Mars Ice Challenge Capture Session Notes

Accessing the Ice
(e.g. drills, the regolith, etc.)

- **What worked?**
  - The interface between the dirt and the ice was perfectly flat
  - A heated auger tip was advantageous
    - Heated tip helpful to soften up overburden
  - The sheath around an auger helped keep the hole from collapsing
  - A percussion drill was very effective at penetrating the overburden
  - Higher RPM was more effective than higher torque
  - **Idea:** Have 2 or 3 different parts of the competition
    - For example using the different kinds of Mars terrains because we said we were examining different types of surfaces/ overburden
  - **Idea:** Make it multiyear competition
    - Year 1 – build rig
    - Year 2 – add autonomy

- **What didn't?**
  - This regolith model may not be perfectly analogous to Mars
    - The teams' regolith wasn't as wet when they practiced
  - Rocks mixed in with gravel were large
    - composition of the material wasn't what they expected

- **What were some unexpected problems that only arose after you got your rig set up?**
  - Was the test environment different from what was advertised?
    - The regolith was a lot wetter than expected and we didn't know how cold it would be
    - Knowing the rock sizes would have helped

Motors

- **Comments:**
  - Lack of knowledge of motor performance specs—research and test this more carefully.
  - Teams were overextending in terms of power and torque
  - Three phase motor put out electrical interference that messed with monitoring
  - It was easy during testing to take motor temperature, listen, etc. but during the actual competition you couldn't touch them
    - Teams used their fingers to test temperature
    - Suggestion: add sensors for temp and torque

- In regard to amperage, teams went over when they had to drill harder which caused a challenge for what motors can handle
    - Ex) Power given to the motors to get through regolith/ overburden
- Time constraint: Difficult to run 6-hour tests prior to coming to the actual competition to test motors
- Industrial motors were more robust; Avoid commercial motors you get at stores like Home Depot or Lowes ("You get what you pay for," and "Our team wasn't rich enough to buy the cheap stuff.")
    - "Our hammer action drill sped things up (like a high rate jack hammer)"
    - **Tool head motors:** Grainger industrial motor worked fantastically and costs about $150
- **Drive systems:** time-belt drives don't work well; used a just ball screw & it worked better

- **How much integrated testing was done? What would you change that would help change problems? (Rick)**
    - Better monitoring on the motors
    - Lean more towards industrial-grade motors as opposed to commercial ones; avoid risk of smoking/ other complications
    - Adding more capabilities to test temperature of motors

- **Individual Team Input:**
    - **VT**: Motor problems with regard to determining torque power
    - **Alfred**: Amperage was a challenge
    - **CSM**: commercial grade drill vs Home Goods store drills; some caught fire (Home Depot drills)
        - **Tool head motors:** use general purpose motor which worked okay; costs about $150
    - **WVU**: 3-phase motor with variable frequency (0-1700 RPMS) worked well & were under limit
        - However, it puts out a large amount of electromagnetic interference which can lead to a jammed motor

- **Suggestion:** Add sensor for temperature & torque would help, in addition to integrated testing and longer time

Water Retrieval
(e.g. extraction method, pumps, filtering, etc.)

- **What worked?**
    - Peristaltic pump – good with debris and can also run dry
    - Having a means of reversing the flow to unclog filters was advantageous

- Having a larger tube diameter helps

- **What didn't?**
  - Smaller diameter tubes got clogged very quickly
  - Pushing the retrieval mechanism into the sediment clogged the opening
    - Some teams taped a screw driver or preset something to clean the augers

- **What would you do differently?**
  - Bring a back-up pump
  - Larger tube diameter
  - Use filters at the end
  - Add a camera – but image quality made them less useful

- What would you do differently to handle the mud?
  - Try to take advantage of the water trapped up in the mud
    - Try to use the mud instead of fight it
  - Add something to clean both the auger and the suction mechanism

- **Individual Team Input:**
  - **NE:** Tubes got clogged during vertical collection of liquid; used no filtering mesh
    - Larger tube diameter helps
    - Vertical vs horizontal tube affects sediment movement
    - Also used a camera starting on the 1st day; wasn't the best quality but still useful to have

Hardware

- **What worked well and what didn't in terms of hardware/materials used?**
  - **3D printing vs machining**
    - PLA was used by 4 teams – ABS was used by 2 teams
      - ABS melted at high speeds
  - 3D printing helped with weight reduction and held up for the duration of the competition
  - PLA worked reasonably well for the drive system
  - Machined pieces may be necessary for the main drill and larger pieces
    - Although combining them may help save weight
  - 3D printed materials and 3D printing on site made systems adaptable

- **Individual Team Input:**
  - **TN:** used 3D printer for mass issues which worked well
    - PLA was used

