THE JOHNSON SPACE CENTER EXPERIMENTAL IMPACT LAB: CONTRIBUTIONS TOWARD UNDERSTANDING THE EVOLUTION OF THE SOLAR SYSTEM

T.H. See[1], F. Cardenas, and R. Montes, [1]Astromaterials Research Group/ESCG, P.O. Box 58447, JE23, Houston, Texas 77258 thomas.h.see@nasa.gov.

Introduction: Impact is the most common and only weathering phenomenon affecting all the planetary bodies (*e.g.*, planets, satellites, asteroids, comets, etc.) in the solar system. NASA Johnson Space Center's Experimental Impact Laboratory (EIL) includes three accelerators that are used in support of research into the effects of impact on the formation and evolution of the solar system. They permit researchers to study a wide variety of phenomena associated with high-velocity impacts into a wide range of geologic targets and materials relevant to astrobiological studies. By studying these processes, researchers can investigate the histories and evolution of planetary bodies and the solar system as a whole.

While the majority of research conducted in the EIL addresses questions involving planetary impacts, work involving spacecraft components has been performed on occasion. An example of this is the aerogel collector material flown on the Stardust spacecraft that traveled to Comet Wild-2. This capture medium was tested and flight qualified using the 5 mm Light-Gas Gun located in the EIL.

Accelerator Area: The Accelerator Area (Fig. 1) is the heart of the EIL where the three accelerators are located: the Flat-Plate Accelerator, the Vertical Gun, and the Light-Gas Gun. In general, all three accelerators essentially work the same way. A driving gas is introduced very quickly into the system at high pressure pushing the projectile down the barrel and toward the target. Experiments are typically conducted under reduced atmospheric conditions (as low as 1 millitorr), but the pressure and composition of the atmosphere in the impact chamber can be modified to simulate that of other planetary bodies (*e.g.*, Mars). Each accelerator is distinct from the others and possesses its own specific strengths.

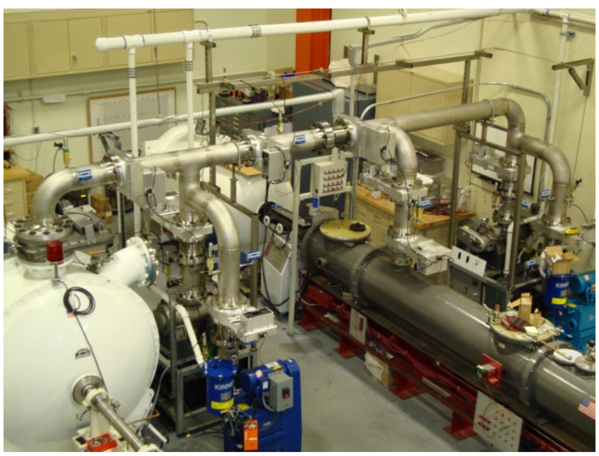

Figure 1. Overhead view of the 5 mm Light-Gas Gun (right) and Flat-Plate Accelerator (white, left) in the Experimental Impact Laboratory at the Johnson Space Center.

Flat-Plate Accelerator: The Flat-Plate Accelerator (FPA) is used to shock-load targets to stresses as high as 70 GPa, after which the samples are recovered to examine the resulting shock effects. The target is typically a disk, when the material is solid rock, about 10 mm in diameter by 1 to 2 mm thick. Unconsolidated materials are typically contained in a "well" machined into the target assembly. Current investigation being supported by the FPA include shock alteration of simple sugars (*i.e.,* GLA/DHA) [1]; the effect of shock on clay bearing, low-porosity rocks [2]; and the reduction of sulfate to sulfide via impact to aid in assessing the origins of sulfide droplets found in gas-rich impact melts in martian meteorites [3].

Vertical Gun: With a variety of different barrels, the Vertical Gun (VG) has launched projectiles as small as 10 µm and as large as 12 mm in diameter at velocities approaching 2.7 km/s. The impact chamber can be refrigerated to around -20°C, supporting experiments involving targets of H_2O ice. This accelerator is particularly well-suited to the study of impacts in which the target consists of sand or other non-coherent materials and supports the ability to photograph and measure the speed of the resulting ejecta (Fig 2).

Current investigations utilizing the VG include collisional processing of cometary surfaces [4], understanding impacts in the piezoelectric-sensor material PVDF [5], and understanding ejection velocities and deposits of fine-grained materials [6].

