Deep Space Cubesat Orbiter and Compact Broadband IR Instrument to determine the systematics of Lunar Water. P.E. Clark[1,3], R. MacDowall[2], D. Reuter[2], R. Mauk[2], J. Didion[2], D. Patel[2], W. Farrell[2], R. Cox[3], [1]IACS, Catholic University of America, Washington, D.C. 20064, [2]NASA/GSFC, Greenbelt Road, Greenbelt, MD 20771, and [3]Flexure Engineering, 3518 Fremont Ave. N, #474, Seattle WA 98103. Contact Email: clarkp@cua.edu

Purpose: We have applied the CubeSat Paradigm to science requirements-driven deep space exploration mission, referred to as a LunarCube, and are developing a compact 'workhorse' instrument for a high priority science application [1]. We focus on cubesat exploration to lunar exploration because of the Moon's proximity and accessibility as a stepping stone to the rest of the solar system, combined with the great international scientific interest in the Moon and its suitability as an analog with extreme range of conditions and thus an ideal technology testbed for much of the solar system.

Science Rationale: Despite the fact that 6U deep space capable cubesat buses and deployers are now available, the development of CubeSat instruments capable of providing focused, high priority science, so critical to achieving the potential for low cost planetary exploration promised by the CubeSat paradigm, lags behind. Understanding the origin and role of volatiles is such a high priority goal. On the Moon, Mercury, Mars, and the asteroids, the source, distribution, and role of volatiles is a major question, with implications for interior, surface, and exosphere formation processes, including differentiation and structure of the bodies themselves, and for the origin of life in the early solar system. The form and distribution of water has implications for human exploration, resource exploitation, and sample curation. Recent lunar missions yielded unanticipated evidence for water from NIR instruments not optimized for finding it, without providing details of the systematics of its distribution, which could be provided by this instrument.

Cubesat Bus: Over the course of this year, we have conducted the equivalent of a pre-phase A study for a lunar orbital LWaDi (water distribution) mission, with a focus on the payload instrument capable of measuring volatiles, which is described below. Subsystems include state of the art cubesat attitude control, propulsion (for transportation from GEO, GTO or Earth escape to lunar capture), communication, power, thermal and radiation protection systems providing lunar orbital operation of a cubesat bus. Based on this work, we have concluded that a 6U bus with state of the art cubesat systems already available or now being built and tested can support a high priority science orbiter in cislunar space, providing the spacecraft is delivered to lunar orbit. We are looking at a series of progressively more challenging missions, including an impactor, and a pathfinder observatory, and considering designs using technology available now, in five years, and in ten years. Particular challenges for orbiters or impactors are communication, navigation and tracking in a volume, power, and bandwidth constrained environment. Thermal and radiation protection will be the principal challenges for landed cubesat deployables. The end result is generic design(s) for a cross-section of future high priority payloads for planetary, heliophysics, and astrophysics disciplines.

Instrument: In response to the need for 'workhorse' cubesat instruments, we are developing BIRCHES, Broadband InfraRed Compact, High-resolution Exploration Spectrometer, a miniaturized version of OVIRS on OSIRIS-REx. BIRCHES is a compact (1.5U, 2 kg, <5W) point spectrometer with a compact cryocooled HgCdTe detector for broadband (1 to 4 micron) measurements at sufficient resolution (10 nm) to characterize and distinguish important volatiles (water, H_2S, NH_3, CO_2, CH_4, OH, organics, oxides, carbonates) and mineral bands. It has built in flexibility, using an adjustable 4-sided iris, to maintain the same spot size regardless of variations in altitude (by up to a factor of 5) or to vary spot size at a given altitude, as the application requires. BIRCHES will address the high priority science goal of understanding the role of volatiles on solar system bodies by 1) enabling broadband spectral determination of the composition and distribution of volatiles in the regoliths of the Moon, asteroids, and Mars, as a function of time of day, latitude, regolith age and composition; 2) providing a geological context for those measurements through spectral determination of major and minor mineral components; and 3) expanding the understanding of the current dynamics of volatiles sources, sinks, and processes, with implications for the origin and evolution of volatiles in the solar system. In this way, we will develop a competitive instrument for future deep space CubeSat opportunities such as EM-1.

References: [1] Clark P.E. et al. (2013) LWaDi: An Overview and Application of the Cubesat Paradigm to lunar orbiter missions, LSA4 http://lunarworkshops.com.