TESTING OF A PNEUMATIC PROBOSCIS HEAT FLOW PROBE IN A VACUUM CHAMBER AND JSC-1A LUNAR SOIL SIMULANT. K. Zacny[1], G. Paulsen[1], J. Shasho[1], J. Craft[1], M. Hedlund[1], B. Mellerowicz[1], T. Makai[1], T. Szwarc[2], S. Nagihara[3], P. Taylor[4], B. Milam[4], [1]Honeybee Robotics (zacny@honeybeerobotics.com); [2]Stanford University, [3]Texas Tech University, [4]NASA GSFC

Introduction: A 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 1 kg 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 THE scientific quality OF THE measurements.

A key challenge for heat flow measurement is to install thermal sensors to A DEPTH LEAST A OF ~3 m SO that THEY are not influenced by the diurnal, annual, and longer-term fluctuations of the surface thermal environment. In addition, once deployed, the heat flow probe should cause little disturbance to the thermal regime of the surrounding regolith.

Pneumatic Proboscis Heat-Flow Probe Concept: OUR 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. ThIS 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 AN integral PART OF 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, THEY can be scavenged from the lander propulsion system, making OUR thermal probe system lighter. Honeybee demonstrated that 1 gram of N2 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.

Testing: We tested the heat flow probe in compacted (1.9 g/cc JSC-1) lunar soil simulant inside a vacuum chamber, Figure 1. The probe reached a maximum possible depth of 70 cm and acquired BOTH thermal GRADIENT as well as thermal conductivity DATA using THE needle heater AT THE BASE OF the cone. The thermal conductivity was calculated to be ~0.04 W/m/K, which is in the range of the conductivities of the REGOLITH at that pressure [4].

The concept of the heat flow probe deployment is shown in Figure 2. The probe is mounted along the leg of the lander (*i.e.*, closer to the ground) and deployed upon LANDING. The required gas is provided in the form of pressurant Helium from the propulsion system.

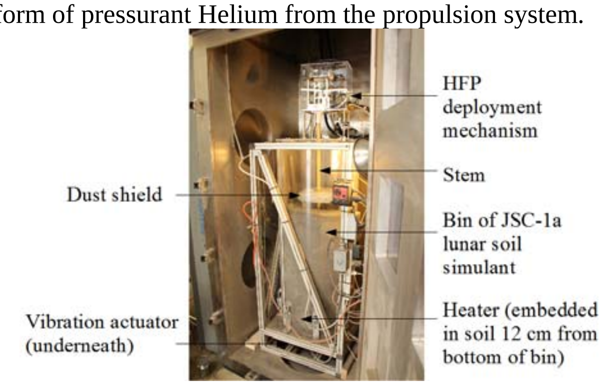

Figure 1. Pneumatic Proboscis heat flow probe being tested inside vacuum chamber in compacted JSC-1a lunar soil simulant.

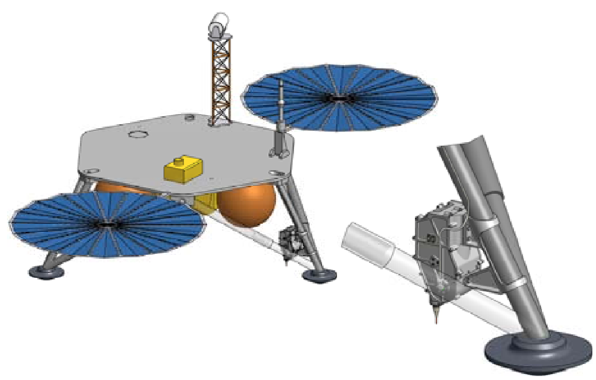

Figure 2. Conceptual Design of the Heat Flow Probe mounted on Spacecraft Landing System

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) *LPSC XXXX*, Abstract #1070.[4] Heiken, G. et al. (1991) Lunar Source Book, 37-38.