KitCube: Lunar CubeSat Mission Demonstrating Free Space Optical Communications and Green Monopropellant Technologies

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KitCube is a 6U CubeSat entry into the NASA CubeQuest Challenge for a launch opportunity on Exploration Mission-1 (EM-1) with the Space Launch System (SLS). KitCube will participate in the "Lunar Derby" competition and demonstrate an advanced miniaturized laser communications payload, and agile, relatively high delta-V propulsion capabilities for CubeSats en route to lunar orbit. A bi-elliptic trajectory to a weak stability boundary (WSB) between the Sun and the Earth at 4.5 times the Earth-Moon distance was designed to manage the excess velocity imparted by the SLS by using multi-body gravitational effects. The low-energy WSB trajectory enables KitCube to achieve lunar orbit with 150 m/sec delta-V or an average thrust of 54 mN during a 9.7 hour finite burn. The propulsion system uses a green monopropellant, AF-M315E, developed by the Air Force Research Laboratory (AFRL), a more stable, less-toxic fuel that still has a relatively high specific impulse compared with hydrazine systems. In order to accommodate the large delta-V requirements of the mission, a custom propellant tank has been designed to maintain ~500 psi as the propellant is depleted. A free space optical communications system has been developed to achieve an expected data rate of >1.5 Mbps over a 30-minute interval from lunar orbit. The use of an optical communications system requires fine pointing and control of the spacecraft. Laser pointing precision and accuracy is partially achieved with a MEMS fine steering mirror. The KitCube design also includes a custom avionics system and commercial off-the-shelf (COTS) components for the Attitude Determination and Control System (ADCS). KitCube's goal in being part of the EM-1 lunar CubeSat explorers is to demonstrate optical communications and green monopropellant propulsion technologies as a pathfinder for capable Earth observing spacecraft as well as for future interplanetary CubeSat missions.