LUNAR FLASHLIGHT: MAPPING LUNAR SURFACE VOLATILES USING A CUBESAT. B. A. Cohen[1], P. O. Hayne[2], D. A. Paige[3], B. T. Greenhagen[2]; [1]NASA Marshall Space Flight Center, Huntsville AL 35812 (Barbara.A.Cohen@nasa.gov), [2]Jet Propulsion Laboratory, Pasadena CA 91109, [3]UCLA, Los Angeles, CA 90095

Introduction: The Diviner instrument on the Lunar Reconnaissance Orbiter (LRO) spacecraft measured temperatures in permantly-shadowed regions (PSRs) of the lunar poles as cold as 25K [1]. Over time, significant amounts of volatile molecules are likely have accumulated in lunar PSRs [2,3]. The Lunar Prospector Neutron Spectrometer (LP-NS) experiment indicated enhanced H abundances in both lunar polar regions [4, 5]. The resolution of the LP-NS is too coarse to determine directly if the H enhancements are associated specifically with permanently shadowed craters and not the polar regions in general. Updated hydrogen maps by collimated neutron spectroscopy show that some areas of enhanced hydrogen do not seem to correlate with either permanent shadow or temperature, an observation that has caused significant scientific controversy [6-9].

The LCROSS mission measured ~3-9 wt.% water in material ejected from the interior of Cabeus crater, along with other volatiles [10]. The LCROSS impact site exhibits no radar signatures indicative of ice, suggesting that such an amount of water ice may not be detectable by orbital monostatic radar, and thus polar ice may be present even in the absence of specific radar evidence for it. In fact, recent narrow-band reflectivity data from LRO's LOLA and LAMP instruments suggest volatiles may be present on the surface, though surface roughness or porosity effects cannot yet be ruled out [11, 12].

Surface water ice and other volatiles, if they exist in sufficient quantities, would be extremely useful for in situ extraction and utilization by future human and robotic missions. Understanding the composition, quantity, distribution, and form of water/H species and other volatiles associated with lunar cold traps is identified as a NASA Strategic Knowledge Gap (SKG) for Human Exploration. These polar volatile deposits could also reveal important information about the delivery of water to the Earth-Moon system. The scientific exploration of the lunar polar regions was one of the key recommendations of the Planetary Science Decadal Survey.

Mission: NASA's Advanced Exploration Systems (AES) program selected three low-cost 6-U CubeSat missions for pre-formulation as secondary payloads on the first test flight (EM1) of the Space Launch System (SLS) scheduled for 2017. The Lunar Flashlight mission was selected as one of these missions, specifically to address the SKG associated with lunar

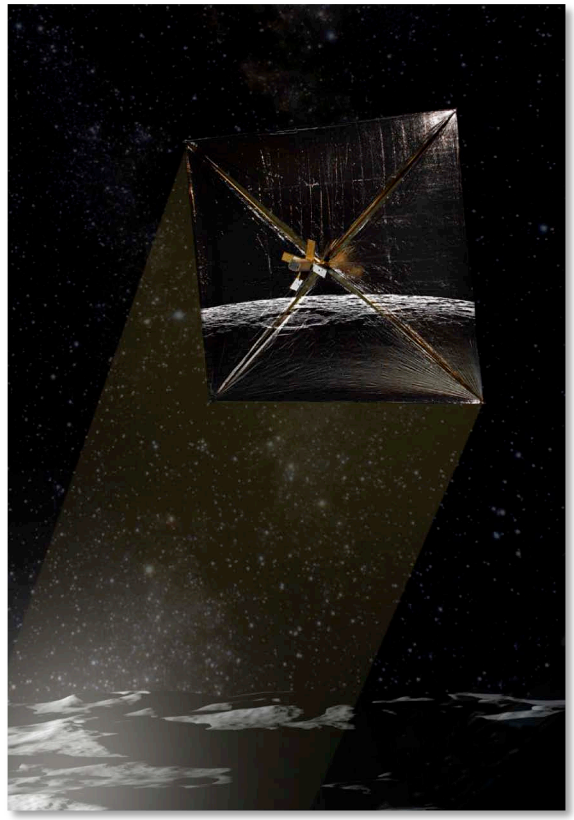

Fig. 1: Artist's concept of the Lunar Flashlight mission over the lunar surface.

volatiles. Development of the Lunar Flashlight CubeSat concept leverages JPL's Interplanetary Nano-Spacecraft Pathfinder In Relevant Environment (INSPIRE) mission, MSFC's intimate knowledge of the SLS and EM-1 mission and experience with development of the NanoSail-D solar sail, and JPL experience with specialized miniature sensors.

