Southern Impact Testing Alliance

One-Stop Shop Combined Capabilities Impact Testing for Space, Department of Defense or Private Industry

Whitney Hubbs
NASA/MSFC
Brian Roebuck
USAFAEDC

www.nasa.gov
Southern Impact Testing Alliance
(SITA)

Efforts to form this Alliance began in 2008 to showcase the impact testing capabilities within the southern United States.

SITA Partners Include:

- Arnold Engineering Development Center Hypervelocity Range Facility
- Auburn University’s Space Research Institute
- Marshall Space Flight Center Impact Testing Facility
- University Alabama Huntsville Aerophysics Research Center
Southern Impact Testing Alliance
SITA

Advantages for the customer:

- Impact testing customers can utilize SITA partner capabilities to provide supporting data during all program phases-materials/component/flight hardware design, development, and qualification.

- This approach would allow programs to reduce risk by providing low cost testing during early development to flush out possible problems before moving on to larger scale/higher cost testing.

- Various SITA partners would participate in impact testing depending on program phase-materials characterization, component/subsystem characterization, full-scale system testing for qualification.

- SITA partners would collaborate with the customer to develop an integrated test approach during early program phases.

- Modeling and analysis validation can start with small-scale testing to ensure a level of confidence for the next step large or full-scale conclusive test shots.
Marshall Space Flight Center
Impact Testing Facility

- MSFC ITF serves as an important installation for space and missile related materials science research

- ITF was established and began its research in spacecraft debris shielding in the early 1960’s and played a major role in the International Space Station debris shield development

- As a result of return to flight testing after the loss of STS-107 (Columbia) MSFC ITF realized the need to expand their capabilities beyond meteoroid and space debris impact testing. MSFC partnered with the Department of Defense and academic institutions as collaborative efforts to gain and share knowledge that would benefit the Space Agency as well as the DoD.

MSFC ITF current capabilities:

- Hypervelocity Impact Testing
- Ballistic Impact Testing
- Environmental Impact Testing
Hypervelocity Impact Range

Micro-light Gas Gun (MLGG)
- Bore size up to 4 mm (0.16 in) diameter
- Velocity Range: 0.3 – 7.5 km/s
- Target chamber approx 1.3 m (4 ft) dia. X 1.6 m (5 ft) long
- Shot Frequency: 5-7 per day or more depending on shot configuration

Light Gas Gun (LGG)
- Bore size up to approx 2 cm (0.8 in) diameter
- Velocity Range: 2.5 - 7.5 km/s
- Target chamber approx 3 m (10 ft) dia. x 6 m (20 ft) long
- Shot Frequency: 2-3 per day

Projectile types for both guns include but are not limited to spheres and cylinders of materials such as aluminum, borosilicate glass, polymers, and ceramics.
Ballistic Impact Range

Large Ballistic Gun (LBG)

- 7.5 cm diameter barrel or custom-made barrel to accommodate a range of projectiles up to 15 cm diameter
- Velocities up to Mach 2

Small Ballistic Gun (SBG)

- Used for hail, and launch and ascent debris simulation
- Projectiles up to 3 cm (1.2 inch) diameter
- Velocities up to Mach 2

The Ballistic Impact Range is an outdoor range used to accommodate full-scale targets and small arms test firing.

This range is used for laboratory ballistic evaluation of items from ball ammunition (up to 50 caliber AP) to 30 mm high explosive incendiary (HEI) rounds, vehicle launch and ascent debris impacts, and ice impacts on radomes and other structures.
Environmental Impact Range

**Single/Multi-Particle Gun**
- Velocities from 500 – 2000 m/s (1640-6562 ft/s)
- Simulating dust, sand, and rain particles from 5 mm down to 10 microns

**Exploding Wire Gun**
- Velocities up to 7 km/s
- Particle sizes: 0.4 - 4.0 mm

**Rain Gun**
- Velocities up to 1430 m/s (4700 ft/s)
- Water drops from 1 - 5 mm dia.
- 30, 45, 60, and 90 degree impacts available, others possible
- Specimen sizes up to 20 mm dia.

