SKYLIGHT: MISSION TO INVESTIGATE AND MODEL A LUNAR PIT. H. L. Jones[1], K. M. Peterson[2], W. L. Whittaker[1,2], and U. Y. Wong[1] [1]Robotics Institute, Carnegie Mellon University (5000 Forbes Ave, Pittsburgh, PA 15213, {hlj|red|uyw}@cs.cmu.edu), [2]Astrobotic Technology, Inc. (2515 Liberty Ave, Pittsburgh, PA 15222, kevin.peterson@astrobotictech.com).

Introduction: Caves on planetary bodies beyond Earth have always been of great interest for science and exploration, but for many years there was no known way to enter. Unprecedented high-resolution imagery from the Lunar Reconnaissance Orbiter has revealed pits that are believed to be skylights – features formed by partial cave ceiling collapse that provide access into caves [1],[2]. Skylights have also been discovered on Mars [3], and similar features may exist elsewhere in the solar system [1]. Discovery of these features changes everything. The Skylight mission takes the next step to closely investigate one of these pits.

Mission Objectives: The Skylight mission seeks to answer science and exploration questions about these newly discovered lunar skylights. The objectives of the mission are to:

1. provide multi-perspective close-up images of a lunar pit,
2. build a detailed, high quality 3D model of the pit, and
3. survey the terrain surrounding the pit.

Mission Decription: The Skylight mission targets the Marius Hills Hole (MHH) in the Marius Hills region of Oceanus Procellarum at 14.2°N, 303.3°E [4]. This pit is selected because of its location on the lunar near side, facilitating mission operations without requirement for installation of expensive communication infrastructure, as well as the indications of lava tubes in surrounding terrain.

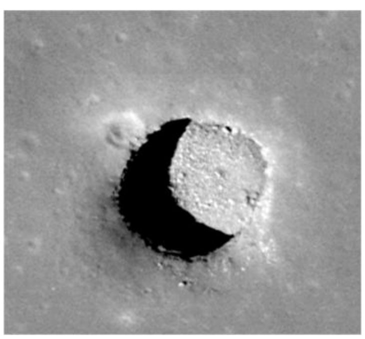

Figure 1. Marius Hills Hole, in LROC image M122584310L, from [4]

The mission flies low over the hole during descent, capturing images and LIDAR data. After the lander touches down near the hole, a rover egresses to circumnavigate the pit, capture low-angle camera and LIDAR data of the pit walls, and survey surrounding terrain. Lander and rover models are combined using complementary flyover and surface modeling technology [5].

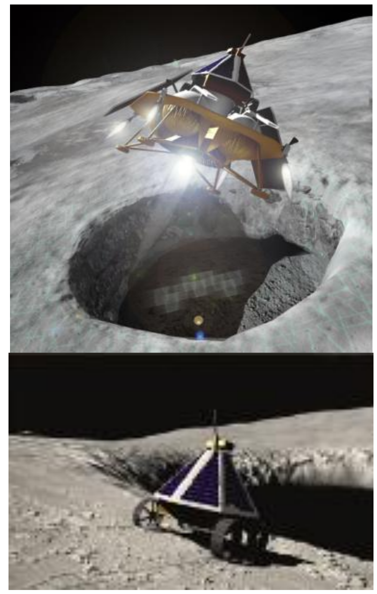

Figure 2. Artist's conception of Skylight mission

Follow-on Mission Activities: The Skylight mission enables follow-on missions that will descend into the pit, take samples from the walls and floor for in situ analysis, determine if trapped volatiles exist inside the cave, and explore the extent of the sub-surface cavern.

Technologies Under Development: Astrobotic Technology, Inc. and Carnegie Mellon University are currently developing technologies to facilitate the Skylight mission and future cave exploration activities.

Precision Landing. The Skylight mission uses new precision landing technology, matching images taken during descent to prior orbital imagery, to land within 100m of a point selected in orbital imagery. This enables the lander to overfly the feature and collect data during descent – impossible with km-scale landing ellipses of prior missions.

Hazard Detection. Past planetary landers have targeted statistically safe terrain and landed blind. This prohibits landing close to sites of interest located in rougher terrain, like skylights. Scanning the target landing zone with LIDAR, building a model on-the-fly, and detecting and avoiding hazards bring the Skylight mission to a safe touchdown.

Complementary Flyover and Surface Modeling. Combining data from a lander and rover can build a more complete model than either can achieve alone.

Planning rover paths from lander data also results in more efficient rover paths.

Lumenhancement. New technology developed at Carnegie Mellon to combine imagery and LIDAR data to create high-quality models holds great promise for visual understanding of terrain features [6].

Cave Access. Astrobotic Technology and Carnegie Mellon are investigating methods for robotic cave access through skylights.

References: [1] Ashley J. W. et al. (2011) *LPSC XLII*, Abs. # 2771. [2] Robinson M. S. et al. (2012) *Planetary and Space Sci., 69(1)*, 18-27. [3] Cushing G. E., Titus T. N., and Maclennan E. (2011) *First Int. Planetary Cave Workshop,* Abs. #8022. [4] Ashley J. W. et al. (2011) *First Int. Planetary Cave Workshop*, Abs. #8008. [5] Jones H. L. et al. (2012) *Proc. Field and Service Robotics.* [6] Wong U. Y. (2012) PhD Thesis, Carnegie Mellon Univ.