SMALL SURFACE PROBES FOR ENHANCED ASTEROID AND COMET RENDEZVOUS MISSIONS.

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Introduction: Flyby and rendezvous missions to asteroids and comets have provided valuable data that have formed our understanding of the nature and diversity of small solar system bodies, including near-earth objects (NEO). In-situ measurements at the surface can provide unique, detailed information regarding the composition, structure, and characteristics of asteroids and comets, and significantly increase the science return of rendezvous missions. To date, only the NEAR-Shoemaker [1,2] and Hayabusa [3] missions have successfully landed a spacecraft on a small solar system object. Although not designed as a lander, touchdown of NEAR-Shoemaker on the NEO Eros returned high-resolution images and composition information that was not obtainable with remote measurements alone. The Hayabusa mission carried a miniature lander called Minerva [4] that was designed to land on the NEO Itokawa and take images across the surface. Unfortunately, the lander was lost in space; however, the Hayabusa parent spacecraft successfully touched down on Itokawa and captured high resolution images. Moreover, the spacecraft will return to Earth and possibly contains dust samples from the asteroid surface.

The Rosetta mission [5,6] was launched in 2004 and will begin orbiting comet 67P/Churyumov-Gerasimenko in 2014. A 100-kg lander will be deployed to the comet surface with a sophisticated instrument suite designed to measure the composition and structure. If successful, this mission will provide a wealth of data for cometary science and subsequently expand our understanding of the very early solar system prior to the formation of planets.

Small surface probes with relatively simple instrumentation could enable valuable in-situ science experiments without requiring a dedicated mission or severely impacting mission cost. For small solar system objects, the low gravity and lack of atmosphere will allow probes to be deployed from an orbiting spacecraft with ballistic transfer to the surface. Systems for controlling the decent and impact are not needed, and the close proximity of the orbiting spacecraft simplifies the communications system and power requirements. Mission scenarios can be designed to take full advantage of relaxed requirements for landed probes imparted by the unique environment of small solar system objects.

Development of Low-Cost Surface Probes: Ball Aerospace & Technologies Corp. is increasing the technology readiness level of critical components for low-cost surface probes through a series of independent research and development (IRAD) projects. Current development efforts are focused on: (1) Fabrication of multifunctional structures that combine subsystems into a single part. The approach allows parts that would be essentially impossible to machine to be fabricated quickly and cheaply based on a CAD drawing. (2) Development of miniature FPGA-based avionics that can be adapted to a range of small probe and instrument suite concepts. The avionics utilize standard interfaces for instrument control and data collection, and provide sufficient processing capability and memory for data management. (3) Development of electronics and packaging approaches for extreme environments and shock tolerance.

Hardware generated from these IRAD projects is being integrated into the cubic engineering development unit shown in Figure 1. The unit currently is at the breadboard stage and incorporates the miniature avionics, a wireless UHF data link, cameras on three of the faces, a three-axis accelerometer, multiple temperature sensors, batteries, and battery current and voltage telemetry. The unit is being used to demonstrate integration of the components into a testable, small form-factor probe, and drop tests will be performed to acquire accelerometer data as a function of simulated soil conditions.

Future development of the engineering unit will be directed at refining the communications system to operate at higher data rates, further reducing the size of the avionics, and integration of multiple instruments. Concepts for probe deployment will be defined and advanced designs, such as shown in Figure 2, will be assessed for increasing payload capacity and maturing the low-cost probe approach.

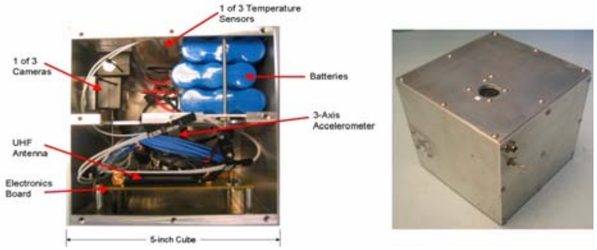

Figure 1. Engineering development unit a for low-cost surface probe concept.

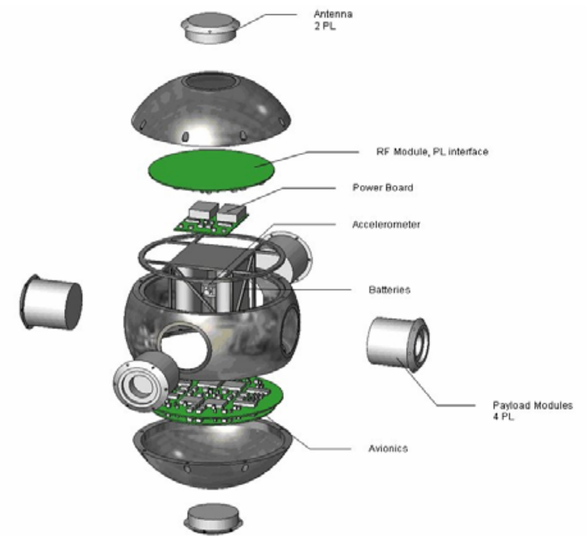

Figure 2. Design concept for spherical surface probe with an orientation-independent payload.

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