Hermes Microgravity Research Facility on the ISS. K. K. John[1], V. L. Saucedo[2], K. R. Fisher[2], M. D. Fries[2], A. R. Dove[3], M. J. Leonard[4], L. D. Graham[1], P. A. Abell[1]. [1]Jacobs, NASA Johnson Space Center, Houston, TX 77058, kristen.k.john@nasa.gov; [2]NASA Johnson Space Center, [3]University of Central Florida, [4]T STAR, Bryan, TX

Introduction: Hermes is a NASA sponsored facility launching to the International Space Station (ISS) at the end of 2018. It is a microgravity research facility that will enable science experiments that fit within the predefined design and operations constraints. It is open to any investigation that can benefit from long-duration microgravity exposure.

Payload Description: Hermes is a reconfigurable on-orbit experiment facility currently aimed at regolith and granular material investigations; however, future users may formulate other areas of interest to investigate. Four user-configurable experiment volumes can be accommodated at a given time. Each experiment is provided lights, a camera, and access to the ISS vacuum system. Power and computation/control will be provided by Hermes. Hermes will be on the ISS as a multi-user facility indefinitely, and will be available to researchers via a selection process (described below). Each set of four experiments is called a Cassette and these will be changed out regularly. The length of time a Cassette remains installed and operating will depend on the four experiments on board, but it is estimated to be no longer than six months and no less than one month. The experiments within the Cassette can run for minutes, hours, days, or the entire month(s) that the Cassette is installed.

Background: Strata-1 was a successful Class 1E payload that investigated asteroid regolith dynamics for a year on board ISS (Figure 1). Hermes is leveraging the Strata-1 heritage and team to inform the Hermes Facility and Cassette design. The clear, polycarbonate tubes used in Hermes are nearly identical to the ones used in Strata-1 (Figure 2); however, the internal components and materials will be changing for Hermes. Hermes will also be Class 1E.

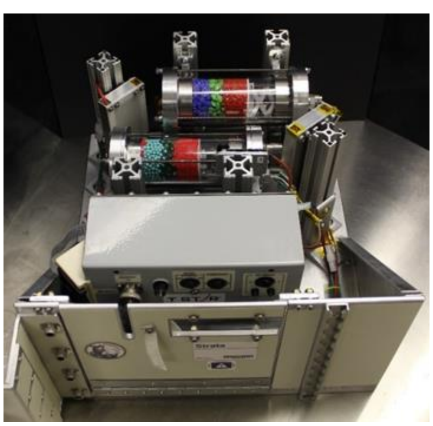

Figure 1: The Strata-1 Experiment

Research Objectives: The initial focus of Hermes is on asteroid and small body investigations, although this may change depending on the nature of each of the four experiments. Small body investigations could include asteroid regolith dynamics, understanding interactions with loosely-aggregated surfaces, investigations of interest to the current sample return missions, applications to the formation of asteroids and comets, impact dynamics, and planetary evolution. The Strata-1 Experiment conducted investigations of this nature using asteroid regolith simulants [1, 2].

The Hermes Facility: Hermes is approximately 17" x 20" x 10". It is divided into a Facility Plate and a Cassette Plate. Each of the four experiments are approximately 10" x 4" x 4" in size. Hermes contains lighting and four cameras. Lighting can illuminate experiments as necessary, and cameras will provide imagery or video for experiment monitoring as needed. Hermes experiments can also connect to the ISS vacuum system (described below). Hermes is equipped with a robust electrical interface that can accommodate several electrical configurations that can provide power, computation, and control to the user. The EXPRESS Rack provides 28 V DC power and RJ45 Ethernet data connections. Individual experiments are provided approximately 15 V and 4 amps.

The experiments are constrained by size and must meet certain structural and electrical interfaces. However, the design of the experiments can be altered per the needs of the investigator. An example experiment design includes clear polycarbonate tubes (Figure 2). The contents of the experiments will vary depending on the particular investigations, and may contain various mechanical components and sensors to obtain additional data. The Strata-1 tubes contained an "Entrapulator" to hold the material in place during launch, release the material on orbit, and re-compress the material for the return home. A new and improved version of this device will be used in the first set of Hermes experiments.

