LunarCube: A Concept for Advancing Solar System Exploration P.E. Clark[1], R. Cox[2], A. Vassant[3], G. Scharfstein[2] [1]Catholic University of America@NASA/GSFC, Greenbelt, MD 20771, [2]Flexure Engineering Inc. (Correspondence email: Pamela.E.Clark@NASA.gov).

Purpose: The Moon is not only the closest and most accessible extraterrestrial frontier. The lunar surface, with its rugged terrain, long diurnal cycle, and wide range of extreme thermal and illumination conditions varying as a function of latitude and local relief, represents a great portion of the entire range of conditions found throughout the solar system. The lunar surface is thus an ideal 'test bed' for exploring planetary surface processes and origins as well as for developing core technologies required for planetary exploration. Thus, any sound approach to planetary exploration should prioritize access to the Moon . The question is how to provide such access at a time when the conventional approaches to space exploration are unable to procie adequate support to achieve planetary exploration goals.

CubeSat Approach: We are proposing LunarCube, an extension of the affordable and successful CubeSat approach, to facilitate access to the Moon. CubeSat has already encouraged and increased access to Earth orbital space over the last 5 years. CubeSat provides the standards for low–cost, focused–objective, Earth orbital missions via an online kit [1], facilitating the implementation process, and reducing development costs, risks, and time.

Four key aspects of design are specified: 1) profile: short duration, low earth orbit; 2) form factor: 10 cm cubes, typically containing structures with several options for standard overall lengths (from 0.5 to 3 U); 3) technology impact: low, incorporating off the shelf electronics and software; 4) risk: Class D, based on the rationale that CubeSat standards have been improved and demonstrated with use, and failures have far less impact, in terms of expenditures and size of groups involved, than conventional government sponsored 'missions'. Part of its appeal is that CubeSat afforded universities access for hands on student education. Now, this approach has the potential to yield scientifically useful monitoring of Earth's atmosphere and climate by several experiments (e.g., CINEMA, CubeSat for Ions, Neutrals, Electron, and Magnetic Fields) [2]. Most recently CubeSat has been proposed as a model for a lunar swirl study mission [3].

LunarCube Concept: LunarCube uses a similar approach for the lunar surface by maintaining the same standard on risk, thereby keeping costs low, but extending the current CubeSat concept in two stages to include several additional features directly relevant to survival in any lunar environment. Stage 1 would specify some additional capability in four key areas: 1) profile: somewhat longer duration that CubeSat (many months instead of many weeks); 2) form factor: small, but potentially larger volumes than current CubeSat, as needed; 3) radiation environment design: accommodation for deep space radiation (with greater radiation hardness provided, for example, by MilSpec components); and 4) thermal environment design: accommodation for variation from equatorial to DeepCryo surface conditions. The first three (LunarCube 1.0) would give access to lunar orbital space to provide, for example, communication satellite capability for near lunar or deep space. The fourth (LunarCube 1.5) would allow access to, as well as survival and operation for at least a limited duty cycle on, the lunar surface. The somewhat larger volume would potentially allow several users to fly experiments, as in the ISS 'nano' rack concept [4]. Stage 2 (LunarCube 2) would enhance capability by allowing the technology impact to increase, enabling incorporation of state of the art or even currently 'under development' technologies in several key areas: 1) electronics and software; 2) precision navigation and control; 3) full deep cryo operation for 'cold cubes'; and 4) advanced payload integration. Full operation on the lunar surface would be possible. At this stage, the LunarCube could be a virtual 'smart phone' with a 'nano–rack' representing a variety of experiments, as open access software applications.

Current Activities: We are developing a prospectus and requirements document and strawman kit to support phase 1 and phase 2. We are currently planning and will have held a workshop by the time of the 43rd LPSC to evolve those requirements and a preliminary design for the LunarCube platform.

References: [1] CubeSat Kit Site, 2011, http://www.cubesatkit.com; [2] UCBerkeley Site, 2011, http://newscenter.berkeley.edu/2011/10/03/students-building-satellite-thats-seen-as-future-of-space-research/; [3] Gareck–Bethel et al, 2011, http://www.lpi.usra.edu/meetings/leag2011/pdf/2038.pdf; [4] SSL Website, 2011, http://ssl.engineering.uky.edu/missions/international-space-station/nanorack-cubelabs/