**Estimates of Grain Sizes Using Instrumented Impactors.** K. J. Walsh\(^1\), A. H. Parker\(^2\), A. Whizin\(^1\) and D. Durda\(^1\). \(^1\)Southwest Research Institute, Boulder, CO, USA (kwalsh@boulder.swri.edu) \(^2\)SETI

**Introduction:** Low-speed impacts into granular material can be used to diagnose the physical properties of the target material \([1,2,3,4]\). Explored in a laboratory setting, an impactor is instrumented with an accelerometer, exposed to a wide range of impact speeds, target bed materials, and a range of gravity levels to develop a series of universal force laws to define the forces expected to be imparted on the impactor \([1,2,3]\). As a tool to explore distant worlds, measured spacecraft accelerations have been similarly used to deduce surface properties for singular encounters with a comet \([5]\) and asteroid \([6]\). Here we continue to explore the utility of specifically designed impactors that are instrumented with accelerometers as tools to understand the grain size distribution on and stratification in a target surface.

**Instrumented Impactors:** The impactors are spheres of sizes ranging from a few centimeters up to 10 centimeters with cavities to house either members of the family of YOST 3-space IMU sensors or TinyShield accelerometers. The suite of equipment allows a wide range of experimental configurations related to relative sizes/densities of impactors to granular bed particle sizes/densities.

**Experimental Setup:** A 40 cm diameter aluminum chamber held either Airsoft pellets or sand for a series of experiments to explore the force profiles exerted on impactors. The Airsoft pellets were used due to their large size (6 mm), which allows for numerical modeling to exactly match the number of particles in a simulation. Meanwhile the range of masses (0.12 g – 0.25 g) allows for explorations of inertial dependences. The contrast in the two granular media, Airsoft and sand, also allows for studies focused on grain sizes and morphology.

**Results:** Here, the finite size of the target material (6 mm Airsoft pellets) and imperfect measurements (limits on recording frequency and noise) provide both challenge and insight into future utility of instrumented impactors as exploration tools. The amount of scatter, or noise, for any single acceleration profile depends on the relative size/mass between the impactor and grain size. We specifically track the properties of the noise as a function of impactor/grain-size, looking to understanding its ability to serve as a tool to establish grain sizes (see Figure 1,2).

For these experiments we have the luxury of multiple impacts with the exact same parameter combinations of impactor mass, impact speed and target bed materials. Using >20 of these averaged together, we tracked for each point, for each drop, its excursion from the mean, and produced a 1 stddev envelope. Intuitively, this depends on the ratio of impactor size to typical target bed particle size, where the large Airsoft beads have 3× larger spread. The challenge going forward is to build a physical model and then use it to extract the impactor/target-particle size ratio from a single acceleration profile, rather than a battery of 20 averaged drops.

**Figure 1:** (top pane) The averaged measured acceleration of an impactor into sand, with the 1 standard deviation envelope. (bottom pane) The magnitude of the envelope as a function of time of the profile.

![Figure 2](image-url) **Figure 2:** Same as above, but with airsoft bead target bed.