Hermes
A Microgravity Facility on the ISS
& A Testbed for 3U CubeSats

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GET INVOLVED!

- RFI out now
- Ideas for experiments
- Help inform the design of Hermes
- Interested in collaboration
HERMES IN A NUTSHELL

- A microgravity experimental facility launching to the International Space Station (ISS) in 2018
- Reconfigurable on-orbit experiment facility
  - Four user-configurable experiment volumes at a given time, each up to 3U in size
- Equipped with a robust electrical interface that can accommodate several electrical connections
- Open to investigations of any nature that can benefit from exposure to microgravity
- Power and computation/control provided by Hermes
- Facilitate science experiments, microgravity exposure testing, concept trials, and any simple payload that fits within Hermes’ simplified design and operations constraints
HERMES HERITAGE: STRATA-1

- Strata-1
  - Asteroid regolith dynamics investigation on the ISS
  - Four regolith simulants of increasing complexity
  - Trapped in place on launch, released (within their evacuated tubes) upon installation on ISS
  - One year in microgravity
  - Hypothesis: Current models accurately describe regolith evolution on small bodies

- Hermes
  - Leveraging the success and design heritage of the Strata-1 payload....
    - ...but creating a facility that can easily be reconfigured with new experiments
    - Creating a cost effective and quick way to test CubeSats and CubeSat components
Regolith covers all airless bodies
- On large (Moon, Mercury) bodies, regolith evolution is dominated by impact processing
- On small bodies (asteroids, comets), inter-grain forces (electrostatic, van der Waals, etc.) *should* dominate…but details are lacking

Future missions, crewed and robotic, that visit small bodies should know how to interact with a loosely-aggregated surface (e.g. anchors, ISRU)

Sample return missions (OSIRIS-Rex, ARM, Hayabusa-1, Hayabusa-2, etc.)
- When you examine material collected from the surface, is it representative of the bulk asteroid or comet? Or is it the product of a particle size/density segregation process?
STRATA-1: RESULTS TO DATE

- One-year mission is complete
- ~75 GB of imagery plus SAMS data
- Presentations and abstract at several international conferences
- Publication pending in *Acta Astronautica* describing Strata-1 experiment
- Future publications will describe scientific conclusions and modeling results
- Data archiving will be achieved via Physical Science Informatics (PSI) database
**HERMES EXPERIMENT PARAMETERS**

- **Entire Hermes volume**
  - 17.34" wide x 9.97" tall x 20.32" deep
  - EXPRESS Rack locker insert

- **The available space for individual experiments (i.e. tube, 3U CubeSat, etc.)**
  - Approximately 12" x 4" x 4"

- **Experiments mounted to 80/20 aluminum posts or strapped to the base of the Hermes structure**

- **Experiments removed from Hermes on a regular basis**
  - Simple mechanisms used for crew members to remove and replace experiments
  - Avoid disturbing any vibration sensitive experiments within Hermes

- **Electrical Requirements**
  - All experiments must meet the electrical interface requirements of Hermès
  - Modular Integrated Stackable Layers (MISL)
    - several layers of circuit boards to accommodate experiments with various electrical requirements
    - unplug old experiment chambers from the MISL interfaces, and plug in new ones
    - MISL stack offThe MISL architecture can provide various layers for microcontrollers, communication, power, and sensors
CUBESAT FORM FACTOR

- Can accommodate 1U, 2U, and 3U CubeSat experiments
- A microgravity test bed for 1U, 2U, and 3U CubeSats
  - test components of CubeSats
  - evaluate the overall function of a CubeSat
  - test certain components in microgravity
  - test science and engineering experiments that require only a 3U CubeSat volume
THE EXPERIMENTS

- “Plug in” to Hermes and remove and replace when complete
- Experiments can operate for hours, days, or months
- Cameras will monitor each experiment (imagery or video)
- Lighting provided to illuminate the experiment if/when necessary
- Software commands can be uplinked from the ground to control the desired behavior of the lighting, camera, and any electrical components
WHAT CAN HERMES DO FOR YOU?

- The facility can be relocated, as required by the experiment needs (e.g. vacuum port availability, micro-g acceleration fields, international module availability, etc.)
- The facility can be reconfigured on-orbit using available tools and crew time
- The Hermes facility will have an electronic interface capable of controlling the following:
  - Wireless interface with the ISS (Minimize crew time & 100% autonomy)
  - Power distribution from the ISS 28VDC input power
  - Activation of lights, cameras, sensors, and electromechanical actuators specific to each experiment chamber; this can be reprogrammed for subsequent experiments
  - Downlink of data and access to data storage
  - Hermes will have a front-end GUI for the crew members to easily monitor experiments and to aid in sending data to the ISS for downlink
**DESIGN QUESTIONS FOR FUTURE USERS**

- Required ISS accommodations and interfaces (e.g. 28 VDC power, data rate, data format, vacuum connectivity (if any), crew time/effort, video vs. imagery, lighting, etc.)

