operations can occur at any time during the competition - whether drilling or identifying layers for the digital core. At no point does the system have to be autonomous (although that would be very cool!). A full description of the Hands-on and Hands-off operations is thoroughly described on the website, as follows:
- The water extraction system must be capable of operating autonomously or via "remote crew-controlled" operations during the competition. Either system operation is acceptable, as either could be used on the Moon or Mars. Autonomous control and remote crew-controlled operations are considered "Hands-Off" operations.
  - Definitions:
    i. Autonomous control refers to no human intervention after the system starts; no further operation from any crew is required at all.
    ii. Remote crew-controlled allows for the use of a computer distinct from but able to communicate with the water extraction and prospecting system (e.g., connected by a cable or Bluetooth, point-to-point, etc.) to operate the water extraction system (e.g. to control the speed of a drill). "Remote crew-controlled" operations indicate that the crew will be nearby their test station (within 5 feet and within line of site), can figure out when problems occur, and can address those problems remotely. Systems should not be built that will require human intervention; instead, they should be built to work on their own while being controlled remotely.
  - During "Hands-off" operations, teams will not be permitted to provide verbal guidance for the operator while they are physically watching the extraction system.
  - Monitoring and making decisions in real-time based on the use of feedback from cameras attached to the system (excluding external hand-held cameras/cell phone cameras) and sensors is encouraged, but not required.
  - Teams may utilize a corded or tethered system that serves as the digital link between humans and machine.
  - There will be no local WiFi access available to the teams for this competition. Teams may implement a direct, localized wireless connection between their water extraction and prototype system and computer/control system, but must accept the risk of possible interference.
  - The computer/control system will operate on a separate power supply from the water extraction and prospecting system

General Technical Questions: Hands-on/Hands-off cont.

7: For the hands-on section, does the team control the system by controlling the system directly or remotely?

- Answer: Controlling the system directly, by placing your hands physically on the system is considered hands-on operations. (Remote-controlled or autonomous operations are considered hands-off operations).

8: Are we able to relocate our system on top of the test bed during competition operation during hands-off?

- Answer: If you have to touch the system (even to move it), those actions will be considered hands-ON operations. It should be noted that once the systems area attached to the top of the test beds, they need to stay attached during the competition run. However, teams may manually move/reposition their actual drills between subsequent "hands-off" operations without penalty. If a team plans to use manual repositioning, careful consideration should be taken in the path-to-flight section of their Project Plan Proposal to articulate how this would translate into operations off-Earth.

9: Could you provide more details as to what exactly "Remote Crew Controlled"? What is meant by "should be built to work on their own while being controlled remotely"? Those seem like opposites?

- Answer: Remote controlled means that teams can tether a computer to the system and provide real-time commands to the system via the computer. In this manner, a system is not operating autonomously because it is receiving real-time commands from a human (versus making decisions on its own).

General Technical Questions: Loads & Weight-on-Bit

10: Guidelines for impact drilling loads?

- Answer: Honeybee TRIDENT hammer drill uses up to 4 J/blow at approx. 20 Hz and less than 100 N WOB.

11: Does the drill force refer to the force applied at the drill tip (i.e. for applied to bit and the force from the bits weight) or just the force applied to the bit?

- Answer: Total force that the bit sees.

12: 100N or 150N Weight on Bit? Conflicting information. Competition basics page has 150N listed, FAQ has 100N Listed.

- Answer: (The FAQ was incorrect, but that error has been fixed). The drill force (also called Weight on Bit or WOB) should be limited to less than 150 N

13: Are the Weight on Bit sensor and power consumption telemetry devices provided?

- Answer: No. Teams must provide their own.

General Technical Questions: Loads & Weight-on-Bit cont.

14: What is the plan for RASC-AL to measure WOB from a team's design?

- Answer: The judges will manually check that the WOB telemetry output from the teams is accurate with the actual WOB that the bit sees. This is done before any drilling can occur. As per the rules, a failure to produce an accurate WOB will incur a penalty

  The judges will manually compare the actual WOB exposed to the bit to the WOB output from each team by:

  1. A judge will place a scale beneath the bit;
  2. The judge will ask the team to move the drill downward until the scale measures 2 specified values (e.g. 5kg and 10kg – TBD);
  3. At each location the judge will compare the value on the scale with the telemetry output from the team.

  We will allow for a 10% error margin. This will be done before any drilling can occur. As per the rules, a failure to produce an accurate WOB will incur a penalty.

General Technical Questions: Restrictions/Limitations

15: Are there restrictions on which programming language to use?

- Answer: No.

16: Any restricted materials? (Low power explosives? Combustible materials?)

- Answer: Explosives, combustibles, open flames, and cutting fluids are strictly prohibited. All hazardous materials, chemicals, systems (pressurized for example) are subject to review and approval by LaRC Safety. Approval from the safety office could take up to 6 weeks.

