LunarCube: Payload Development for Enhanced yet Low Cost Lunar Exploration;

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We are proposing LunarCube, a space architecture that extends the affordable and successful CubeSat approach, to facilitate access to the Moon. CubeSat provides standards for bus design and operation for low–cost, focused–objective, Earth orbital missions via open access documentation and even online purchasable kits, facilitating the implementation process, and reducing development costs, risks, and time. The bus provides standardized interfaces and shared access by guest 'instruments' to all subsystems using CubeSat protocols. Four key aspects of specified design are: 1) profile: short duration, low earth orbit; 2) form factor: multiple 10 cm cubes (U), typically varying 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. After a decade of development, this approach is beginning to yield scientifically useful monitoring of Earth's atmosphere and climate through combined experiments (e.g., CINEMA, CubeSat for Ions, Neutrals, Electron, and Magnetic Fields). Most recently CubeSat has been proposed as a model for a lunar swirl study mission.

LunarCube deals with risk analogously by bus standardization and modularization, still keeping costs low, while extending the current CubeSat concept in stages to include additional capability required for deep space operation in five key areas: 1) profile: increase duration from months to years; 2) form factor: grow to at least 6U as needed; 3) control: active attitude control and propulsion, made sustainable with onboard intelligence for routine multi-platform operation; 4) information transfer: more robust communication and C&DH to support onboard processing, made sustainable with onboard intelligence for routine multi-platform operation, and 5) thermal/mechanical design: greater hardness to deep space radiation and ruggedness for extreme thermal variation, potentially using MilSpec components initially, but ultimately requiring state of the art cold temperature electronics and power developments for deep cryo operation. Accomplishment of these, with some degree of onboard intelligence, would allow multiple platform operation in cis-lunar space, as well as survival and operation for at least a limited duty cycle on, the lunar surface. More robust and larger 6U CubeSat concepts exist. Stage 2 would require fully implementing onboard intelligence (3 and 4) and deep cryo design in electronics, power systems, mechanisms (moving parts), precision navigation and control, and 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.

A critical need for LunarCube development is obtaining inputs on required resources (Mass, power, bandwidth, volume) for the broad range of instruments required to do cutting edge science, and continuing the development of onboard intelligence to support processing for highly selective data return as well as guidance, navigation and control without 'ground control', allowing temporally and spatially distributed measurements of 3D systems from distributed platforms with minimal bandwidth.