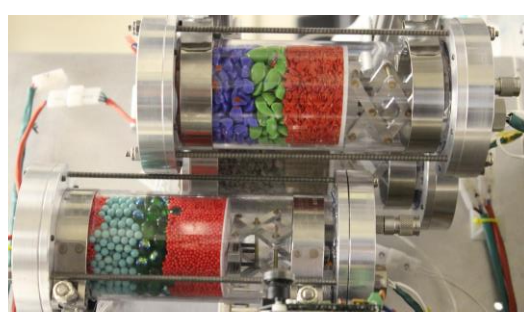

Figure 2: Strata-1 Tubes filled with simulants.

Concept of Operations: Hermes will be located in the US Lab of the ISS in an EXPRESS Rack. The facility will fit within a single EXPRESS locker assembly (Figure 3) giving approximately 17" x 20" x 10" for Hermes. A Cassette contains four experiments at a time and will be launched regularly to the ISS to be integrated with the EXPRESS locker. Hardware commanding and data downlink will be performed from the ground by Hermes. Hermes health and status data will be provided for payload insight and monitoring by Payload Operations Integration Center (POIC) and NASA Marshall Space Flight Center in Huntsville, Alabama. As a facility, experiments will be removed and installed from Hermes, with simple mechanisms used for crew members to remove and replace experiments. This will only occur when all experiments are complete. Other than installation, there will be minimal to no crew interaction, as the command and data handling is controlled from the ground.

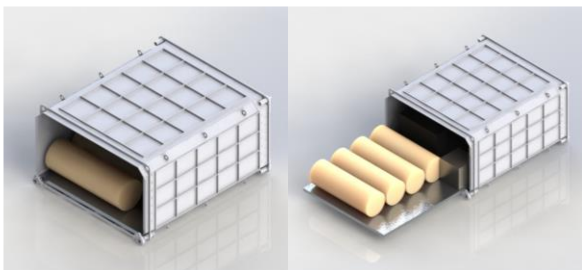

Figure 3: Single EXPRESS Locker Assembly (Tubes shown for reference; this is not a full model.) The Facility and Cassette Plates can be pulled out for easy crew access.

Hermes Manufacturing and Testing: Hermes is currently being built at NASA Johnson Space Center. Testing will begin in the summer of 2018. The electronics box is being built at Texas A&M University and T STAR. The tubes and internal tube components are being built at the University of Central Florida based on heritage from the previous Strata-1 and CATE experiments [1-3]. All Cassettes will have to go through the ISS Integration process, meeting certain safety and integration requirements.

Each experiment tube is constructed from a clear, polycarbonate tube with aluminum endcaps with o-ring seals designed to allow the tubes to be operated at high vacuum (few mTorr). Each endcap can be configured to have electrical or vacuum feedthroughs, or both. Experiments can be loaded through either end, depending on the nature of the investigation. Similar to Strata-1, most of the experiments for Hermes will contain an "Entrapulator" used for controlled compression of the material in the tube. This is controlled by a linear actuator that can be commanded to extend or retract.

Vacuum: Hermes will be connected to the ISS vacuum resource system (VRS), allowing experiments the option to operate at vacuum for the duration of their time on board ISS. Each experiment can be maintained at 10^{-3} torr indefinitely with exception to the pump-down period following installation. The pressure within each experiment will be monitored. A series of solenoid valves will be used to isolate experiments from each other and the VRS except during pump-down.

A Facility for Asteroid Science and Beyond… The architecture of Hermes allows for multiple users to use a simplified facility design for a variety of different investigations requiring microgravity exposure. It is expected that the nature of investigations within Hermes will be diverse, and will be determined by the investigators leading each experiment. Example investigations include asteroid regolith investigations, life cycle tests of engineering components, and penetrometer and anchoring demonstrations. Any investigation that can benefit from exposure to microgravity can be incorporated into Hermes as long as it meets the specified structural, electrical, and safety standards.

How to Apply? A selection process is being developed now and is likely to be similar to the peer review process used for science proposals. Up to four Principal Investigators could be selected for a given Cassette, one for each of the experiments. These PIs will work closely with the Hermes Payload Developers to navigate through the ISS safety and integrations processes. For more information, please contact the authors of this abstract.

References: [1] M. Fries, et al. (2016) in LPSC 47 2799. [2] M. Fries, et al. (2018) Acta Astronautica 142 (87-94). [3] J. Colwell, et al. (2015) AGU Fall Meeting, Abstract #ED14A-02