17: Restrictions on pressure vessels and pressurized liquids (hydraulics and pneumatic)?

- Answer: Any design using pressure vessels or pressurized liquids will need to be reviewed by the NASA Safety Office before they are admitted to the competition. Approval from the safety office could take up to 6 weeks.

18: Restrictions on introducing foreign materials into bore hole, overburden, or ice?

- Answer: Within the other restrictions on what can be used, you can introduce foreign materials into the test bed; however, you are responsible for separating any water you acquire from those other materials before delivery to the collection bucket

General Technical Questions: Restrictions/Limitations cont.

19: Are there any restrictions on drill type? On where we source our drill from?

- Answer: No. The design and all materials needed to support the design are up to each team.

20: What would be the limitation for the use of electronics?

- Answer: There are no limitations on electronics other than the overall system mass and power constraint. Please follow up with a more detailed question if you have something specific in mind.

21: What weight limit do we have for the vehicle? If not a limit, what general range?

- Answer: There is no vehicle expected in this competition (instead, we are expecting a static water extraction system). The weight limit for the system is identified in the “Prototype Design Constraints & Requirements” section of the Competition Basics page on the challenge website. The water extraction and prospecting system (and everything used on the system, including the water transfer equipment) must have a mass less than or equal to 60 kg.

General Technical Questions: Power

22: Is it allowed to have a separate power strip on board of our power circuit?

- Answer: System power management and distribution design details are the responsibility of the teams. Nothing external to the system should be powered by the system.

23: Is storing energy for augmentation later allowed? (Collect energy in a kinetic or potential energy device when not drawing full 10A and use it for later?)

- Answer: No. The reasoning for the power limit is to simulate a real-world robotic mission off-earth, and that power constraint includes all power being used by the system. This is why batteries are not allowed for the on-site portion of the competition. Although clever, on device storage to temporarily bypass this constraint will not be allowed. In addition, please note that this year's guidelines require that teams incorporate a 9 A fast blow fuse that will limit the current your system can draw.

General Technical Questions: Overburden Layers

24: The digital core requires “identifying the correct number of overburden layers (including the ice)”. Does the ice count as one (ice), two (two blocks of ice), or three (two blocks of ice separated by water) layers?

- Answer: The ice will constitute as one layer.

25: What does "system telemetry" entail? Does it mean some form of reading measurements using the system itself and using load cell, etc? Or does this mean a more "sonar" type approach?

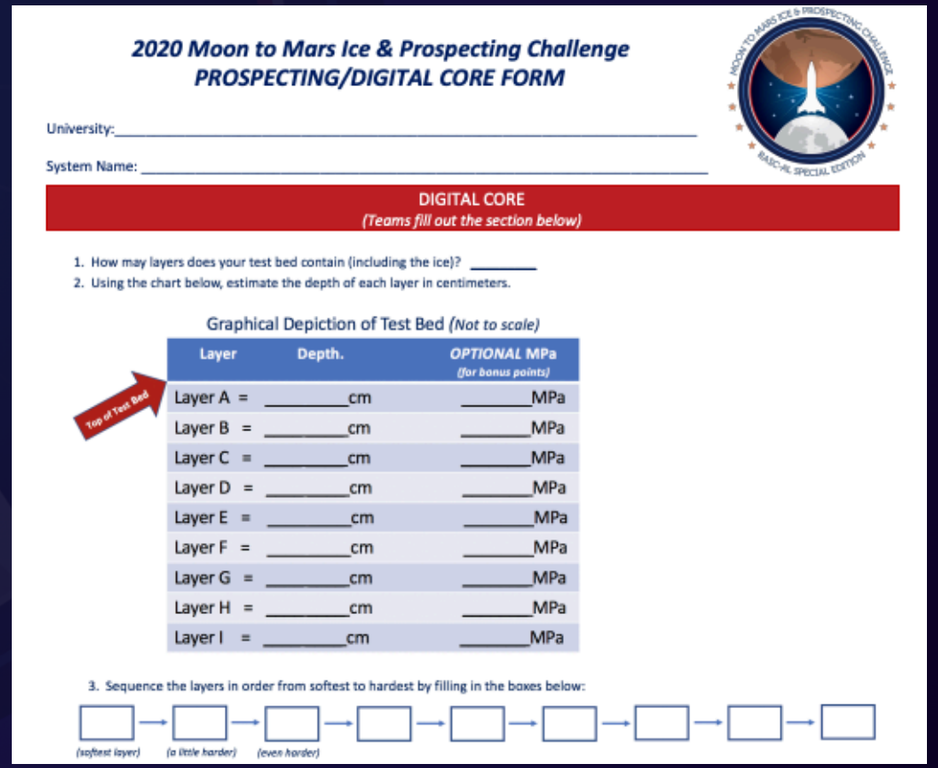
- Answer: The former: information about the current system performance (e.g. power draw, load cell reading).