ITF test systems provide capabilities for rain, hail, sand, and dust impacts. Applications previously tested include radome, IR window, rotor blade materials.
AEDC RANGE COMPLEX INCLUDING RANGE G AND RANGE I
MODEL / WATER DROPLET IMPACT SEQUENCE (TWO IMPACTS)

Model Velocity: 2,460 m/sec  
Range Pressure: 354 torr  
1.2-mm-diam Water Droplets
SNOWFIELD GENERATOR INSTALLATION IN AEDC RANGE G

Range C

Instrumentation for Snowfield Definition

Laser Camera

Single Plate Snow Generator Installation

Launch Tube
Sabot Stripper

Location of Laser Stations
(Distance from Range Entrance, ft)

11 ft (Typical)
The UAH Aerophysics Research Center began operations in 1991 on Redstone Arsenal, AL following the donation to UAH by GM Delco of three two-stage light gas guns.

Primary Function is conducting experimental research on hypersonic flight and hypervelocity impact.

Programs supported range from basic research through prototype development. While the government laboratory community is the principal customer, student/faculty research, SBIR projects and contractor IR&D efforts are also performed.
University of Alabama in Huntsville –
108 MM Pump Tube Light Gas Gun

45' Long x 4.25” Diameter Pump Tube
25' Long Interchangeable Launch Tubes
Launch Tube Diameters from 0.75” to 1.2”
6’ Diameter x 14’ Long Impact Chamber
Launch Mass’s up to ~ 130 g.
Launch Energy’s up to ~ 1 MJ.
University of Alabama in Huntsville – 133 MM Pump Tube Light Gas Gun

- 60’ Long x 5.25” Diameter Pump Tube
- 50’ Long Interchangeable Launch Tubes
- Launch Tube Diameters from 1.15” to 1.4”
- 8’ Diameter x 22’ Long Impact Chamber
- Launch Mass’s up to ~ 300 g.
- Launch Energy’s up to ~ 1 MJ.
University of Alabama in Huntsville –
254 MM Pump Tube Light Gas Gun

125’ Long x 10” Diameter Pump Tube
75’ Long Interchangeable Launch Tubes
Launch Tube Diameters from 2.2” to 6.0”
10’ Diameter x 41’ Long Impact Chamber
Launch Mass’s up to ~ 12 kg.
Launch Energy’s up to ~ 25 MJ.
University of Alabama in Huntsville – Overall Mass/Velocity Test Capability

Projectile Velocity [kmlsec]

254 mm LGG
133 mm LGG
108 mm LGG

Equivalent MACH # at Sea Level

Projectile Mass [grams]

1 Megajoule
10 Megajoules
20 Megajoules

Projectile Kinetic Energy Curves
Auburn University Space Research Institute

- **Arc Driven Plasma Drag Gun**
  - Accelerates 5 to 50 particles per test (10-150μm diameter)
  - Velocity 5 to 12 km/s
  - Individual particle size, velocity and location identified.
  - Micrographs and measurements
  - Minimal gun debris, clean targets

- **Cryogenic & Elevated Temperature**
  - Liquid Helium Cooling
  - Infrared Heating
  - Target Temp: 24 to 450K

