2021 Moon to Mars Ice & Prospecting Challenge
Q&A Session Summary Document
October 14, 2020; 4:00 – 5:00 PM Eastern

General Technical Questions

1. **For the power supplies, is the idea to join them on a bus and use only one AC plug, or to use an independent plug for each supply?**
   - There needs to be a single power cable connected to the volt/amp meters to measure the electrical power being consumed by the test hardware. After this point, multiple plugs connected to individual pieces of hardware/computers is allowed. The power meter must be able to measure all power used by the test hardware. Power management and distribution in the test hardware is a design responsibility of each team.

2. **If a sleeve is implemented to reinforce drilled holes in the overburden, is it required for it to be extracted after completing a day of competition?**
   - Because subsequent days require a new hole, the general answer is yes – the sleeve should be removed at the end of a competition day. However, you could theoretically still leave the old sleeve in the regolith but would need to use a new sleeve for the new hole the next day and the mass of all sleeves counts towards the limit.

3. **Regarding the regeneration requirement of the filter: if our filtration system can function for 12 hours without needing to regenerate, should our assembly still include a regeneration/backwash mechanism? Would it instead be sufficient to explain how we could hypothetically do regeneration?**
   - You do need to explain how your system would be regenerated in actual operations on Mars (taking into account environmental effects). If you do not need to regenerate your filter during the competition, then you do not need to demonstrate it.

4. **Is there a specific location/terrain we should base designs on (as Mars has multiple terrains)?**
   - No. Teams should review recent literature/research on Mars to determine the best location/terrain for harvesting ice with their proposed system, and provide a good rationale for their selection.

5. **What are some successful tactics that we can use to test the effectiveness of our drilling and water extraction?**
   - Tips from the Judges:

1. Integrate your subsystems early and leave plenty of room for testing and revisions.
2. Test to the limits/boundaries of the requirements
3. You are doing the right thing by planning your test strategy early on. One of your team members needs to lead the test effort and make the test environment as realistic as possible. Start designing and building the test environment in parallel with the drilling and water collection system.
4. We want teams to come up with their own creative solutions for all aspects of the competition, including testing – this competition is designed to glean new ideas from our country's collegiate community. That being said, we encourage you to review the technical papers from the winning teams (found on the Archives webpage) as well as carefully review the Lessons Learned documentation available on the Resources webpage). You may find tips in there of things to avoid or watch out for.

6. Where can we find data to test our prediction models, besides the running of our own tests?

- This one is highly dependent on the specific system being proposed, and your best bet is to run your own tests to support your models.
- Again, we encourage you to review the technical papers from the winning teams (found on the Archives webpage as well as carefully review the Lessons Learned documentation available on the Resources webpage).

7. Can we expect a theoretical Rodwell that is created on day 1 of competition to be in the same state as day 2 of the competition?

- At the end of day 1 all hardware must be withdrawn from the test cell and turned off. The test bed will be covered with an insulating "space blanket" for the overnight period under ambient conditions but no other provisions (other than the dry ice already inside the test bin) will be made to protect it from environmental conditions at the time of the completion. Teams should expect the test bed conditions to be similar to those at the end of day 1 but there is no guarantee that they will be identical at the beginning of day 2.
  - Note: teams will not be allowed to use the same hole on day 2 for scoring runs. However, if they have a Rodwell and want to assess its condition, use of ***robotically deployed*** cameras from the system would be allowed to inspect the hole.

8. Can ambient air be blown into the core to improve the efficiency of melting?

- The competition is based on teams designing extractions concepts based on operation under actual mission conditions. For 'ambient' are to be blown into the core to improve melting efficiency
  1. The airflow mass and temperature should be equivalent to Mars atmosphere conditions for non-sealed drill holes or
  2. The drill hole needs to be sealed with corresponding inflow/outflow valving and air pump.

