DEVELOPMENT AND TESTING OF GAS ASSISTED DRILL FOR THE EMPLACEMENT OF THE CORNER CUBE REFLECTOR SYSTEM ON THE MOON. K. Zacny[1], D. Currie[2], G. Paulsen[3], A. Avanesyan[4], P. Chu[5], T. Makai[6], T. Szwarc[7], [1]Honeybee Robotics (zacny@honeybeerobotics.com), [2]University of Maryland, [3-6]Honeybee Robotics, [7] Stanfod University

Introduction: The Lunar Laser Ranging Retroreflector Array for the 21st Century (LLRRA-21) in combination with a Lunar Laser Ranging (LLR) program within the International Laser Ranging Service (ILRS) would provide extensive new information on the lunar interior, General Relativity and cosmology. Since the Apollo, the ground stations improved the ranging accuracy by 200x and now the Apollo arrays located on the lunar surface provide a significant limitation of the LRR accuracy. One of the objectives of the current program is to provide for the further improvement in ground station accuracy over the next few decades.

During the day/night lunar cycle, the regolith will rise and fall by almost 500 µm. Yet, it is estimated that the thermal variation 0.5 m - 1 m below the surface is less than 0.1 °C throughout the month. Thus to achieve 10 µm ranging performance, the CCRs must be anchored to that thermally stable mass at 0.5 m or greater depth.

Pneumatic Drilling Approach: The proposed emplacement approach uses gas-powered drill consisting of a 1 m long, slim hollow rod with perforated anchor-cone at its lower end and the CCR mounted to the top. Gas supplied from a small tank is directed into and down the rod and out through the cone lofting the soil out of the hole and allowing the rod to sink to 0.5 m depth.

Laboratory Tests: We conducted a number of tests in compacted JSC-1a lunar soil simulant and inside a vacuum chamber (see Figure 1). In all tests, the rod with a cone at the end (see Figure 2) was placed on the top of the soil surface. Once vacuum was reached, the soil bin was temporarily vibrated to compact the soil.

The test involved opening and monitoring gas flow and recording the rate of the rod sinkage into the soil. The rod and the CCR can on top weighed 1.6 kg. This mass provided the only vertical force (16 Newton) to the cone.

In several tests, the rod successfully sunk to a 50 cm depth in 4-6 minutes. The gas pressure was 101kPa absolute and the mass of gas used was 10-20 grams.

The gas-ejected soil particles travel up the hole (between the hole and the rod), and were effectively deflected sideways by the shield.

These tests successfully demonstrated the gas assisted drilling approach. Thus, the LLRRA-21 will require no power and could be deployed from light-weight lunar platforms.

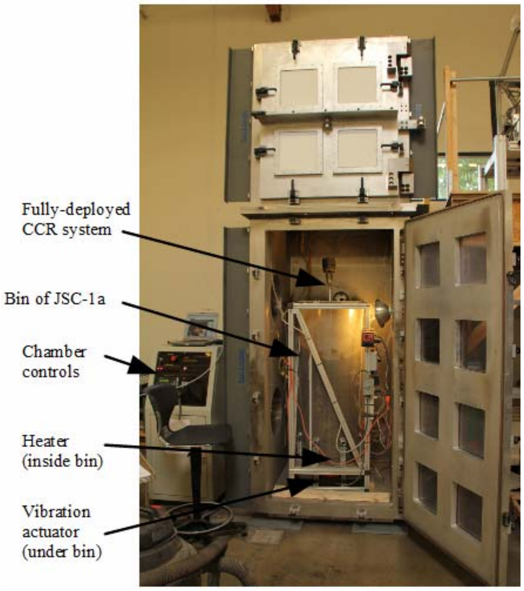

Figure 1. The CCR system was successfully deployed to 50 cm depth into compacted JSC-1a soil inside a vacuum chamber.

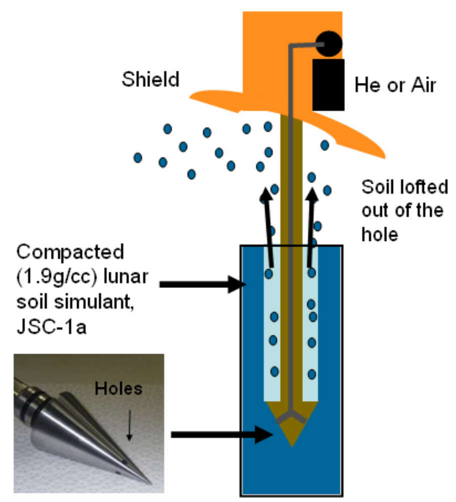

Figure 2. The details of the cone experimental set up.

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