- **Oil Free Pumping**
  - suited for optical samples where post test characterization is desired.
<table>
<thead>
<tr>
<th>Gun</th>
<th>Velocity Range</th>
<th>Projectile</th>
<th>Target size</th>
<th>Target Chamber</th>
<th>Velocity measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hypervelocity Range</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro light gas gun</td>
<td>2.5 - 7.5 km/s</td>
<td>2-19 mm (1/8”-3/4”)</td>
<td>up to 3 m dia.</td>
<td>4 ft dia. X 5 ft length</td>
<td>photo diode</td>
</tr>
<tr>
<td>Large two-stage light gas</td>
<td>2.0 - 7.5 km/s</td>
<td>0.2 - 1.0 mm</td>
<td>up to 1 m dia.</td>
<td>10 ft dia X 20 ft length</td>
<td>photo diode</td>
</tr>
<tr>
<td><strong>Outdoor Range</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Ballistic Gun</td>
<td>up to 3000 ft/s</td>
<td>3 - 8 inch</td>
<td>open-air range</td>
<td>open-air range</td>
<td>high speed video</td>
</tr>
<tr>
<td>Small Ballistic Gun</td>
<td>up to 3000 ft/s</td>
<td>0.5 - 1.0 inch</td>
<td>open-air range</td>
<td>open-air range</td>
<td>high speed video</td>
</tr>
<tr>
<td><strong>Environment Impact Range</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrometeor (Rain) Gun</td>
<td>up to 4200 ft/s</td>
<td>&lt;20 mm</td>
<td>&lt;12 X 12 inch</td>
<td>18 X 24 X 36 inches</td>
<td>high speed video</td>
</tr>
<tr>
<td>Single or Multi-particle Wire Gun</td>
<td>up to 6000 ft/s</td>
<td>12 - 14 mm</td>
<td>open air range</td>
<td>open-air range</td>
<td>high speed video</td>
</tr>
<tr>
<td><strong>University of Alabama Huntsville (UAH) Aerophysics Research Center</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hypervelocity Range</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Pump Tube Diameter)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>108 mm two-stage light gas gun</td>
<td>up to 7.5 km/s</td>
<td>up to 130 grams</td>
<td>up to 1 MJ</td>
<td>6’ dia. X 14’ long</td>
<td>25’ long, 75-1.2’ dia.</td>
</tr>
<tr>
<td>133 mm two-stage light gas</td>
<td>up to 7.5 km/s</td>
<td>up to 300 grams</td>
<td>up to 1 MJ</td>
<td>7.9’ dia. X 22’ long</td>
<td>50’ long, 1.15-1.4’ dia.</td>
</tr>
<tr>
<td>254 mm two-stage light gas</td>
<td>up to 7.5 km/s</td>
<td>up to 8000 grams</td>
<td>up to 1 MJ</td>
<td>10’ dia. X 41’ long</td>
<td>75’ long, 2.2-6.0’ dia.</td>
</tr>
<tr>
<td><strong>Arnold Engineering Development Center (AEDC) Hypervelocity Range Facility</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Pump Tube Diameter)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>355 mm two-stage light gas</td>
<td>up to 7.5 km/s</td>
<td>up to 20,000 grams</td>
<td>up to 1 MJ</td>
<td>10’ dia. X 940’ long</td>
<td>125-190’ long, 272-331.666’ dia.</td>
</tr>
<tr>
<td>203 mm two-stage light gas</td>
<td>up to 7.5 km/s</td>
<td>up to 1,000 grams</td>
<td>up to 1 MJ</td>
<td>10’ dia. X 33’ long</td>
<td>95’ long, 207’ dia.</td>
</tr>
<tr>
<td>38,76,77 mm two-stage light gas</td>
<td>up to 8.5 km/s</td>
<td>up to 6.0 grams</td>
<td>up to 1 MJ</td>
<td>6’ dia. X 15’ long</td>
<td>12, 14, 36’ long, 3.5, 8, 75’ dia.</td>
</tr>
<tr>
<td>Compressed air launcher</td>
<td>98 - 1200 ft/sec</td>
<td>4,535 grams</td>
<td>N/A</td>
<td>Open</td>
<td>33’ long, 6’ dia.</td>
</tr>
<tr>
<td><strong>Erosive Field Characteristics</strong></td>
<td>Field Length</td>
<td>Projectile Diameter</td>
<td>Concentration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust</td>
<td>800 ft</td>
<td>200,325, 650 microns</td>
<td>&lt; 2.0 gm/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rain</td>
<td>800 ft</td>
<td>1.0 - 2.0 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snow (Cirrus, Dendritic)</td>
<td>800 ft</td>
<td>0.2 - 3 mm</td>
<td>&lt; 1.0 gm/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Auburn University Space Research Institute</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hypervelocity Range</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plasma Drag Gun</td>
<td>5 - 12 km/sec</td>
<td>10-150 um diameter</td>
<td>5 to 50 particles/test</td>
<td>3.9’ X 6.8’</td>
<td>24 - 450K</td>
</tr>
</tbody>
</table>
Contact Summary

- Marshall Space Flight Center (MSFC)
  - Whitney Hubbs
  - Office: 256-544-0615
  - whitney.s.hubbs@nasa.gov
  - Andy Finchum
  - Office: 256-544-1635
  - andy.finchem@nasa.gov

- Arnold Engineering Development Center (AEDC)
  - Brian Roebuck
  - Office: 931-454-7106
  - brian.roebuck@arnold.af.mil
  - Dennis Huprich
  - 931-454-5310
  - dennis.huprich@arnold.af.mil

- University of Alabama in Huntsville (UAH) Aerophysics Research Center
  - Mark Zwiener
  - Office: 256-464-8000 x 23
  - mark.zwiener@uah.edu

- Auburn University Space Research Institute
  - Brian Wells
  - Office: 334-844-5967
  - wellsbk@auburn.edu