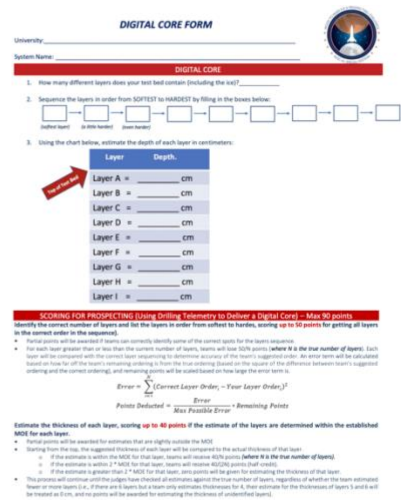
In both cases, mass/power for the hardware will count toward the total system specifications. The design report will also need to elaborate on what the actual design would look like on Mars.

9. Can a heat exchanger be used to take advantage of ambient air conditions outside the ice box?

- A heat exchanger is a thermal management device which is allowed. The team will have to explain how a real heat exchanger for a Mars water extraction system equates to the heat exchanger used under Earth ambient conditions. The mass/power/volume for the hardware will count toward the total system specifications.

10. **What material properties are required for the digital core (specific hardness, impact strength, compressive strength)? Do we need to determine what each material is in the overburden area or just the material properties?**
    - The digital core form is only looking for very basic properties. (# of layers in the test bed; general sequencing of layers in order from softest to hardest; estimating the depth of each layer in centimeters)
    - However, if your system can produce more specific property information (I.e., estimated MPa of the layers, etc.) we would love to see it! Who knows, there may even be a special award presented for the most detailed (and accurate) digital core.

Digital Core Form


DIGITAL CORE FORM

University:

System Name:

DIGITAL CORE

1. How many different layers does your test bed contain (including the ice)?

2. Sequence the layers in order from SOFTEST to HARDEST by filling in the boxes below:

3. Using the chart below, estimate the depth of each layer in centimeters:

Layer	Depth.
Layer A =	______ cm
Layer B =	______ cm
Layer C =	______ cm
Layer D =	______ cm
Layer E =	______ cm
Layer F =	______ cm
Layer G =	______ cm
Layer H =	______ cm
Layer I =	______ cm

SCORING FOR PROSPECTING (Using Drilling Telemetry to Deliver a Digital Core) – Max 90 points

Identify the correct number of layers and list the layers in order from softest to hardes, scoring up to 50 points for getting all layers in the correct order in the sequence).

Estimate the thickness of each layer, scoring up to 40 points if the estimate of the layers are determined within the established MOE for each layer.

11. **Are there any safety requirements regarding microwave heating? Assuming that all necessary safety concerns are addressed, would it be acceptable to use microwave radiation to melt the ice?**
    - We will not automatically rule out the use of microwave radiation to melt the ice. However, any plans proposing the use of microwave radiation will be subject to NASA and Air Force Safety Office approval. EMI interference issues will also need to be taken into consideration. (The NASA Hangar is shared with the Langley Air Force Base, so there are additional safety precautions that must be taken to ensure all appropriate safety standards are met from the military's perspective as well).
    - If selected as a finalist, any team proposing microwave radiation will be subject to multiple safety reviews throughout the year: an initial safety review at the proposal stage, a follow-up review at the mid-project point (including detailed diagram and photos of the set up and detailed description of any leak testing that was performed and the instrumentation used), and a final radiation leakage test on-site at the competition. During any of these safety reviews, the NASA Safety Office has the ability to refuse approval for use at Langley.

12. **For a water recirculation system, we might need some priming water in the system. This water would be the initial source of heat before any ice is melted, and would continue to recirculate through the heat exchanger and Rodwell until collection time.**
    - Unsure what the actual question is? Likely asking if they can have some amount of pre-measured water to prime their system which we would then subtract from their total?
    - A pre-tank of water can be included in the competition hardware to allow for priming. However, the water needs to be weighed and added with a Judge before the start of the competition and will not counted toward the water extracted amount. The team should discuss how the water tank would be incorporated into an actual mission design in the final report.