- Whether an EXPRESS rack is an acceptable operational location

- Whether the electrical interfaces and requirements stated are acceptable

- Whether the volume requirements stated are acceptable

- Other experiment constraints (e.g. micro-g acceleration levels, acoustic levels, magnetic field strength, orientation relative to ISS acceleration vector, etc.)
HERMES-A, -B, -C...

- What experiments are flying?
  - Asteroid regolith investigations courtesy of Strata-1 science team
  - Tubes will contain advanced technology including compression mechanisms, force sensors, and penetrometers

- Any relevant investigation that benefits from microgravity
  - ISRU
  - Anchoring
  - Space suit material compatibility
  - PLSS filter study
  - Mechanical Joint Study
  - Dust Mitigation
  - UV Radiation Study
  - Meteorite material (bulk material behavior)
  - Applications to formation & behavior of asteroids & comets
  - Regolith dynamics investigations needed for computational models
  - Impact dynamics
  - Food grain industry
1. Construct Hermes assembly: To consist of four clear, polycarbonate tubes (each filled with a different regolith simulant, as well active components), four HD cameras, UV lighting, an electronics box; enclosed in aluminum structure that fits in rack; perform ground testing of penetrometers.

2. Launch Hermes assembly

3. Install in rack; connect to power, data, and vacuum ports; activate

4. Release material within tubes using Entrapulator

5. Autonomous operations & data downlink; Activation of active components

6. Time lapse imagery/videos created using data

7. Scientific results & publications on formation of asteroids/comets, regolith dynamics, compressibility of surface materials, etc.

8. HEOMD Exploration conclusions relevant to anchoring, ISRU, space suit material, mechanical joints, etc.

9. Return Hermes-A tubes; Replace with Hermes-B tubes
STRATA-1 SCIENCE TEAM

1Marc Fries(PI), 1Lee Graham (PM) and 1Kristen John (DPM)
1Paul Abell, 1Stan Love, 2Julie Brisset, 2Daniel Britt, 2Joshua Cowell, 2Adrienne Dove, 2Akbar Whizin, 3Dan Durda, 4Christine Hartzell, 5Dan Scheeres, 6Matthew Leonard, 6Joseph Morgan, 7Jayme Poppin, 5Paul Sanchez-Lana
1JSC, 2U. Central Florida, 3SWRI, 4U. Maryland, 5U. Colorado, 6T STAR, 7Boeing

HERMES DESIGN TEAM

PI: Dr. Kristen John (JSC) kristen.k.john@nasa.gov 281.244.0897
Hermes Design Team: Nick Robbins, Matt Hernandez, Hester Yim, Lee Graham, Marc Fries
Hermes-A Team Members: Jim Mantovani (KSC), Jerry Sanders, Amy Ross, Paul Abell, Jack Bacon, Stan Love, Andi Harrington, plus Strata-1 Science Team
YOU!
Submit an idea to me

- kristen.k.john@nasa.gov

Due date: Friday, June 2\textsuperscript{nd}

Responses to this RFI must be delivered to kristen.k.john@nasa.gov, no later than Friday, June 2, 2017 at 5:00 pm CST. Responses should not exceed 5 pages in length, with no smaller than 12 point type.
If certain interfaces and electrical connections are emphasized during the RFI process, we will work to incorporate those as appropriate.

The MISL architecture can provide various layers for microcontrollers, communication, power, and sensors. MISL can support 10/100 based Ethernet, RS-232, and RS422/485 connections. MISL can support a 28V power supply, low or high power microcontrollers, wireless communication, and various sensor interfaces. MISL uses standard power bus (ERM8/ERF8) and data bus (ERM5/ERF5) connectors. Microcontrollers include MSP430 microcontroller, Concerto (F28M36x) microcontroller, and RM48 microcontroller. Wired comm interfaces include UART serial and 802.3 Ethernet. Wireless comm interfaces include 802.11b/g/n Board, Zigbee Mesh Network Board, 802.15.4A WPAN Board, and ISA 100.11 Wireless Board. However, Hermes will likely have a standardized connection from the experiments to Hermes, therefore eliminating the need for wireless capabilities on the experiments themselves. Sensor layers include multi-sensor demo board, 4-20 mA sensor interface board, charge amp board for tri-axial accelerometer, analog voltage board, high voltage instrument interface board, solenoid value interface board, and high speed DAQ board. MISL can store data with a microSD card up to 4 GB, as well as other data storage technologies.