General Technical Questions: Overburden Layers

26: Does the condition of the digital core extracted also taken into consideration for scoring? Does the digital core extracted have to be intact (in one piece)? Can it be sealed inside the drilling valve? Does it have to be contained?

- Answer: There seems to be some confusion. A digital core is not the same thing as a physical sample core. A digital core is just a written description that represents their knowledge and understanding of where each of the layers are, the general hardness of each different layer, and the thickness of each layer. Note: individual layers will have a uniform thickness horizontally across each test station, with depths that vary among each layer. The digital core will include:
  - Identifying the correct number of overburden layers (including the ice)
  - Sequencing the layers in order from softest to hardest
  - Estimating the thickness of each layer in centimeters (cm)

The Digital Core Form (provided on site) is the only thing that has to be turned in and must be presented to a judge prior to the end of the final competition run. Once the form has been handed to a judge, it is considered a final submission of the team's digital core.



2020 Moon to Mars Ice & Prospecting Challenge
PROSPECTING/DIGITAL CORE FORM

University:_____

System Name: _____

DIGITAL CORE
(Teams fill out the section below)

1. How may layers does your test bed contain (including the ice)? _____
2. Using the chart below, estimate the depth of each layer in centimeters.

Graphical Depiction of Test Bed *(Not to scale)*

Top of Test Bed

Layer	Depth.	*OPTIONAL* MPa *(for bonus points)*
Layer A =	_____cm	_____MPa
Layer B =	_____cm	_____MPa
Layer C =	_____cm	_____MPa
Layer D =	_____cm	_____MPa
Layer E =	_____cm	_____MPa
Layer F =	_____cm	_____MPa
Layer G =	_____cm	_____MPa
Layer H =	_____cm	_____MPa
Layer I =	_____cm	_____MPa

3. Sequence the layers in order from softest to hardest by filling in the boxes below:

(softest layer) *(a little harder)* *(even harder)*

General Technical Questions: Digital Core/Telemetry

27: Will the layer sample be provided to the team before the competition day? If not, is any guide to obtain/create similar layers for testing?

- Answer: No. We do not provide a guide to obtain/create similar layers for testing, but instead encourage teams to test all of the potential overburden materials listed - in varying depths. A major part of the challenge for teams is dealing with unknown layering and materials, so we don't want to give away too much information. See Q. 33

28: What is the maximum and minimum thickness of a specific overburden layer? Is there a possibility that the entire overburden could be one specific layer?

- Answer: The entire overburden will NOT be one specific layer. There will definitely be multiple layers, and you've been told that the entire overburden section will be between 0.4 and 0.5m. and each layer will be an identifiable measurement (i.e., we will not try to include a 0.0003 mL thick layer). The real world will not tell us minimum/maximum layer thicknesses and we need to learn how to determine this; challenge teams are part of this general learning process for themselves and for NASA.

29: Will each overburden layer be uniform through the entire horizontal layer? Or will different horizontal locations of a layer have a different type of overburden?

- Answer: Each horizontal overburden layer will contain only one material layer as listed in the Competition Basics guidelines - so that it is consistent throughout the entire layer. It is important to note that one overburden layer may have rocky inclusions throughout that entire layer.

General Technical Questions: Digital Core/Telemetry cont.

30: Will there be layers that are only consisting of sand? Or 100% clay?
- Answer: Possibly.

31: What exactly is the "ice-cemented soil?" Is it essentially frozen mud? Or is it a different?
- Answer: Ice-cemented soil is cement with various concentrations of water included in it (anywhere from 5% water by mass to 30% water by mass), then frozen into blocks.

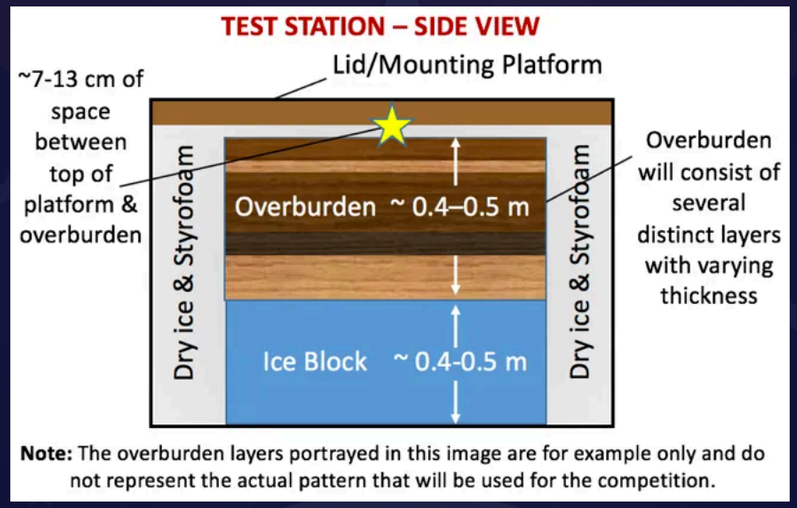
32: Will there be more possible layers than the five described on the RASC-AL website? If so, what are they?
- Answer: No - there will not be any surprise materials.

