Hermes – A New ISS Research Facility for Multiple Regolith Experiments. K. K. John[1], V. L. Saucedo[2], K. R. Fisher[2], P. H. Curiel[2], A. L. Chavalithumrong[3], A. R. Dove[4], M. J. Leonard[5], J. A. Morgan[6], M. D. Fries[2], L. D. Graham[2], P. A. Abell[2]. [1]Jacobs, NASA Johnson Space Center, Houston, TX 77058, kristen.k.john@nasa.gov; [2]NASA Johnson Space Center, [3]University of Nevada-Reno, [4]University of Central Florida, [5]T STAR, Bryan, TX, [6]Texas A&M University.

Introduction: Hermes is a research facility for studying asteroid regolith and granular materials on the International Space Station (ISS). Hermes, a NASA sponsored facility, is launching to the ISS in 2019. Hermes science packages, known as Cassettes, are inserted into the facility to perform investigations that benefit from long-duration microgravity exposure. Cassette-1, launching in 2019, will study granular segregation, gain insight about how grain size and shape effect regolith dynamics, investigate regolith cohesion and adhesion, and characterize compressive forces. *Payload opportunities will be available to the science community for flight on future Hermes Cassettes on a competed basis.*

Payload Description: Hermes is an on-orbit facility capable of accommodating up to four user-configurable experiment volumes at a time. Hermes is designed to provide support to interchangeable experiments so that the experiments are as simple and low-cost as possible. In addition to extended exposure to microgravity, the facility also provides vacuum (at least 10^{-3} torr), power, lighting, cameras, customizable experiment tools, downlink of data, access to data storage, autonomous monitoring, acceleration measurements, and ground commanding of the lighting, cameras, and experiments tools for each experiment. The facility is intended to support research related to regolith and granular material investigations with applications to asteroids, planetary science, and exploration. The ISS is an ideal place for studying asteroids. With access to long-duration microgravity, vacuum, simulated impacts (crew movement and docking of spacecraft), and a simulated diurnal cycle (24 hour cycle of crew activity), the ISS is an invaluable resource for conducting research on small bodies.

Hermes Science Packages: Hermes hosts up to four experiments at a given time, all integrated on the ground as a “Cassette”. The Cassettes are constrained by size and meet certain structural, electrical, and thermal interfaces. Nominally, one Cassette consists of four experiments, although this can be adjusted to meet the researcher’s needs. The contents of the experiments vary depending on the particular investigations (e.g. regolith simulants), and may contain various “tools” or mechanical components and sensors to obtain additional data. The robust system developed allows for up to seven “tools” per experiment with several different compatible types of electrical connections.

Hermes Facility: Hermes experiments operate for months at a time, nominally between 3-12 months. The Hermes Facility is equipped with overhead lighting that illuminates the facility and experiments inside. Hermes provides the capability to operate four cameras at a time, each integrated on the Cassette such that they can be pointed at the appropriate sections of the experiment. Hermes provides vacuum to the individual experiments through use of the ISS Vacuum Resource System (VRS) and a series of vacuum hoses, pipes, valves and transducers mounted within Hermes. This will provide at least 10^{-3} torr. Hermes is an ISS Express Rack locker payload, and is housed inside a single Express Rack locker assembly. The total volume of the facility is 17.34” x 20.32” x 9.97”. Hermes is equipped with an electrical interface that provides power, computation, and control to the user. Software commands for desired lighting brightness, camera cadence, and experiment tool parameters are uplinked from the ground to Hermes and can be adjusted throughout the experiment. Data is downlinked continuously and can be accessed by facility users as often as needed.

Figure 1: Hermes Facility during EMI Testing.

Cassette-1 Experiments & Science Investigations: Hermes will fly to the ISS in 2019, carrying Cassette-1 on board. Cassette-1 is a good example of the experiments Hermes is intended to operate. Cassette-1 utilizes four experiment containers, each made of cylindrical polycarbonate tubes. Each tube is monitored by a camera, filled with a regolith simulant, and contains various tools used to move the regolith and to take measurements. Each tube includes the Entrapulator (a linear actuator powering a scissor jack device used to hold the material in place during launch and return). One of the tubes also includes a load cell and two force sensors for regolith dynamics measurements.

