THE INAUGURAL OVER THE DUSTY MOON CHALLENGE. K. M. Cannon[1,2], A. Abbud-Madrid[1], C. B. Dreyer[1] and G. S. Sowers[1], [1]Space Resources Program, Colorado School of Mines, Golden CO 80401. Email: cannon@mines.edu. [2]Department of Geology and Geological Engineering, Colorado School of Mines.

Introduction: As we work toward building up infrastructure and industry on the Moon, one of the more important tasks is learning how to work with the dusty regolith that covers the surface of every landing site. Previous challenges like NASA's Lunabotics Robotic Mining Competition [1] and NASA's 3D-Printed Habitat centennial challenge [2] have focused on initial excavation, as well as end use cases like construction with regolith-based materials. Key gaps between these steps include transporting and handling large volumes of regolith over a range of distances and combining vertical/horizontal transport systems with transfer points. Working with Lockheed Martin, we conceived and then implemented the Over the Dusty Moon Challenge (https://www.overthedustymoon.com) to solicit and evaluate creative solutions for conveying regolith while minimizing dust generation. Phase 1 judging is complete, and we will present results from the Phase 2 in-person competition that immediately precedes Space Resources Roundtable.

The Challenge: Construction, mining, and other activities on the lunar surface will require moving and handling large volumes of regolith with high degrees of autonomy. Consider a scenario where a molten regolith electrolysis (MRE) system is being used to extract oxygen and metals from the lunar soil. The regolith is transported from an excavation and beneficiation site located tens of meters away from the processing plant. Once the regolith is transported over this distance, it is handed off and then lifted vertically to an inlet funnel for the MRE reactor. Transfer points connect these different subsystems of the overall conveyance system.

This scenario was presented as a design and prototyping challenge to teams of college students worldwide (undergrad and/or grad). Their task was to design a system to transport regolith between a dispensing hopper and the MRE reactor (both assets assumed to be provided). Sixteen teams from eight different countries registered for the challenge. In Phase 1, teams submitted a written report detailing their engineering design with estimated performance and illustrations. Scoring was based on scientific and technical merit, feasibility of the design, creativity of the design, estimates for mass of regolith transported, power use, and landed mass, how well the lunar environment was accounted for in the system design (e.g., dust, vacuum, gravity), and quality of writing and illustrations.

Phase 1 Results: Based on the Phase 1 judging, six teams were invited to CSM to compete in the in-person competition with prototypes of their systems. The following teams are currently planning to compete:

Moon Aixperts (RWTH Aachen, Germany). System is based on directed vibration with modular horizontal components (Fig. 1).

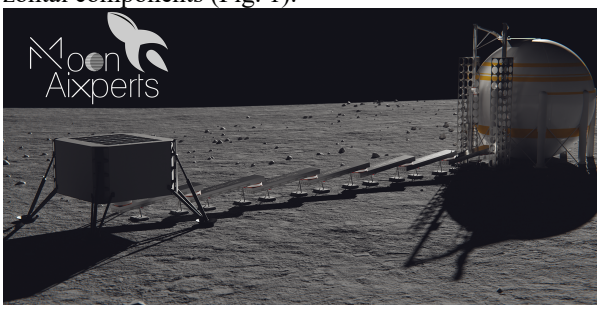

Fig. 1. Entry from Moon Aixperts.

Laurentian Lunars (Laurentian University, Canada). A portable screw conveyor system (Fig. 2).

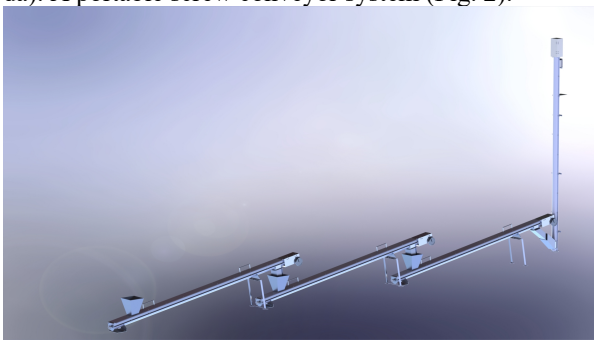

Fig. 2. Entry from Laurentian Lunars.

Team UNSW (University of New South Wales, Australia). Proposed a lunar cable-car conveyance system (Fig. 3).

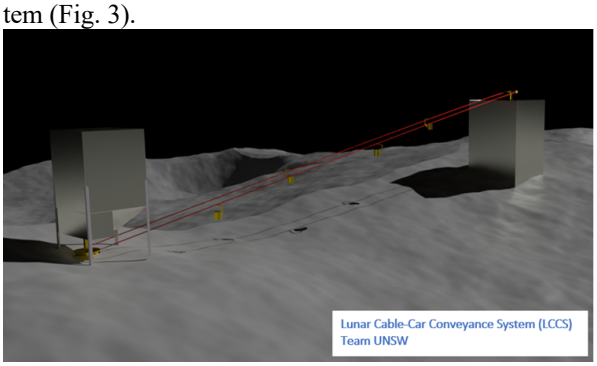

Fig. 3. Entry from Team UNSW.