13. **Are multiple tethers/cords allowed between the system and the operators? Are multiple operators/computers allowed? If more than one operator is allowed, are the two operators allowed to communicate with each other?**
    - Multiple tethers/cords are allowed between the system and the operators. Multiple operators and computers are allowed. The two operators may communicate with each other during "Hands-On" operations, but not during "Hands-Off" operations.

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- Exception: two operators who are not physically observing and relaying system state (I.e., both at the same table) could still talk to each other even during "Hands-Off" operations.

14. What kind of control should the user have from the computer?
- That is up to each individual team. Do what works for you.

15. Is the maximum thickness of a layer 25cm? We found this information in the 2019 Q&A
- The entire overburden will be comprised of multiple layers and you've been told that the entire overburden section will be between 0.4 and 0.5m. 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; MMIP Challenge teams are part of this general learning process for themselves and for NASA.

16. What is the threading of the 3" carriage bolts that can be used for mounting?
- 1/2" x 13 tpi. These are actually 5" Through/Bolt/ Carriage Bolts (½" diameter), with 3 inches of the bolt exposed "above deck" (from the washer/nut up).
- Note: The carriage bolts will not come standard on the test frames (as most teams simply mount their rig to the wooden frame). Teams will need to ask for the 3" carriage bolts in their proposal if they would like to make use of them for their mounting system.

17. Regarding the concrete used in the competition: What is the type of aggregate? What is the type of cement? Do you have a specified concrete mixture? This information will help us create our own mixture and simulate the conditions of the competition.
- While we applaud your desire to replicate the competition environment for testing ahead of time, we are not providing any specifics about the overburden to teams. Part of the competition will be drilling through relatively "unknown" substances.

18. Are there any chemical or material restrictions for electrical/chemical-based filtration systems?
- Explosives, combustibles, open flames, and cutting fluids are strictly prohibited. All hazardous materials, chemicals, and pressurized systems (pressure vessels or pressurized liquids) are subject to review and approval by LaRC Safety. Approval from the safety office could take up to 6 weeks.
- Teams will need to submit an MDS (Material Data Sheet) for anything that may be hazardous with their proposal (and please list any chemicals you plan to use in your proposal).
- While not restricted per se, it is not recommended to use a coagulant to melt the ice.

19. Does the system need to be both manually controllable and automated?
- 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 Prototype Design Constraints & Requirements section of the Challenge Details webpage:

- 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:
  - **Autonomous control** refers to no human intervention after the system starts; no further operation from any crew is required at all.
  - **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.

(Please see Prototype Design Constraints & Requirements section of the Challenge Details webpage for full details).

20. What are the dimensions of the collection container and is it located at the base of the system or at ground level?

- The collection container (i.e., external accumulation tanks) is 15" (38 cm) tall, with a 31 cm diameter (22 Quart capacity). Teams can choose to place the collection container on the ground outside of the test station, or on a table next to their test station.

21. Since our peristaltic tubes are rated in hours, is longevity a scoring criterion? If so, what is the expected longevity of our system?

- Longevity is not a scoring criterion. (Please see the Proposal Evaluation Criteria and the Final Scoring Matrix)
- **Evaluation Criteria:**
  - Description of how prototype system will accomplish required tasks (Max – 20 points)
  - Description of concept's 2 anticipated "Paths-to-Flight" (Max 20 points)
  - Water Extraction of subsurface ice on Mars
  - Prospecting on the Moon
  - Technical merit and feasibility of project plan (including lessons learned) (Max – 20 points)
  - Project plan capability – degree to which team can accomplish tasks (Max – 20 points)
  - Adherence to project plan guidelines (Max – 10 points)
  - Proposed "flight-like" testbed enhancements (Max 5 points)
  - Innovation (Max 5 points)
- At a minimum, your system needs to last through the 3-day competition at Langley. Beyond that, there is no specific length of time the system has to last. In the Path to Flight section of your technical paper,

you can address modifications you'd make to your system to allow it to survive for several years on the Moon/Mars.

