IN-SITU SMALL BODY SURFACE CHARACTERIZATION ENABLED BY THE PLANETARY OBJECT GEOPHYSICAL OBSERVER (POGO)

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Introduction: The Planetary Object Geophysical Observer (POGO) is a self-contained, fully autonomous ride along payload that is able to be delivered to, and dropped on, small body surface by a host spacecraft. Once on the surface, POGO would provide to the host spacecraft, via a telecommunication system, in-situ elemental and compositional information of the small body surface. The POGO concept provides a simple, low-cost in-situ sampling capability that can simply ride with the host spacecraft to the target small body. Once POGO is released, the host spacecraft has no commanding responsibilities of POGO; rather, it only is needed to receive transmitted data and locate POGO on the surface of the asteroid.

The POGO payload is a self-contained, fully autonomous system that integrates necessary bus subsystems (Power, Telecomm, Avionics, Thermal, and Mechanical) around a core impulse mechanism and a modifiable instrument package. POGO provides a host mission with a low cost, low impact to overall mission capability for in-situ regolith characterization across the surface of the visited small body.

Due to the somewhat unpredictable thermal environment to be encountered on a visited small body surface, POGO incorporates a thermally isolated core design that houses all bus subsystems and instrument electronics. The isolated core thermal design relies on a constant power dissipation to maintain the subsystems at an acceptable operational temperature. Instruments hosted by POGO are able to be mounted both inside and outside of the thermally isolated core depending on their FOV and thermal requirements.

Power for surface operations is provided by four banks of primary batteries. The POGO design has excluded the use of solar arrays due to power production concerns, from solar distance, angle, temperature and shadow, as well as their lack of ruggedization. Although batteries have a finite lifetime, by choosing primary batteries as the power source, POGO is guaranteed continuous operations on the small body surface no matter its location on the asteroid or sun state (shadow or sun). POGO is designed to operate until the batteries are exhausted; once this threshold is reached, the POGO mission will come to an end.

Mission duration of POGO is dependent upon final battery configuration; however, with a full complement of batteries, POGO is capable of operating on the surface of a small body for approximately 10 Earth days while performing constant surface measurements followed by relocation ‘hops’. Relocation hops, followed by 6-12hr dwell times enabling surface elemental and compositional measurements, would be continued on a pre-scheduled basis until POGO lost power and was no longer able to continue operations.

The current POGO configuration, as tested in FY13, incorporated the services and physical mounting accommodations for two APXS (Alpha Particle X-ray Spectrometer) instruments, and a single GRS (Gamma Ray Spectrometer) instrument. The APXS measures the abundances of major and minor elements from Na to Zn to ±10% if present at greater than >100 ppm using X-ray fluoresences technique, and C to ±20% if present at > 1% percent abundance using alpha backscatter for >6-12 hour (depending on the element) integration time. The GRS provides elemental abundancs of Mg, Si, K, and Fe at > 1% abundance with 15% precision for >12 hour integration time. The two APXS instrument heads are mounted to the opposite faces of the POGO body, one of which will be facing down at the small body surface following landing. Placement of the APXS on these two panels places the APXS detector outside of the thermal core, allowing it to be cooled by the ambient environment to the required operational temperatures. APXS electronics are housed within the thermal core of the POGO payload, allowing the electronic design to utilize standard parts. POGO also has control of the APXS doors, and uses accelerometers to figure out which side is facing up, so only the APXS sensor facing the regolith have its door open. The GRS instrument, also accommodated by the existing POGO design, is mounted in a battery mount, replacing a single stack of primary batteries. This mounting location places the GRS within the thermal core of POGO, keeping the instrument within traditional temperature limits, and allowing for a greater unobstructed field of view. GRS electronics are also housed within the thermal core. The POGO structure is well characterized, and has been calibrated with the GRS sensor.

Although the existing POGO design has selected two APXS and a single GRS, POGO has been designed to be able to be reconfigured for its specifc mission. The current configuration of POGO, with two APXS and a single GRS,has additional avionics and power interfaces for an another instrument. As a part of any mission feasibility study, the entire instrument suite can be traded. Changes in the instrument suite will cause some small design changes within POGO; however, the POGO design has been executed with the desire to have flexibility in accommodations for instrument suites based on the mission it is asked to perform.

