LUNAR FLASHLIGHT: SEARCHING FOR ACCESSIBLE WATER FROST. B. A. Cohen[1], P. O. Hayne[2], B. T. Greenhagen[3], D. A. Paige[4], C. A. Seybold[5], J. D. Baker[6]; [1]NASA Goddard Space Flight Center, Greenbelt MD (barbara.a.cohen@nasa.gov), [2]University of Colorado, Boulder CO; [3]JHU Applied Physics Laboratory, Laurel MD, [4]UCLA, Los Angeles, CA; [5]Jet Propulsion Laboratory, Pasadena CA.

Introduction: Lunar Flashlight is a very small satellite (6U bus, or 12x24x36 cm) developed and managed by the Jet Propulsion Laboratory that will search for water ice exposures and map their locations in the Moon's south polar region. The Lunar Flashlight mission will demonstrate technologies for NASA such as green propulsion and active laser spectroscopy while proving the capability of performing a planetary science investigation in the CubeSat form factor. Lunar Flashlight was selected in 2014 by the NASA Advanced Exploration Systems (AES) program within the Human Exploration and Operations Mission Directorate (HEOMD); the mission is currently funded as a technology demonstration mission within NASA's Space Technology Mission Directorate (STMD) portfolio. Lunar Flashlight will be one of 13 secondary payloads launched on the first test flight (EM-1) of the Space Launch System (SLS), currently scheduled for 2020 [1].

Polar water deposits: Near the poles of the Moon, permanently shadowed regions (PSRs) may hold a record of volatile delivery, transport, sequestration, and loss through geologic time [2-3]. Trapped water could be an important target of in situ resource utilization (ISRU), for life support or fuel and propellant [4-6]. Lunar polar water ice consists of two reservoirs: deeply buried ice deposits, and surficial water frost. The Clementine, Lunar Prospector, and Lunar Reconnaissance Orbiter (LRO) missions made observations consistent with ice deposits cm- to meters-deep with ~1% H_2O by mass [7-10], but not all PSRs contain ice signatures. LCROSS revealed 5-7 wt% of H_2O in the upper few m at Cabeus, along with a comet-like array of volatiles [11]. At the lunar surface, LRO and the Moon Mineralogy Mapper (M3) data are consistent with water frost at concentrations ranging from ~0.1 up to ~10 wt% with a patchy distribution [12-14]. However, the distribution of apparent water frost does not match the subsurface distribution, and neither is its occurrence proven everywhere temperatures are cold enough to permit trapping of water molecules [15]. Current data are not yet sufficient to conclude the form, quantity, or distribution of lunar H_2O at concentrations sufficient for in-situ resource utilization (IRSU), or to predict the distribution of ice at scales of a rover or human landed mission. To be "operationally useful" for such missions, H_2O concentrations of greater than ~0.5 wt% are required [16].

Lunar Flashlight measurements: The Lunar Flashlight mission will make definitive detections of surficial water frost within PSRs if it is present in quantities above ~2 wt% in areas measured by the mission. The Lunar Flashlight illumination system uses stacked laser diode bars to emit energy pulses at four near-IR wavelengths diagnostic of water ice in rapid sequence, while a receiver system detects the reflected light [17]. Derived reflectance and water ice band depths will be mapped onto the lunar surface to identify locations where H_2O ice is present at the scale of ~10 km along-track, and about 30 m cross-track. In order to increase the SNR, the measurements can be added along-track to create the desired mapping resolution (~10 km). The total duration of laser firing per pass will be approximately 2-3 minutes during closest approach over the South Pole, potentially mapping the interiors of Shackleton, Shoemaker, Haworth, and Faustini craters. By repeating these measurements over multiple points, Lunar Flashlight will create a map of surficial water frost concentration that can be correlated to previous mission data and used to guide future missions. All calibrated data and derived data products will be publicly archived in NASA's Planetary Data System (PDS).

Synergy with other missions: Two other missions on EM-1 (Lunar IceCube and LunaH-Map) will make complementary lunar volatile measurements [18-19]. Although each mission uses a different design and measurement approach, the results from these missions will be synergistic as a fleet of missions simultaneously exploring the nature and distribution of water on the Moon ahead of human exploration.

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