SIMULATION OF RECOVERY IMPACTS FOR THE PROTOTYPE HERA ASTEROID SAMPLE COLLECTOR. S. Azouggagh-McBride[1,2], L. A. Roe[1,3], M. A. Franzen[1,4], J. A. Buffington[1,3], and D. W. G. Sears[1,4], [1]Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, AR 72701, [2]Dept. of Mechanical Engineering, University of Texas at Tyler, TX 75799, [3]Dept. of Mechanical Engineering, University of Arkansas, Fayetteville, AR 72701, [4]Dept. of Chemistry and Biochemistry, University of Arkansas, Fayetteville, AR 72701.

Introduction: There is a recent increasing emphasis on sample return missions to provide primitive materials representative of the early formational stages of the solar system. Hera is a proposed Discovery-class mission to retrieve multiple, nominally 100-gram, samples from a near-Earth asteroid and return those samples safely to Earth for analyses that cannot be reasonably obtained by in-situ measurements. To fit within the budgetary constraints of a Discovery mission, a maximum effort is necessary to develop highly reliable, robust, yet reasonably inexpensive hardware and mission operations.

The proposed sampling approach is the utilization of multiple sample collecting pads. After a reconnaissance to identify optimum sampling locations, the spacecraft will use a hover-descent-touch-ascent sequence to allow the touch-and-go-impregnable-pad (TGIP), located on the end of a robotic arm, to collect a sample of loose material from the surface. The TGIP has been designed as a simple, passive collector which can collect ~100 g per sample with particles ranging from dust to centimeter-size clasts. Once the collection sequence is complete, each TGIP will be examined by an on-board camera to ensure successful sample collection and then stowed in a sample return canister. At the end of the flight phase of the mission, an Earth Return Capsule (ERC) containing the sample return canister with the TGIPs will be detached from the spacecraft in the vicinity of Earth and will deliver the samples safely to the ground.

One cost-effective option for the return of the ERC is a direct (sans-parachute) atmospheric entry and deceleration. This ballistic entry has the advantages of lower cost and higher reliability than a parachute-based design. However, the survival of the samples at ground impact must be assured. To address the survivability of the collected samples under typical impact accelerations, an experimental evaluation was conducted.

Experimental Methods: The prototype TGIP has a diameter of approximately 12 cm and consists of an aluminum backing plate and retractable ring. The backing plate provides the hard-point for connection to the spacecraft robotic arm, and supports the leaf springs that hold the retractable ring. The ring serves to protect the sample collection substrate, a Dow Corning silicone grease. During the sample collection operation, the force applied by the TGIP mechanism against the asteroid surface forces the ring to retract and presses the exposed grease into the surface. Upon retraction, the loose material of the surface is retained by the grease. While it was expected that the grease would, in addition to its collection duties, provide cushioning of the sample at eventual Earth impact, this assumption required evaluation.

For the first series of tests, a sub-scale (approximately 5-cm diameter) steel canister was fabricated and filled with a 1-cm layer of silicone grease. The canister was then pressed into a layer of sand, chalk, and small gravel, representing the collection of potential asteroid regolith. A retaining cap was attached to cover the exposed surface. This canister was then struck with an impactor. A timing circuit was used to determine the duration of the impact, and a second timing circuit measured the velocity of the canister immediately after the impact. The average acceleration experienced by the canister could then be calculated..

A second test series was conducted with a prototype TGIP sampler installed in a steel housing. As with the first test series, the primary interest was the sample itself, not the TGIP or its container. Steel was chosen for the housing to provide a low-deformation impact, with a corresponding short contact duration, thus allowing relatively high accelerations without the necessity for high velocities. The container, with the prototype TGIP and surrogate sample, was dropped repeatedly onto a steel plate. A timing circuit was again utilized to determine the average acceleration experienced by the container during the impact.

Results and Discussion: In a prior series of drop tests conducted at the Utah Test and Training Range, Fasanella et al. [1] measured peak impact accelerations ranging from 85 g to 1700 g for penetrometers impacting on the soil surface of the range. This is considered typical of the values that might be expected for the Hera sample return canister if a direct entry is utilized. For the first series of impact tests on the sub-scale canister, our measured mean impact accelerations ranged from 1850 g to 1880 g. Our instrumentation was capable of measuring only the mean, not the peak accelerations, but the peak accelerations certainly exceed those values determined by Fasanella et al. Figures 1 and 2 are representative pre-impact and post-impact photographs of the samples. No apparent damage is evident, and none was evident after the samples were removed from the collecting substrate.

For the series of drop tests using the TGIP sampler, the mean accelerations ranged from 1440 g to 2890 g. Again, the maximum peak accelerations during these tests exceeded those anticipated for an actual landing. Figures 3 and 4 show a sample prior to, and following impact. As with the sub-scale tests, no apparent damage is evident.

The surrogate samples used in these tests consisted primarily of sand, sandstone, glass, and chalk, to provide a range of material properties that might be representative of asteroid regolith.

Conclusions: Based on visual examination, surrogate asteroid sample material immobilized by silicone grease similar in nature to that anticipated for use in the Hera TGIP sampler survived mean and peak accelerations in excess of those anticipated for impact after a direct, parachute-less entry into Earth's atmosphere. Since both the samples and collecting substrate are representative of those anticipated for the proposed Hera near-Earth asteroid sample return mission, the utilization of a parachute-less mission is feasible.

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Reference:

[1] Fasanella, E. L. et al. (2001) AIAA Paper 2001-1388.

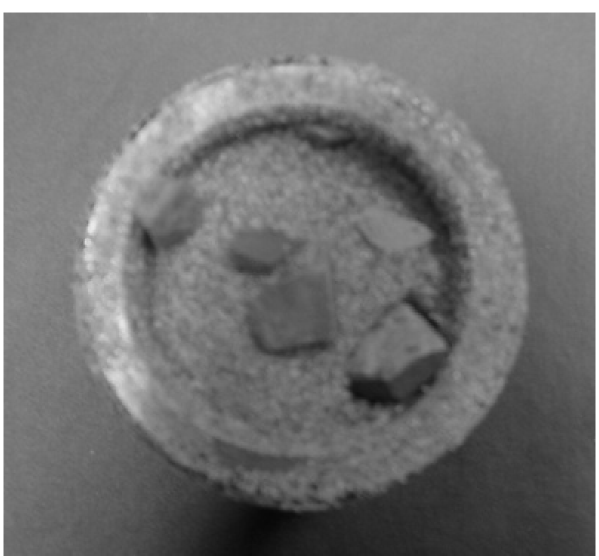

Figure 1. Sub-scale canister and sample, pre-impact.

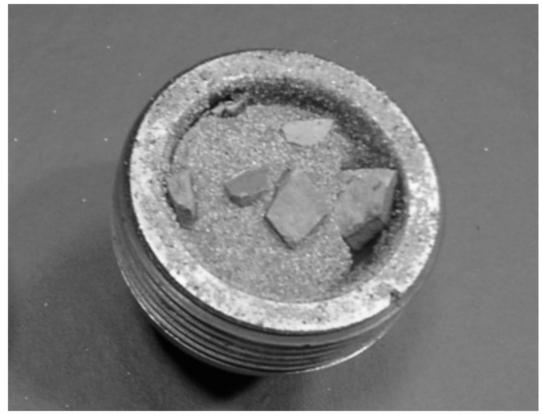

Figure 2. Sub-scale canister and sample, post-impact.

Figure 3. TGIP sampler and sample, pre-impact.

Figure 4. TGIP sampler and sample, post-impact.