Surface mobility is realized through the use of a voice coil actuator that accelerates a mass over a short distance and is then arrested through contact with its housing. Due to the abrupt stopping of the mass, an impulse is introduced into the POGO vehicle, allowing it to overcome the meager surface gravity of the small body, propelling it along a parabolic projectile motion path. Distance traveled can be modified through varied current introduced in the coil; coil performance can be optimized to account for different sized asteroids. This locomotion approach has no mechanisms that come in contact with the asteroid surface, eliminating contamination concerns of the POGO payload from regolith.

POGO relocation is uncontrolled in terms of direction and attitude; the only aspect of the relocation hop is distance, which is controlled through the input power to the impulse mechanism. Because of the uncontrolled nature of these hops, the POGO payload has been designed to force POGO to settle on one of two surfaces. Both of these surfaces incorporate instrument apertures that enable POGO to make surface characterization measurements regardless of its landing orientation.

POGO will be propelled toward the surface of the small body by the separation system housed on the spaceccraft, and once landed on the surface, POGO will begin surface characterization measurements. Since POGO has no receive capability in the telecomm system, and cannot receive commands from the host vehicle, surface operations will be pre-programmed and run continuously, regardless of POGO location on the asteroid. When surface characterization measurements are completed (estimated at 6-12hours), POGO will cease instrument operations and charge a capacitor bank for voice coil actuation. Initial hops following delivery to the surface will be short distance hops of 1-10m in the attempt to fully characterize the local area of the small body. Following each relocation hop, POGO will restart instrument measurements followed by another hop. After several small distance relocation hops followed by surface characterization measurements, POGO will then perform a large scale relocation hop of 10-100m to move it to a different region of the small body. As with the smaller relocation hops, the larger relocation hop will be followed by surface characterization measurements. Figure 1 illustrates the POGO concept of operations.

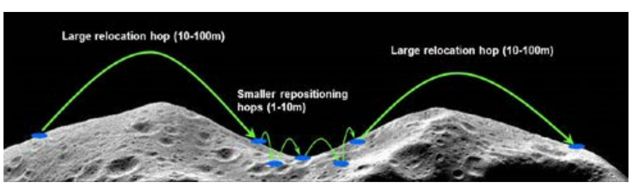

Figure 1 – POGO concept of operations

The POGO vehicle currently stands at TRL 6, having completed thermal vacuum testing of a POGO bus prototype system in the fall of 2013. The POGO bus prototype incorporated a complete thermal control system, avionics, power, telecommunication and propulsion (impulse mechanism) subsystems. Thermal vacuum testing simulated hot, cold and survival cases for POGO while exercising all subsystems in accordance with the conceptual surface operations as described. Instrument electronics and apertures were physically, electrically and thermally simulated through the use of mass models, heaters and electrical loads. Figure 2 shows the POGO prototype model, without MLI blankets, in preparation for thermal vacuum testing.

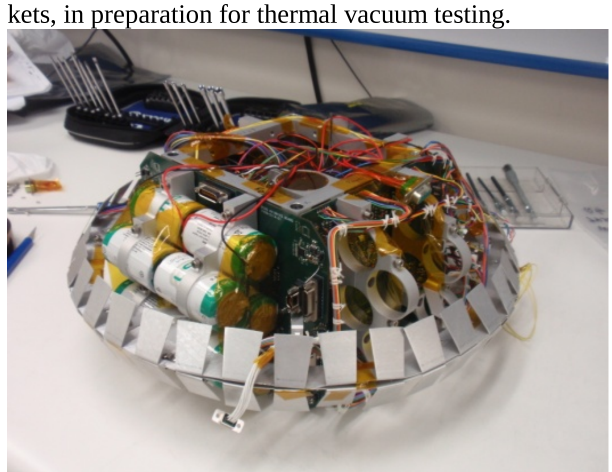

Figure 2 – POGO internal core fully integrated for thermal testing