Another tube also includes an agitator and a force sensor for regolith response tests. The Entrapulator in this experiment has spacesuit material on its face for exposure testing. The science objectives for these experiments are to determine the forces at play during regolith particle interactions, including cohesion, adhesion, and compression measurements. The science objectives of the other two experiments are to determine the role that grain size and shape play in regolith dynamics and to validate and improve small body models. These experiments use Entrapulators and silica glass beads of various sizes. The data obtained from the vibrational environment via the Space Acceleration Measurement System-II (SAMS) can be correlated to the experimental data (imagery, sensor measurements). These experiments can be directly compared to the data from the ISS Strata-1 experiment [1-3].

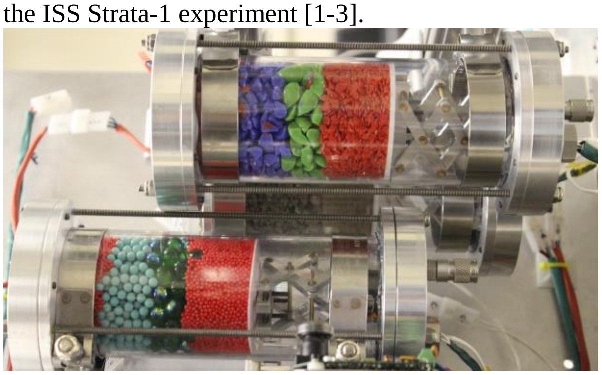

Figure 2: Strata-1 Tubes filled with simulants [1].

Why Study Regolith? Regolith is the layer of material covering the surfaces of airless bodies. On large bodies such as the Moon where gravity is significant, regolith is dominated by impact processing. On small bodies such as asteroids and comets, however, intergrain forces (electrostatic, van der Waals, etc.) dominate, but more research is needed to understand regolith dynamics so that future missions, crewed and robotic, will know how to interact with a loosely-aggregated surface.

Many questions about interacting with regolith need to be answered. What is the best way to sample/move material? How do you set anchors? How do you safely move and process material for ISRU? What material properties should you expect for the surface? How much will fly free when disturbed? On sample return missions, is material collected from the surface representative of the bulk asteroid or comet? In addition to answering questions about interacting with regolith, Hermes Cassette-1 can begin to answer questions about asteroid formation and planetary evolution. For example, many comets and asteroids we have seen up close are bi-lobate, suggesting they have deformed significantly. JAXA's Hayabusa-1 mission to asteroid Itokawa returned small grains, some of which are rounded by mechanics. On Earth, rounded grains arise from water or wind action. On Itokawa, the only explanation is that the body is actively moving and abrading grains, indicating significant motion of the asteroid regolith. Recent missions such as JAXA's Hayabusa-2 and NASA's OSIRIS-REx are providing new information about the diversity of asteroids and their surfaces. Making comparisons of Cassette-1 data to these observations can shed light on the formation of asteroids.

The full set of experiment data can be compared to observations made on small bodies, such as migrating regolith patterns, the Brazil-nut effect, size sorting, landslides, and the similarity of the particle distribution with meteorites such as regolith breccias.

Hermes Manufacturing and Testing: Hermes was designed and built at NASA Johnson Space Center. The electronics were built at Texas A&M University and T STAR. The tubes and tube components were built at the University of Central Florida. Design heritage comes from the previous Strata-1 mission on the ISS [1-3]. Verification testing for Hermes and Cassette-1 was performed at NASA Johnson Space Center and NASA Marshall Spaceflight Center. Significant effort has been put into the process for designing, building, and testing Cassette-1, so as to streamline the process for future Cassettes.

Facility & Cassette-1 Operations: Hermes will be permanently installed in an Express Rack in the US Lab module. Cassettes will be inserted into the facility via regular service by astronauts. Once installed, the Cassette and Hermes Facility will be powered on. SAMS acceleration measurements will begin and continue for the remainder of the experiment. The vacuum system will be activated and once a sufficient vacuum level has been reached, Cassette-1 will be activated.

Hardware commanding and data downlink is administered from the ground. Facility users have complete control over all facility and experiment parameters. Hermes health and status logs provide payload insight and monitoring. Crew interaction is minimal. Autonomous operations will continue until the end of the experiment, only interrupted to install/activate or uninstall a Cassette. The Hermes Facility will remain on ISS until end of ISS life, but Cassettes will be returned to Earth after being uninstalled.

How to Apply? A peer reviewed selection process will be utilized to determine future Cassettes. Selected Principal Investigators will work closely with the Hermes Payload Developers to navigate through the ISS safety and integration processes. For more information, please contact the authors of this abstract.

References: [1] K. John, et al. (2018) in LPSC 49 1790. [2] M. Fries, et al. (2016) in LPSC 47 2799. [3] M. Fries, et al. (2018) Acta Astronautica 142 (87-94).