The goal of Lunar Flashlight is to determine the presence or absence of exposed water ice and its physical state, and map its concentration at the 1-2 kilometer scale within the permanently shadowed regions of the lunar south pole. After being ejected in cis-lunar space by SLS, Lunar Flashlight deploys its solar panels and solar sail and maneuvers into a low-energy transfer to lunar orbit. The solar sail and attitude control system work to bring the satellite into an elliptical polar orbit spiraling down to a perilune of 30-10 km above the south pole for data collection. Lunar Flashlight uses its solar sail to shine reflected sunlight into PSRs and non-PSRs on the lunar night side, measuring surface albedo with a four-filter point spectrometer at 1.1, 1.5 1.9, and 2.0 μm. Water ice will be distinguished from dry regolith from these measurements in two ways: 1) spatial variations in absolute reflectance (water ice is more reflective in the continuum channels), and 2) reflectance ratios between absorption and continuum channels. Derived reflectance and reflectance ratios will be mapped onto the lunar surface in order to distinguish the composition of the PSRs from that of the sunlit terrain.

Status: The Lunar Flashlight mission goals underwent a non-advocate peer review in June 2014 and the project will have presented its Mission Concept Review in August 2014. We will report on the current mission status and plans at the meeting.

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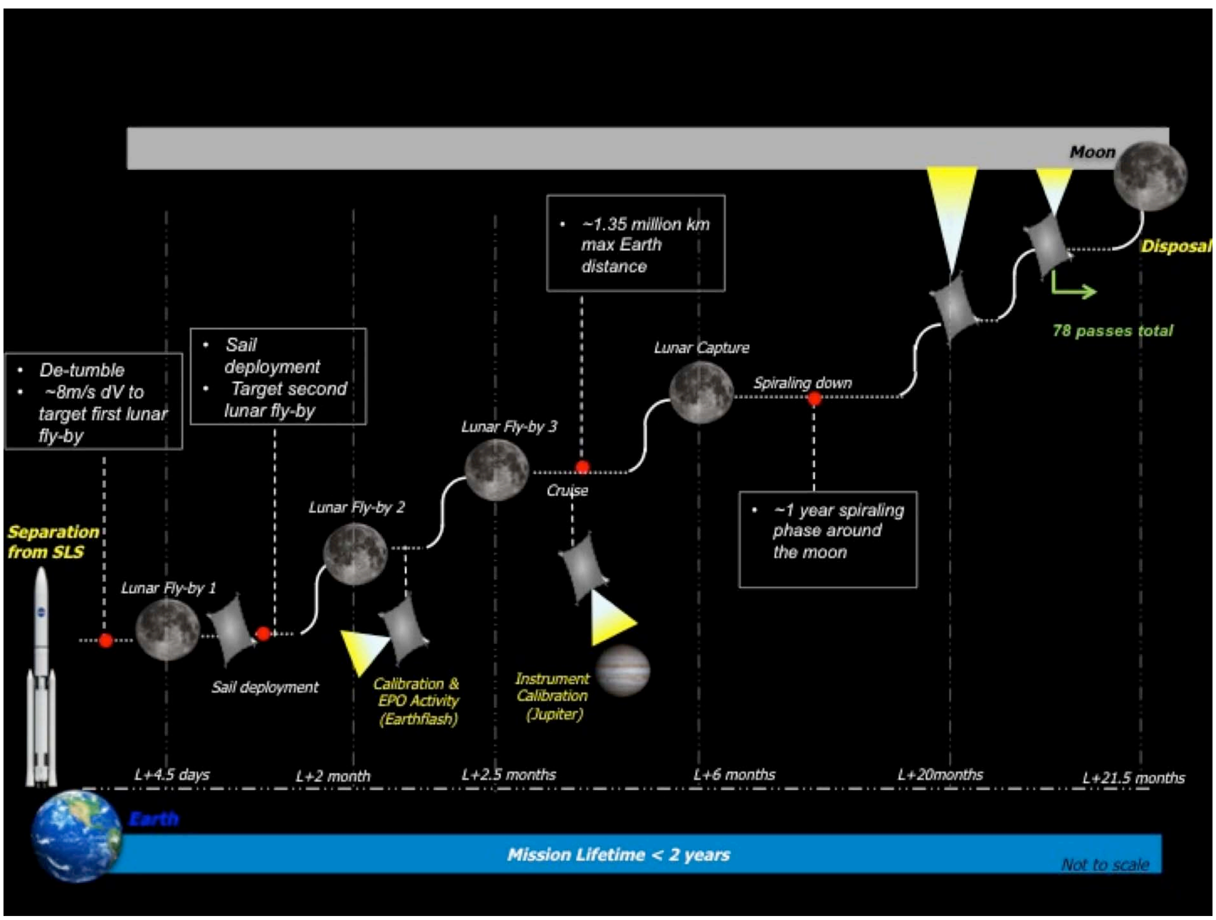

Figure 2: Notional concept of operations for the Lunar Flashlight mission.