Light-Gas Gun: The 5 mm, two-stage Light-Gas Gun (LGG) is the largest and most complex accelerator in the EIL, capable of accelerating projectiles smaller than 5 mm in diameter to velocities up to 8 km/s. With this accelerator we can launch projectiles to more than twice the velocity of those achieved with the other two accelerators, but the price we pay for that capability is a relatively long time between shots. While we can comfortably shoot the VG and FPA up to five or so times a day, each shot with the LGG typically requires a full day.

The table below summarizes some of the important characteristics and parameters of the three accelerators located in the Experimental Impact Lab at JSC.

	Flat-Plate Accelerator	Vertical Gun	Light-Gas Gun
Bore Size	20 mm and 25 mm	5.56 - 20 mm, interchangeable	5 mm
Barrel Configuration	Smoothbore	Rifled and smoothbore	Smoothbore
Maximum Velocity of Projectile	1.7 km/s	2.7 km/s	8 km/s
Projectile Shape	Cylindrical	Spherical and cylindrical	Spherical
Projectile Size	22 mm discs, up to 20 mm spheres	Up to 12.5 mm	Up to 5 mm
Detonation Mechanism	Electrical current	Mechanical firing pin	Electrical current
Special Characteristics	• Target is subjected to a controlled shock pressure to stresses as high as 70 GPa and recovered for subsequent analysis.	• The impact chamber may be cooled to -20°C. • The gun is mounted vertically, making possible the use of non-cohesive targets, such as sand.	• Hydrogen gas is compressed by a powder-driven piston to accelerate the projectile.

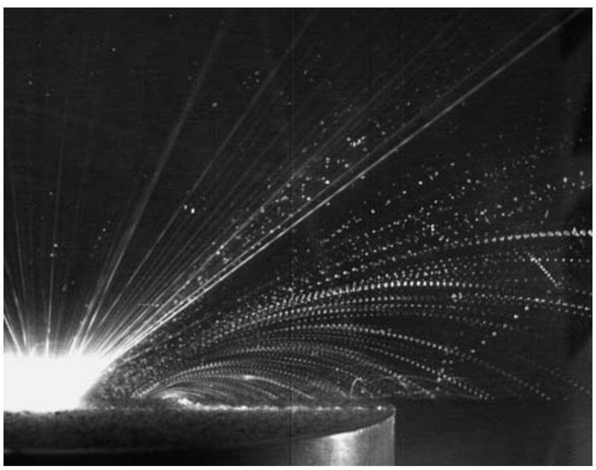

Figure 2. EVMS photograph of ejecta from the impact of a 3.18 mm glass sphere into coarse sand at 1.26 km/s. Each parabolic track is defined by multiple images of a sand grain following its own trajectory. A laser was illuminating the scene from the right; each flash of the laser lasted 100 µs and was separated from adjacent flashes by 1900 µs. The bright area near the lower-left corner is the flash from the projectile's impact, and the side of the cylindrical target container is visible at the bottom center. The projectile traveled downward, along the left-hand edge of the frame. The long, straight, continuous streaks are self-luminous, high-speed fragments, while odd trajectories were caused by pieces of sand ricocheting from the chamber wall and passing back through the "sheet of laser light. Since the timing between laser flashes is known and the scale and viewing geometry of the picture was established before the experiment, it is a straightforward procedure to determine the velocity of each imaged particle.

Machine Shop: A machine shop in the EIL comprises standard floor tools, including various sized lathes, grinders, a band saw, a table saw, an end mill, and smaller power and hand tools. Targets and special parts for the accelerators and their peripheral equipment, custom-fitted parts, and special configurations can be fabricated with this equipment.

Target Preparation and Analysis Room: The Target Preparation and Analysis Room is where targets are prepared, sieved, disassembled, or otherwise subjected to pre- and post-experiment treatment.

For more information about this laboratory, contact the ESCG lead, Thomas H. See (thomas.h.see@nasa.gov; 281-483-5027).

References: [1] E. Bennett *et al.* (2012) *LPS LXIII*, this volume. [2] T. Sharp and J. Michalski (2012) *LPS LXIII*, this volume. [3] M.N. Rao *et al.*, (2012) *LPS LXIII*, this volume. [4] S. Lederer *et al.*, (2011) *EPSC-DPS*, 1324. [5] M. Horanyi (2012) *LPS LXIII*, this volume. [6] J.L.B Anderson *et al.* (2010) LPSC 2010 #2084.