SpaceTeam AGH (AGH University of Science and Technology, Poland). A combination of a rod scraper conveyor for horizontal, and a bucket elevator for vertical (Fig. 4).

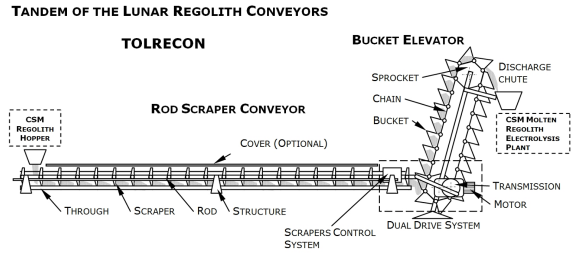

Fig. 4. Entry from SpaceTeam AGH.

The Dusty Horns (University of Texas at Austin, United States). Pneumatic tube transport (Fig. 5).

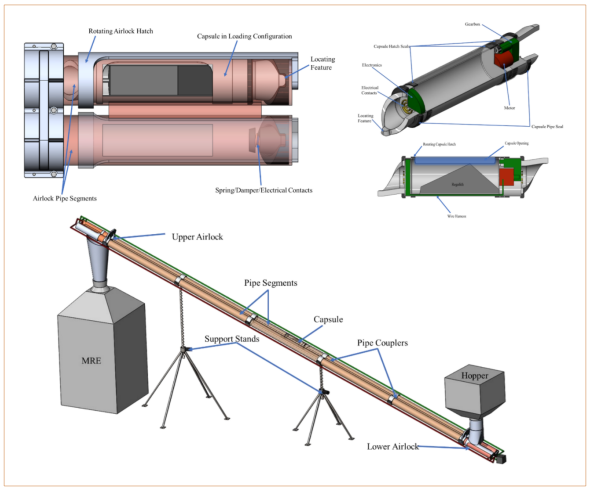

Fig. 5. Entry from The Dusty Horns.

DustBusters (Colorado School of Mines, United States). Lunar material ropeway (Fig. 6).

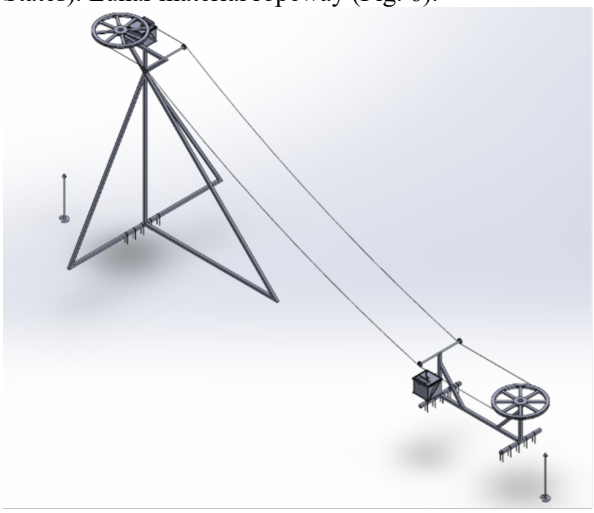

Fig. 6. Entry from DustBusters.

The proposed designs took on a wide range of conveyance modalities, and overall, most entries were very high in quality with rigorous analyses, technical drawings, and CAD models. The entries not selected included some of the same types of concepts shown in Figs. 1–6, and novel ideas like magnetically levitated buckets traveling along an enclosed linear track.

Phase 2: Phase 2 is taking place from June 2–3 on campus at Colorado School of Mines. A track will be set up, and two assets provided by CSM will be put in place at each end: the dispensing hopper, and the receiving bin meant to represent the MRE plant. The distance between them will be adjustable by the teams up to 5 m, and the vertical distance to the delivery point will be adjustable between 2–3 m. After set-up, each team will have 1 hour to conduct a run of their system. Scoring will include passing a mandatory safety check, the amount of regolith transported, mass and power of the system, dust tolerance of the design, dust generation, autonomy, and overall performance. Judging will be carried out by a panel of judges from industry and space agencies.

Conclusions: CSM and Lockheed Martin have launched the inaugural Over the Dusty Moon Challenge for university students worldwide to compete with system designs that transport large amounts of regolith over the lunar (or martian) surface. So far, the Challenge has been well received, and by allowing international participation we greatly increased the diversity of designs and provided an opportunity for students who are often excluded from government-run competitions.

References: [1] Mueller, R. P. et al. (2021), *Earth and Space 2021*, 497-510. [2] Roman, M. C. et al. (2017), *AIAA Space and Astronautics Forum and Exposition*, 5279.