TESTING HEAT FLOW PROBE IN LUNAR ANALOG SITE ON MAUNA KEA, HI. K. Zacny[1], N. Kumar[1], E. Mumm[1], M. Hedlund[1], J. Shasho[2], A. Pierides[2], and P. Morgan[3] [1]Honeybee Robotics Spacecraft Mechanism Corp. (zacny@honeybeerobotics.com); [2]The City University of New York, [3]Nothern Arizona University,

Introduction: The heat-flow probe directly addresses the goal of the Lunar Geophysical Network, which is to understand the interior structure and composition of the Moon [1].

To place 1kg on the surface of the Moon costs ~$50k to$100k. Thus, any scientific instruments must be efficient with respect to limited spacecraft resources such as mass, power, and volume without compromising on quality scientific measurements.

A key challenge for a heat-flow probe will be getting to a 3m depth, i.e. below the depth of penetration of the annual thermal wave.

Pneumatic Proboscis Heat-Flow Probe Concept: The heat flow probe system uses a pneumatic (gas) approach to lower the temperature and thermal conductivity sensors attached to a bi-convex tape to >3 meters. The system is a revolutionary innovation for small landers as it has extremely low mass, volume, and simple deployment.

The pneumatic heat flow architecture implements concave/convex tapes in a different manner to arrive at a bi-convex (lenticular) shape. A set of two tapes are arranged in a biconvex configuration and bound together, forming a rigid rod capable of pressing the needle tip into the soil. RTDs are integral to the tape. The tape is coiled around a deployment drum similar to how a tape measure functions. The full length of the heat flow probe can then be packaged in a small form factor around the drum. Compressed gas is plumbed to the nozzle at the end of the tape which provides the mechanism for penetration into the regolith. A heating needle with an RTD protruding from below the cone measures the temperature and conductivity of undisturbed regolith ahead of the cone.

Helium gas, used for pressurizing liquid propellant and typically vented once on the surface, can be scavenged from the lander propulsion system, making the thermal probe system lighter. Honeybee demonstrated that 1 gram of N_2 at 5 psia can lift 6000g of JSC-1a in lunar conditions (vacuum, 1/6g) [3]. Thus, only a small amount of gas would be required.

The purpose of the heat flow probe experiment was two-fold. First, it was to demonstrate deployment of the probe into the air-dry tephra on the slopes of Mauna Kea volcano on the Big Island of Hawaii to a depth of ~50cm (20 inches) using pneumatic-proboscis system. Second, it was to demonstrate data acquisition system by acquiring thermal data, that includes actual temperature in at least two subsurface locations and to acquire thermal conductivity data of the soil.

The system successfully reached a depth of ~50cm (maximum extend of the proboscis tape) and acquired thermal data (thermal gradient and conductivity using a needle probe). We calculated thermal conductivity and found it to be ~0.2 W/m/K.

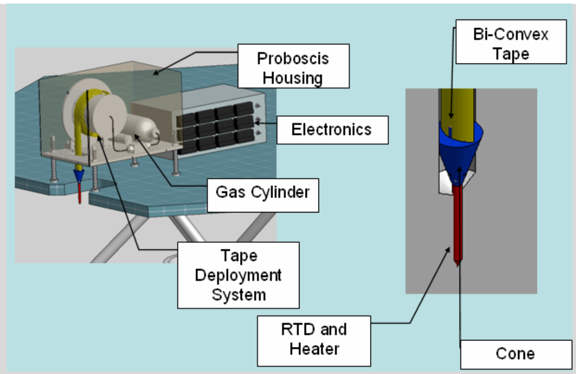

Figure 1. Pneumatic Proboscis deployment of heat flow probe uses compressed helium gas to advance below the regolith surface.

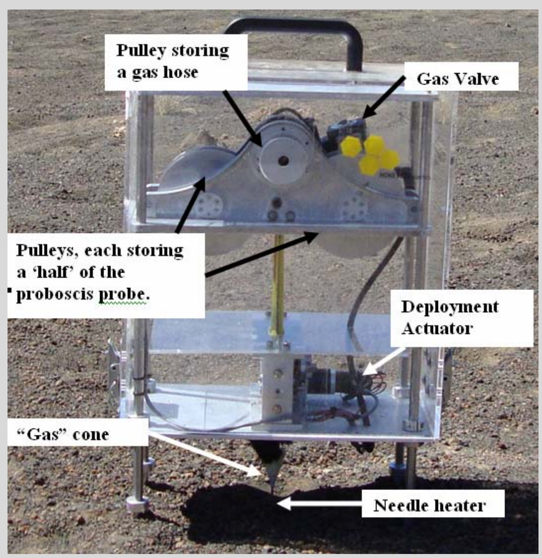

Figure 2. The prototype system a size of a laptop was deployed on Mauna Kea lunar analog in February 2010.

References: [1] Science Definition Team for the ILN Anchor Nodes, ILN Final Report (2009). [2] Zacny, K. Methods and Considerations for Heat Flow Probe Deployment, NLSI (2009). [3] Zacny, K. (2009) *LPS XXXX*, Abstract #1070.