Impact Cratering and Ejecta Scaling Experiments on Reduced Gravity Flights. A. D. Whizin\textsuperscript{1}, A. Soto\textsuperscript{1}, Z. Meyer\textsuperscript{1}, A. H. Parker\textsuperscript{2}, and K. J. Walsh\textsuperscript{1}, \textsuperscript{1}Southwest Research Institute, \textsuperscript{2}Search for Extraterrestrial Intelligence (SETI) (awhizin@swri.edu).

**Introduction:** Recent missions to small rubble-pile asteroids (101955 Bennu) observed a highly cobbled and weak surface deficient in small craters and lacking fine regolith, implying a different thermal and collisional environment from larger asteroids [1, 2, 3, 4]. Impact craters and their resultant ejecta may break down boulders, while launching some particles in escape trajectories, or otherwise collisionally process the surface [5]. We have designed a reduced gravity flight investigation involving the building and execution of low-speed impacts into regolith analog targets. This study is designed to answer key questions related to the existing size-frequency distribution of mm-cm-sized cobbles on Bennu’s surface by applying impact scaling relations to experimental results.

**Ejecta Scaling:** Non-dimensional scaling relations have been used to understand cratering processes occurring at planetary scales on asteroids [6, 7]. Dimensionless ‘PI scaling’ relations allow us to extend results from lab scale experiment to determine cratering outcomes, such as crater size, excavated mass, and ejecta velocities [7]. In our study, we use impacts over a range of velocities and impactor/target properties to fit results to scaling relations via coupling parameters similar to [8]. We created a 1D scaling model using a similar approach to [8, 9, 10] in order to optimize the experimental flight payload’s investigation and to test sensitivity to variation in initial conditions. In Figure 1, we show output from the model for impacts from 10-100 m/s into quartz sand under vacuum. Assumptions regarding impact ejecta angles (40-55 degrees) were made using empirical data from [8, 10], and the model’s output was tested against and was found to be in rough agreement with data from [9, 10]. We plan to test the model’s output against our experimental results from our reduce gravity flights planned later this year in order to validate the results prior to applying scaling to asteroid surfaces.

**Impact Experiments:** We are running experiments on a benchtop version of the flight payload that fires a projectile vertically into a tray of regolith. A laser sheet bisects the crater and illuminates a 2D profile, which we use to analyze the ejecta and crater morphology and trajectories. Figure 2 shows a test impact using this set up, creating a ~5 cm crater with a 6 mm low-density projectile shot at ~30 m/s. A ‘stacked’ image is also shown to demonstrate both the ejecta profile, their velocity distributions, and how we analyze the results. We are running experiments over a parameter space covering variations in impactor density and speed, and will present results from these first sets of experiments.

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![Figure 1: The impact cratering and ejecta scaling model developed to quantitatively locate the ideal placement of the GrazvETAS volume element. By inputting the velocity of the impactor, density of target material and impactor, and other variables, the scaling relations predict the resultant properties of the ejecta, allowing us to compute trajectories.](image1)

![Figure 2: Cratering experiment performed at 1-g. A 6mm projectile is launched downward into a target bed of quartz sand and the resulting crater is formed in a laser sheet. A high-speed camera captures the illuminated ejecta for analysis. A stacked image (right) shows the ejecta plume profile and crater depth/width.](image2)