SPACE EXPLORATION SYMPOSIUM (A3)
Solar System Exploration (5)

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PLANETARY CUBESATS COME OF AGE

Abstract

In 2014-15 three significant CubeSat-related developments occurred at the Jet Propulsion Laboratory, all bearing on the feasibility, utility, and practicality of extending the “CubeSat revolution” to the planets: 1) JPL delivered INSPIRE, the world’s first (twin) interplanetary CubeSats, to launch readiness; 2) JPL began development of a slate of 2nd-generation interplanetary CubeSats – Lunar Flashlight and NEAScout (in partnership with NASA MSFC) and the twins MarCo; and 3) JPL developed a diverse portfolio of seven nanosat concepts designed around specific technology-demonstration and primary-mission science-enhancement objectives. A credible set point is now emerging for the combination of purpose, capabilities, risk, and cost appropriate for planetary-mission nanosats, which now may be compared usefully to expectations set by Earth-orbiting CubeSats. For reference, brief descriptions are provided first for the first five planetary-nanosat builds: the INSPIRE pair, NEAScout and Lunar Flashlight, and the MarCo pair. Contrasts are drawn to Earth-orbiting CubeSats, to clarify the effects of unique requirements imposed by planetary environments and mission objectives – particularly for system lifetime, navigation and telecom, thermal control, propulsion, power, payload accommodation, radiation and temperature regimes, and operations cost. Due to these considerations, planetary CubeSats inhabit a somewhat higher cost regime than Earth orbiters. However, particularly in conjunction with larger primary missions, CubeSat architectures allow a type of higher-risk, high-payoff science enhancement otherwise inaccessible to Principal Investigators. An array of demonstration and science objectives is presented, representing high intrinsic value of nanosat missions, and high marginal value for nanosat adjuncts in the context of parent missions.

These objectives are cross-allocated into seven concepts just proposed to NASA as secondary objectives on larger missions: 1) close-proximity magnetometry mapping of a metal asteroid; 2) second-viewpoint imaging of rubble-pile asteroid disruption experiments; 3) controlled penetrometry for impact-strength measurements of indurated cometary crust; 4) self-selecting hyperspectral mapping of surface ice upon asteroid flyby; 5) soft landing on Phobos, with composition measurements via gamma-ray spectrometry, and measurements of low-gravity dust behavior; 6) multi-year auto-navigation along the weak-stability boundary from Sun-Earth L2 to L5, enabling a search for Earth Trojan asteroids; and 7) noble-gas mass spectrometry of the Venus atmosphere below the homopause, upon aeropass released from orbit. The discussion closes with a catalog of nanosat-compatible capabilities – instruments, measurement-enhancing technologies, subsystem adaptations, system-level performance, and formulation tools – that JPL is using to help Principal Investigators take advantage of the cost efficiencies and risk paradigm provided by nanosats.