22. Is power going to be a limitation?

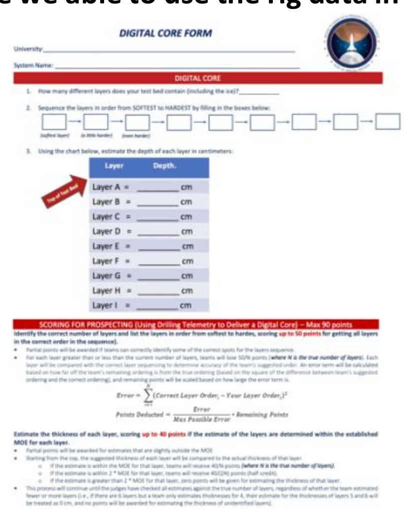
- Please see the Prototype Design Constraints & Requirements section of the [Challenge Details webpage](). It states:
    - The water extraction and prospecting system must be capable of operating on limited power supply. Teams will be provided with 120 VAC (GFCI protected) power, via an outlet.
    - Teams will be required to incorporate a 9 A fast-blow fuse into their circuitry.
    - Teams will be required to monitor and log their electrical current usage via the same data logger that is monitoring and recording the WOB load limits.
    - Augmenting the system's power supply via batteries, solar power, etc. is not allowed.
    - This power limitation only applies to the water extraction and prospecting system itself. Separate power sources (i.e., a standard wall outlet) will be supplied for the remote crew-controlled computer/control devices for the system. The control system may not provide power to the water extraction system.

23. Do we only have to submit the Digital Core Form to the judges at the end of the competition?

- You can submit the Digital Core Form to the judges any time prior to the end of the competition, but once you hand it over, it is considered a final submission and you will not be able to make additional changes.

24. Do we have to show a picture/graph of the layers drilled through, or are we able to use the rig data in any way that we want?

- Each team will use their rig data to fill out the same designated [digital core form]().


DIGITAL CORE FORM

University: ____

System Name: ____

DIGITAL CORE

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SCORING FOR PROSPECTING (Using Drilling Telemetry to Deliver a Digital Core) – Max 90 points

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Miscellaneous Questions

25. My team and I are currently conducting technical research. We have been using the public domain of the NASA Technical Reports Server and have not found it particularly useful. Is there anywhere else for us to find technical reports from NASA?

- Harvesting water from extraterrestrial subsurface ice is a relatively new area of study. This competition is designed in part, to enlist the university community in adding to the knowledge in this area. We encourage you to view the Recommended Reading list on the Competition Resources webpage.

26. What is the needed longevity of the Rover/Ice Mining System?

- At a minimum, it needs to last through the 3-day competition at Langley. Beyond that, there is no specific length of time the system has to last. In the Path to Flight section of your technical paper, you can address modifications you'd make to your system to allow it to survive for several years on the Moon/Mars.

27. What are some challenges that are overlooked when adapting the design to function in Martian environments?

- Address potentially natural and/or toxic impurities (like perchlorate salts) thought to be in Martian water and ice in the system's path-to-flight filtration. Natural impurities have not been considered in depth yet in our Challenges. We have limited the filtration to keeping the sediments out of the hoses/valves/pumps/etc. The Path to Flight section should make mention of how natural impurities might be addressed if this were a real Mars operation.

Programmatic Questions

28. Is there a unique aspect of the design you would like to see someone incorporate this year?

- The purpose of the competition is not necessarily to examine unique designs, but to have teams consider the same problem and determine their own path to success. Designs that focus more on operating under actual mission environments versus those that might work best under Earth ambient air and pressure conditions are preferred.

29. What are some common design flaws teams in the past have run into?

- The judges prefer not to answer this question in too much detail. However, they would like to emphasize that common flaws have included:
- Failure to test an integrated system in a test environment that closely resembles the competition environment, and
- Failure to allow enough time to change and retest design features that fail to work as expected in integrated testing.
- Again, we encourage you to review the technical papers from the winning teams (found on the Archives webpage as well as carefully review the Lessons Learned documentation available on the Resources webpage). You may find tips in there of things to avoid or watch out for.

