The Lunar Water Assessment Transport Evolution and Resource (WATER) Mission Concept Study. C. A. Hibbitts[1], D. Blewett[1], P. Brandt[1], L. Burke[2], B. Clyde[1], B. Cohen[3], J. Dankanich[4], D. Hurley[1], R. Klima[1], D. Lawrence[1], W. Patterson[1], J. Plescia[1], J. Sunshine[5], J. Westlake[1], [1]JHU-APL (11100 Johns Hopkins Rd., Laurel, Md 20723; karl.hibbitts@jhuapl.edu), [2]GRC, [3]GSFC, [4]MSFC, [5]Univ. of Maryland

Introduction: Over the last decade, many lunar measurements have revealed that water is more ubiquitous on the Moon than previously thought. With this new knowledge, there is a clear need for a focused lunar orbital mission to better understand this water and related processes at the Moon. The science objectives – e.g., understanding water-related volatiles in the inner solar systems – are high-priority objectives in the 2014 NASA Science Plan, the 2013-2022 Decadal Survey, and directly address Lunar Strategic Knowledge Gaps.

While a Discovery-class mission could conduct the full set of science objectives, large subsets of the objectives can be accomplished using small-sats. These low-cost missions can be enabled by leveraging rideshare launch options (e.g., EELV Secondary Payload Adapter), implementing innovative propulsion technology (e.g., solar electric propulsion), miniaturizing instruments, and using more efficient communications compared to interplanetary missions. The associated trade studies will consider orbital requirements, instrument payload, and mission duration.

Science Rationale and Approach: Previous missions have made ground-breaking discoveries about lunar water but also have been dramatically limited in their subsequent investigation by not obtaining both a global perspective of the Moon with a wide range of terrains seen at once at different local times of day, and also by not being able to observe inside and outside of permanently shadowed regions (PSRs) with the appropriate measurements at the appropriate spatial scales to characterize the water/geologic/temperature dependencies. Within PSRs, high spatial resolution (~10 km/pixel) neutron mapping correlated with surface frost imaging (UV and/or active IR) and archived temperature maps within PSRs could resolve complex relationships of the chemistry and distribution of water to provide insight into the origin and evolutionary processes that led to the current distribution of water at the poles. Spectral mapping of the 3-μm feature on the illuminated Moon across a range of local times will determine its chemical composition and unambiguously characterize any diurnal variation for possible accumulation of H_2O at the poles. Combined with neutron observations, the 'water cycle' that may transport H_2O globally and within the near surface could potentially be understood. Quantitative estimates of the global distribution and variability of solar-wind-proton implantation rates and simultaneous observations of OH band depth will provide insight into the source and loss of OH in the lunar surface. Other measurements would greatly increase the science return to include radar sounding the PSRs to search for subsurface ice deposits. Additionally, in-situ sampling of possible water molecules released from the surface would help quantify specific source mechanisms. The payload capability of a smallsat is extremely limited; thus, the scientific value of a measurement will be traded against the available spacecraft resources.

Technical Approach: A goal of this study is to determine a feasible payload suite from a variety of possible instruments. A highly eccentric orbit is essential for the science and instrument measurements. A duration of greater than one lunation is the minimum time needed to separate exogenous inputs and loss mechanisms. A high apoapsis (1000s of km) enables global correlations between surface 'water' chemistry, abundance, surface temperature, and solar wind input. A low-altitude polar perilune will enable high-spatial-resolution measurements of polar volatiles such as with a neutron spectrometer (NS), an active IR multispectral imager, a multispectral UV imager to characterize the water in the PSRs, and/or a low-resource radar sounder to characterize subsurface ice. At apolune, global information is obtained on the formation, loss mechanisms, and evolution of OH and H_2O on the illuminated Moon using a Faraday cup to measure the solar-wind proton flux impinging on the surface, a neutral atom imager to understand the reflected portion of the solar wind, and a single channel mass spectrometer for quantifying molecular water production. An IR spectral imager can investigate the OH and any H_2O formed.

The general orbital approach is straightforward; it will be either drop-off from a spacecraft passing the Moon or will require a transfer orbit from, for instance, geosynchronous orbit to spiral into lunar orbit. A gradual transition from either GEO, combined with the need for constant input to maintain a low periapsis requires significant deltaV and makes this mission suited for solar electric propulsion. It also provides ample time to execute global observations of the Moon

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