Deployment and Burial of Lunar Seismic Sensors using Pneumatically Assisted DIABLO. Vishnu Sanigepalli[1], Robert Van Ness[1], Kris Zacny[1], and Hop Bailey[2], [1]Honeybee Robotics, [2]University of Arizona. (Contact: kazacny@honeybeerobotics.com)

Introduction: The DALI-funded Seismic instrument is a science instrument designed to bury a sonde, seismic sensor payload, into the surface of the Moon. The burial of the seismic sensors improves the attenuation and decreases the large thermal fluctuations on the payload through a lunar day/night. The pneumatic burial system deploys the sonde with a threshold burial depth requirement of 0.6 meter and can drill up to 1.1 meters (with 0.9 clearance from tip-to-surface) into the lunar regolith, Figure 1.

Figure 1: Instrument mounted on the belly-pan of a lander using DIABLO to deploy the sonde up to 2 meters from a stowed configuration.

The instrument's deployment technology is based on DIABLO, Deployment of Interlocking Actuated Bands for Linear Operations, which deploys a sheet metal band in a tubular form. The SS301 .005" band is stowed in a Storage Reel in a clockspring patter and is deployed with a BLDC actuator. DIABLO's HDM, Helical Drive Mechanism, semi-permanently assembles the band together from a flat sheet to a tubular structuring with deployment and retraction capabilities. The retraction capability of the system is used to recover from obstacles by the dither operation, which dislodges rocks obstacles and convey them to the surface.

The gas for pneumatic drilling is fed through a PTFE tube that is deployed in spiral-like fashion and expands like a telephone cord within the ID of the tube along the sensor/power lines for the seismic sensors shown in Figure 2. The gas is emitted to the nozzles of the sonde housing that expands in the vacuum and excavates the regolith. The flow of gas that is stored in tanks is controlled via a series of pressure transducers, valves, and sensors that are autonomously controlled by avionics during deployment.

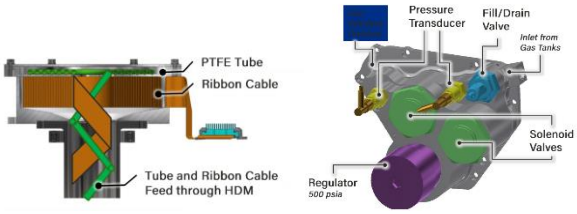

Figure 2: Pneumatic gas controlled via the manifold is conveyed through a PTFE Tube. A Ribbon Cable power and provides DAQ of seismic sensors.

After the sonde reaches the desired depth, the pneumatic system PWMs the gas to self-bury the sonde by depositing regolith onto itself to increase sonde-to-regolith coupling. A release mechanism is used to mechanically detach the sonde and retract the DIABLO structure to prevent any vibrations or thermal shocks that be transferred from the lander. An umbilical ribbon cable spooled out to ensure the sonde does not get dislodged from the surrounding regolith (Figure 3).

Testing and Demonstration The instrument has been demonstrated in a vacuum chamber at 7 Torr with a vacuum compacted BP-1 Fines [1]. The system has penetrated up to 0.8 meters autonomously. These tests have demonstrated and increased the end-to-end instrument mechanism and ConOps to a TRL 5/ 6 along with capturing the data from the seismic sensors to detect earthquakes.

Figure 3: (left) Instrument in stowed configuration (middle) Deployed stated after burial of sonde (right) Sonde deployed at target depth with umbilical ribbon cable.

References:

[1] Zacny et al. Lunar Drilling, Excavation and Mining in Support of Science, Exploration, Construction, and In Situ Resource Utilization (ISRU).

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