33: What type of regolith are we drilling through (basalt, sedimentary)? Is it mostly sandy or is it mostly rocky?
- Answer: The Competition Basics webpage (under “Simulated Martian & Lunar Subsurface Ice Test Station”) lists several potential overburden materials that teams may encounter. Teams can expect to encounter distinct overburden layers and each of these layers will be made up of material taken from the following list (Note: not all of these materials will be used and some of these layers may be in the form of a single block of the same horizontal area as the ice block. Some of the materials may be found in more than one layer)
  - Dry, fluffy play sand with rocky inclusions (between 3”- 6” in diameter)
  - Clay mixed with 20% sand
  - Solid/consolidated stone (i.e., single slab of stone)
  - Solid/consolidated aerated concrete (single block)
  - Ice-cemented soil

General Technical Questions: Miscellaneous

34: How deep are we expected to drill?

- Answer: Deep enough to get into the ice and extract water. The test bin dimensions are listed on the The Competition Basics webpage (under “Simulated Martian & Lunar Subsurface Ice Test Station”). Drill bits are limited to 38” in length.



35: What would be the pressure of the water buried underneath the ice?

- Answer: In the testbed, it will be under 1 atmosphere of pressure. On Mars, that is for you to estimate.

Off-Earth vs. On-Earth & Path-to-Flight Questions

36: Mars has very low surface temperatures. Should there be mechanisms on the device that would make it work in the Martian temperatures?

- Answer: Yes.

37: Since we cannot simulate the effects of a Martian or lunar atmosphere, would the design components meant to make the system work in such an environment have to be included in our final design? Or simply described in our path to flight?

- Answer: Described.

38: What considerations do we have to make for gravity and atmosphere differences? Are those gravity and atmosphere considerations supposed to be addressed in our design or theoretically in our paper?

- Answer: In the paper.

39: Does the paths-to-flight take considerations of the vibration of the launch system to the prospecting system and planetary protection factors?

- Answer: If you think your system would be significantly impacted by launch loads, you should address that.

Programmatic Questions

40: Are post doc students allowed to be team members for the competition?

- Answer: The competition is open to undergraduate and graduate students currently enrolled at an accredited U.S.-based university. Because postdocs are (by definition) persons professionally conducting research after the completion of their doctoral studies, they are not eligible to serve as a team member for the competition. However, there are ways a postdoc can still participate in the challenge as a non-student team member. If the post doc is employed by the university with an academic or research position, he/she can be considered a faculty advisor for the project. If he/she is not employed by the university, he/she can be considered an industry advisor or consultant that can provide unlimited support to your team (but you would still need to have an official university-employed faculty advisor on the team as well).

41: The team size is restricted to 5 members and 1 faculty advisor. Will it be okay to bring other members on our own behalf that act as spectators that will not interact with the system at all during the competition operations?

- Answer: Unfortunately, only 5 team members and 1 faculty advisor per team may attend the onsite competition at NASA Langley Research Center. These are due to stringent escort-to-visitor ratios enforced in NASA Langley's aircraft hangar (a highly secured facility).

42: Will help be provided on transporting the system to the NASA site?

- Answer: No. Each team will be responsible for transporting themselves and their system to NASA. Most teams opt to rent a large truck and/or trailer. Once teams have arrived at the NASA hangar, there will be flatbed dollies that you may borrow to transport your system from your vehicle to the test bed inside the hangar .

Additional Questions?

Please direct all future questions to the RASC-AL Program team at rascal@nianet.org.

Each question will be responded to directly, as well as posted on the FAQs page for everyone to see.

We encourage you to visit the FAQ's page often!
http://specialedition.rascal.nianet.org/frequently-asked-questions/

RASC-AL Resources

RASC-AL Special Edition Website (http://specialedition.rascal.nianet.org)

- Resources page – http://specialedition.rascal.nianet.org/resources
- Previous winning papers are available on the Past Participants page (click the project title to view)

Important Dates

Deadline to submit Project Plan Proposals (Nov. 24th @ 11:59 pm Eastern)

Teams will be notified of their Selection Status (Dec. 13th, 2019)

Onsite Competition at NASA Langley Research Center (June 1 – 4, 2020)