Testing in Asteroid-Relevant Environments aboard Sub-Orbital Flights for Technology Development and Science Applications

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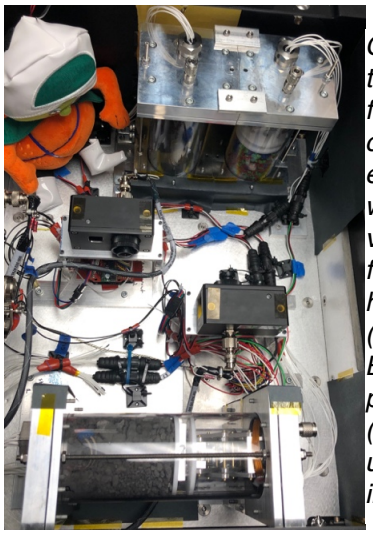
Abstract
Suborbital platforms can be used to provide an environment for testing in microgravity conditions similar to those found at asteroids and other small planetary bodies. The Strata-S1 experiment was developed and flown on a suborbital flight in order to test and improve upon the hardware used in the Strata-1 ISS experiment, to test hardware that could be used on the ISS Hermes facility, and to assist with data analysis of those experiments. Testing of the experiment in a suborbital platform can enhance our understanding of the initial and final conditions of this family of experiments, which is essential for data analysis. Important data on granular mechanics behavior is also gathered during the microgravity portion of the flight.



Overhead view of the Strata-S1 flight configuration. Two experiment tubes were mounted vertically (top of figure) and two horizontally (bottom of figure). Blue Origin-provided GoPros (center) were used for in-flight imaging.

Strata-S1

The Strata-S1 payload flew on Blue Origin's New Shephard suborbital vehicle in April 2019. The Strata (now Hermes) series of experiments is designed to utilize microgravity environments to gain insight into geophysical properties of small, airless planetary bodies in space. It takes advantage of the microgravity and vibrational environment aboard the International Space Station (ISS) or on suborbital flights to explore the stratification, size segregation, and evolution of bulk density of particles in a column of regolith. Overall, the hardware for S1 was similar to that flown on the Strata-1 ISS experiment (Fries *et al.*, 2018), and tubes in all experiments are filled with granular materials simulants that span a range of fidelity with respect to planetary regoliths. Modifications to the experiment tubes were made in order to improve experiment operation and to enable study of compressive pressures on the regolith column under varied conditions (1-*g*, high- and low-*g*) enabled by the suborbital flight. Additional components included load cells and other force sensors for measuring distributed forces throughout the column of regolith. Testing these components through an entire flight cycle provided an opportunity to characterize the effects on the experiment due to in-flight conditions, to study the granular material behavior in high-*g* and low-*g* conditions, and to provide context for the initial images from the Strata-1 data.

Initial Results

Strata-S1 operated as expected and demonstrated successful measurement by some sensors and challenges with others. We saw differences in behavior between the vertically- and horizontally-mounted experiments, which indicates that launch conditions and orientation may affect initial conditions of the experiments on orbit. The few minutes of microgravity on the flight were illustrative of the quiescent periods occasionally seen on the ISS and allow us to study the settling of the granular materials after small perturbations. We will use these results to inform interpretation of data for Strata-1 and for the Hermes experiment that is currently on the ISS, and which has instrumentation similar to that tested in the S1 experiment.

References

M. Fries, *et al.* (2018) The Strata-1 Experiment on Small Body Regolith Dynamics, *Acta Astronautica*, 142, 87-94.

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