30. How much programming needs to be reflected within the project proposal?

- You should be able to summarize how your system works; however, you do not need to include your code or any detailed algorithms.

31. Should the proposal be written considering the on-site competition, or its actual use on Mars or the Moon?

- The judges need to see that the rig you are proposing can be successful at the Earth-based on-site competition, but that you've put a lot of thought into the design for use on the Moon/Mars. Use your path-to-flight section to highlight how your concept could be feasible for use on the Moon/Mars.

32. What aspects of space deployability haven't been addressed in past experiments?
- We're not looking for teams to explore new ideas for deployability, except in how they enable their systems to support prospecting on the Moon and acquiring water on Mars.

33. Can you please clarify what you mean by "Teams can manually reposition the drill between subsequent hands-off stages"?
- 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 are attached to the top of the test beds, they need to stay attached. However, teams may manually move/reposition their actual drills between subsequent "hands-off" operations without penalty. However, 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.

34. Our team will likely seek help from more faculty members as the year progresses. Can additional academic advisors be added to the project later?
- Absolutely. We simply ask that all contributors to the project be acknowledged in the proposal and then later in the final technical paper.

35. We have a few members who are graduating in December but would like to stay in the team and help with the project. Is that permissible? Would these graduates be allowed to represent the team at the on-site competition?
- Yes. However, please work with your university on their policy for supporting those students travel after they've graduated.

36. If we encounter new advisors before the proposal submission, do we need to add them to the initial list of advisors? If so, how do we do that?
- You do not need to add them to the initial list of advisors listed on the NOI. Instead, simply list them on the proposal.

37. How many teams signed up in 2019 vs how many were selected?
- We do not publish that information – but we can tell you the pool was competitive, and 10 teams were ultimately selected.

38. We have a prototype from last year's Mines team which did not make it to competition due to COVID. Would we still count this as a returning team even though they did not originally compete?
- Yes, your team would be a returning team because technically they were accepted into the 2020 competition.

39. Is there any transportation for prototypes that NASA will provide or recommend?
- NASA does not provide transportation for prototypes. Each team will be responsible for transporting themselves and their systems 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.
- Teams can ship the prototype to their hotel or drive it to Hampton with them. Unfortunately, you cannot ship your prototype directly to NASA Langley). Any freight company you trust should be able to ship your prototype to your hotel, but we've found that most teams prefer to travel with their prototype (even across long distances.
- Tips from previous teams:
  - Some shipping methods may affect the integrity of the rig
    - The back of a UPS truck is a dangerous place for poorly packed instruments
    - Put your electronics in foam to dampen the effects of vibration

40. If questions arise after this Q&A as our design efforts progress, will we have any point of contact or opportunity to clarify them before the Project Plan submission deadline? If questions arise after the Project Plan submission deadline, will there be any point of contact or opportunity to clarify them before competition?
- Absolutely. All future questions can be sent to rascal@nianet.org and we will provide a written response to you, as well as post the information on the FAQs so that everyone else also has access to the same information.

41. Will the containers that will be drilled into be kept at a certain temperature during the procedure?
- The containers are not monitored for exact temperatures, but they are very well insulated and contain a significant amount of dry ice to keep things very cold. A space blanket is added to the top of your container each evening. Historically speaking, the ice blocks have remained frozen for an entire week, even in 90+ degree temperatures. Teams should assume that the atmospheric temperature is going to be between 25-30 deg. C; the overburden will have a gradient from 20 deg. C at the surface to –10 deg. C at the ice interface.

42. How long in a day can you drill / pump?
- Each team will have 12 hours total to drill/pump/extract water from the simulated planetary test bed. (Could be a 6-hour/6-hour split, or 4-hour/8-hr split, for example).

43. What sort of interface capabilities will the integrated windows 10 computer have?
- That question is outside of the scope of this competition.