SIMULATION OF EXTRATERRESTRIAL SAMPLE ACQUISITION. J. A. Buffington[1,2], M. A. Franzen[1,3], S. Azouggagh-McBride[1,4], L. A. Roe[1,2], and D. W. G. Sears[1,3], [1]W. M. Keck Lab for Space Simulation, Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, Arkansas 72701, [2]Department of Mechanical Engineering, University of Arkansas, Fayetteville, AR 72701, [3]Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, AR 72701, [4]Department of Mechanical Engineering, University of Texas at Tyler, Texas 75799.

Background and Objective: The Hera Mission is a Discovery class proposal to return several 100 g samples from a near-Earth asteroid [1]. The mission will meet objectives of the NASA Roadmap [2], Decadel Survey [3], as well as seven of the eleven goals of the Space Science Enterprise Strategic Plan [4]. Ultimately, Hera also aligns with the President's New Vision for NASA by providing an intermediate step for exploration between the Moon and Mars [5].

The actual mechanics of the mission are as follows [6]:

- Spacecraft will rendezvous with asteroid, begin orbit and imaging stage
- The velocity and rotation of the asteroid will be matched
- The space craft will approach the asteroid and begin the sampling phase of the mission (Hover, Descent, Touch, Ascent -HDTA)
- Samples will be packaged on-board and returned to Earth

As HDTA is an operation that has never been performed before, much effort was expended on the part of the Hera team to validate the collector and sampling process. The Hera team conceived and constructed a mechanism that would satisfy the scientific desires of the mission while negotiating the engineering constraints. The research presented in this abstract focused on the Verification and Validation (V & V) of the collector mechanism, called the TGIP (Touch-and-Go-Impregnable-Pad). Pictured below is the prototype TGIP, which was filled with a Dow Corning vacuum grease as the sample collection substrate.

Fig. 1. Three angle view of sampler prototype.

This prototype is approximately 12 centimeters in diameter and consists of a back-plate and retractable ring, both of machined aluminum. The back-plate is the central piece of hardware and provides the hard-point for connection to the spacecraft's arm, as well as connection for the leaf springs that hold the retractable ring. The ring serves to protect the sample collection substrate.

Experimental Setup and Procedure: The engineering constraints placed upon design and development of the TGIP were as follows:

- The collector must meet scientific requirements for reproducible and reliable collection
- Major physical properties of the regolith must be conserved
- Collector design based on current spacecraft data and laboratory research

These constraints dictated the actions of the V&V process. In short, a simulation apparatus was needed that was capable of running remotely in the Andromeda Environmental Chamber, which would provide vacuum conditions. The apparatus had to have the ability to apply a variable contact pressure, as well as provide a quick turn-around time between experiments. Upon consideration of these factors, a test rig (named Pegasus) was designed and fabricated to fulfill the requirements.

Fig. 2. Pegasus & Control Box.

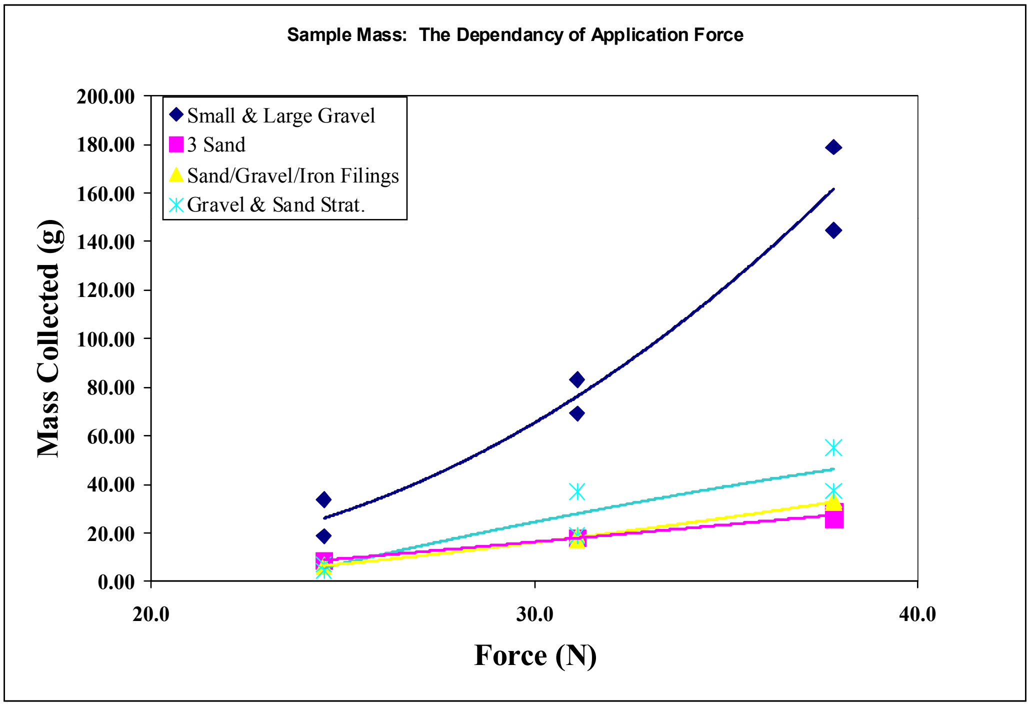

Fig. 3. Collected mass as a function of application force

Pegasus consisted of an aluminum frame on which four linear actuators were mounted. These were used to provide the down-force needed to simulate the spacecraft's robotic arm. The number of actuators facilitated speedy tests by allowing four TGIPs and mock regoliths to be tested simultaneously in a given run. The actuators were manipulated by a control box which was connected via a twenty-conductor Trey cable.

After construction, Pegasus was loaded with the TGIPs and lowered into the Andromeda Chamber. In all, six individual vacuum tests were made, utilizing the following procedure:

- A standard amount of grease was loaded in each TGIP, each time
- A vacuum of 3.8×10^{-1} Torr was pulled on each test
- Application forces of 24.5, 31.1, and 37.8 N were utilized
- Each application force was run twice
- Four regolith analogs utilized: Sand, small and large gravel mixture, sand/gravel/iron filings, and a gravel and sand stratification

Results and Conclusions: As Figure 3 illustrates, for a given analog the collected mass is directly proportional to the applied force. Also, the collected mass curve is shifted upwards for each analog that contains respectively larger clasts, indicating that the collected mass depends not only upon application force but also the physical nature of the analog. All data at this point indicate that the mechanical actions of the TGIP, in conjunction with the vacuum grease, perform in a more than adequate manner to fulfill the science requirements of the mission.

Current and Future Work: Currently, designs are being completed and fabrication has begun on two more aspects of the sample acquisition simulation. These are:

- Analysis of non-normal contact angle (relative to asteroid surface)
- Transverse velocity components (should the velocity/rotation match be less than optimum)

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