        - Caused LOTS of vibration & it helped
        - Ball screws helped as well; teams needed aluminum
    - **NE:** used 3D printer
        - 150N MAX – you can use 3D printed materials
        - **Brought a 3D printer w/ them which was very helpful**
        - Also used IMADX cables for structure weight
    - **CMU:** impressed by MIT's structured parts that were 3D printed
    - **MIT:** held up at end of day 2; started to peel back
    - **WVA Evans:** TBU used for vibration
    - **NE:** used ½ 3D printed material ½ metal
        - Would be helpful in the future

- **Question: How does plastic hold up on mass?**
    - Answer: Don't know

Autonomy

- **How do we encourage more autonomy and less tele-operations?**
    - Planning for all of the fail-cases is a gargantuan task
    - Potentially removing the team's ability to view their system in operation with their eyes, and the implementation of time delays would have encouraged autonomy
    - An incentive (more point) for more autonomous systems would give teams a reason to pursue it
        - Using Lunabotics as a scale factor as a possibility for more points
    - Perhaps raise the profile of software in the competition
        - Push people to break boundaries
    - More monitoring/sensors
    - **If we want more complexity, we need more time**
        - MATLAB via Arduino led to time issue at the end
        - Communication to machine using software systems w/ **real time** responses

- **Individual Team Input:**
    - **Taskin:** Low load, use AI; high load, use human commands

- **Suggestion:** Require fully integrated tests the last 10 days before the competition

Augers

- **Augers have not been very successful is lifting anything last year or this year. Why?**
    - It's a delicate balance – right speed, right pitch
    - Didn't get the material out, but did make a hole
    - Hard to manage the transition from mud to ice

- An ice corer was able to complete its mission
- More research on it is needed

- **Individual Team Input:**
  - **VT:** Big challenge was finding the right speed and right pitch which left lots of room for errors
  - **CSM:** Auger made a big hole but it wasn't efficient
    - Augers for extracting ice is also a challenge because it's not just pure ice

Pre-Competition Information

- **Question: What else would have been helpful to have in advance?**
  - The pre-briefings were useful, but it would be better learn it after teams have been selected to compete (or hold another session). It wasn't as helpful during the proposal stage
    - They would've liked a pre and post proposal briefing session
  - More of those activities would have helped
  - Clearer rules and requirements in advance would be better – be specific; can't be too specific.
  - Resources in regard to software – especially on the site
    - Only one link is provided now to SolidWorks.
  - A running Q&A and on-going **community forum**
  - Resources in regard to hardware and suggested places to find materials would have helped
    - A list of quality of brands/ potential funding would've helped too
  - Direct POCs at suppliers/machinists – a learning opportunity
  - Know what the dirt will be like
  - Management advice – integration and communication

- **Question: What would you change about your development timeline?**
  - **What worked? What didn't?**
    - Testing for 6 hours straight in advance was very difficult (didn't anticipate motor burn outs)
    - Dividing the system/responsibilities into sub-groups worked for the design phase, but made integrating and interfacing with the control system difficult
    - Knowing/starting earlier in terms of the proposal/application
    - Regular tag-ups "what are you working on this week?" was great
    - Size of team was an issue; everyone assumed the other person was working on something
      - Team sizes varied from 6-23 members; larger teams were a challenge
      - Led to commitment issues of team members

- **What would you do differently?**
  - Setting up design cycles
  - **Send a working prototype check-in about a month before the competition**
    - Possibly require a video upload of the working system to force integration

- **Question: What advice would you give to next year's team?**
  - Test early and often
  - Listen to the lessons of the last year
  - Try to maintain contact with previous teams
  - Larger teams did not work for these newer programs
  - Smaller teams helped keep things focused and helped get things started
  - Make cuts to your team for missing meetings.
- **Individual Team Input:**
  - **CMU:** divided their team into subgroups
    - Biggest issue was integrated testing especially with control system
    - Harsh cutoff date on design would have helped development. Too many design changes was a time consuming.
    - Setting up design cycles would have helped
    - Require working prototype 1 month into the competition—forces necessary integration.
  - **NE:** Met Monday night every week which helped
  - **VT:** Requirements flow down would have helped; ID root causes
  - **CSM:** listen to lessons learned briefing, and test early & often
    - Lost contact w/ returning team due to graduating
    - Want to send junior engineers to competition in the future to help with continuity because senior design team consisted of 3 people who were very committed, but they should've asked for junior help

Post-Competition Information

- **What was the most valuable lesson?**
  - Integration & communication is what takes you up the ladder
  - Use of ladders---have an actual one for teams' to access bins
  - A 3D printer and/or an onsite machinist would be incredibly helpful

- **Suggestions:**
  - We need more incentives tele-operated/autonomous operation.
  - **Project management tips would be helpful**
  - Make post competition lessons learned session 2 hours instead of 1
  - Have Langley sponsor a machining area and 3D printer access?

- Possibly purchase bins for testing at university; MIT said that it didn't help as much as they hoped because overburden consistency was different at competition.