NASA AMES RESEARCH CENTER

THERMOPHYSICS FACILITIES BRANCH

FACT SHEET

SPACE TECHNOLOGY DIVISION

RANGE COMPLEX

NASA Ames has a long tradition in leadership with the use of ballistic ranges and shock tubes for the purpose of studying the physics and phenomena associated with hypervelocity flight. Cutting-edge areas of research run the gamut from aerodynamics, to impact physics, to flow-field structure and chemistry. This legacy of testing began in the NACA era of the 1940's with the Supersonic Free Flight Tunnel, and evolved dramatically up through the late 1950s with the pioneering work in the Ames Hypersonic Ballistic Range. The tradition continued in the mid-60s with the commissioning of the three newest facilities: the Ames Vertical Gun Range (AVGR) in 1964, the Hypervelocity Free Flight Facility (HFFF) in 1965 and the Electric Arc Shock Tube (EAST) in 1966. Today the Range Complex continues to provide unique and critical testing in support of the Nation's programs for planetary geology and geophysics; exobiology; solar system origins; earth atmospheric entry, planetary entry, and aerobraking vehicles; and various configurations for supersonic and hypersonic aircraft.

SUMMARY DESCRIPTION OF THE TEST COMPLEX

The Test Complex currently consists of three ranges: the Ames Vertical Gun Range (AVGR), the Hypervelocity Free Flight (HFF) Facilities and the Electric Arc Shock Tube (EAST).

The Ames Vertical Gun Range is used to simulate the physics and mechanics of planetary impact cratering and micrometeoroid impacts. The facility utilizes various model-launching guns that can achieve impact velocities approaching 7 km/sec. The angle of elevation of the gun with respect to the horizontal plane can be varied in 15-degree increments from 0 to 90 degrees, thus permitting oblique angles of impact with respect to the gravitational vector. Impact events can be recorded with a variety of high-speed imaging options.

The Hypervelocity Free-Flight Aerodynamic Facility (HFFAF) is used to examine the aerodynamic characteristics of atmospheric entry and hypervelocity vehicle configurations, and to study flow field structure and gas dynamic phenomena. The Hypervelocity Free-Flight Gun Development Facility (HFFGDF) is used to expand light-gas gun operational capabilities, and to perform hypervelocity impact testing experiments. Both facilities support three of NASA's Mission Directorates: Aeronautics, Exploration and Science. The HFFAF is the Agency's only aeroballistic capability, and can provide critical aerodynamic parameters such as lift, drag, static and dynamic stability, flow characteristics, and pitching moment coefficients for velocities ranging from 0.5 to 8.0 km/s. The HFFAF is the only ballistic range in the nation that is capable of testing in atmospheres other than air. In addition the HFFAF has high-speed thermal imaging capabilities, which can be used to measure global surface temperature distributions and hence determine aerothermodynamic characteristics. Much of the research effort to date has centered on Earth atmosphere entry configurations (Mercury, Gemini, Apollo, and Shuttle), planetary entry (Viking, Pioneer-Venus, Galileo, and Mars Science Lab), supersonic and hypersonic flight (X-15), aerobraking (AFE) configurations, and scramjet propulsion studies (NASP). Both facilities have been used for meteoroid/orbital debris studies (ISS, and RLV).

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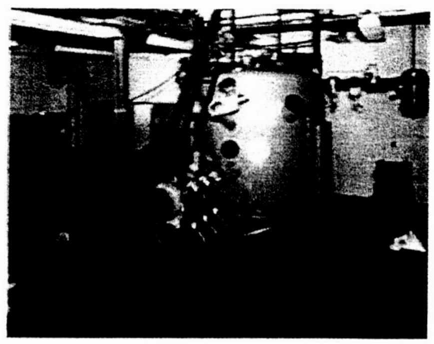
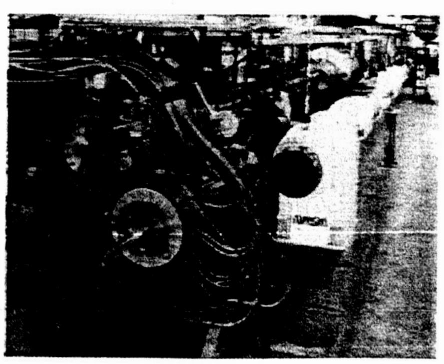
The Electric Arc Shock Tube (EAST) Facility is used to investigate the effects of radiation and ionization that occur during very high velocity atmospheric entries. The EAST can also provide air-blast simulations requiring the strongest possible shock generation in air at initial pressure loadings of 1 atm or greater. The facility has three separate driver configurations. Depending on test requirements, the driver can be connected to a diaphragm station of either a 4-in or a 24-in shock tube. The high-pressure 4-in shock tube can also drive a 30-in shock tunnel. Energy for the drivers is supplied by a 1.25-MJ-capacitor storage system.

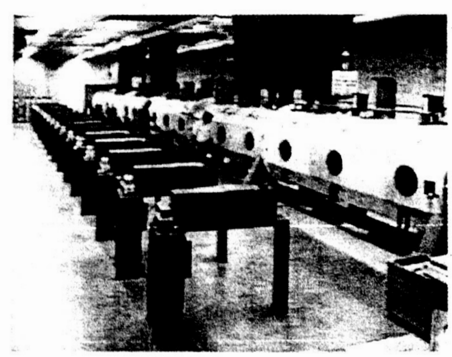
The Ames Range Complex provides the Nation with the capability to conduct low-cost “flight tests” in ground-based facilities.



Ames Vertical Gun Range
Impact & Cratering



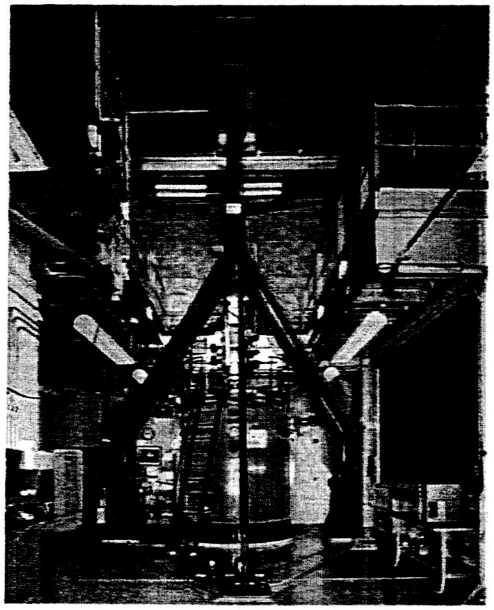
EAST
Outer Planetary Entry
&
Radiation / Ionization Study



HFFF
Atmospheric Entry

AMES VERTICAL GUN RANGE (AVGR)

The Ames Vertical Gun Range (AVGR) was designed to conduct scientific studies of lunar impact processes in support of the Apollo missions. In 1979, it was established as a National Facility, funded through the Planetary Geology and Geophysics Program. In 1995, increased science needs across various discipline boundaries resulted in joint core funding by three different science programs at NASA Headquarters (Planetary Geology and Geophysics, Exobiology, and Solar System Origins). In addition, the AVGR provides programmatic support for various proposed and ongoing planetary missions through special arrangements with the Facility Manager and Science Coordinator.



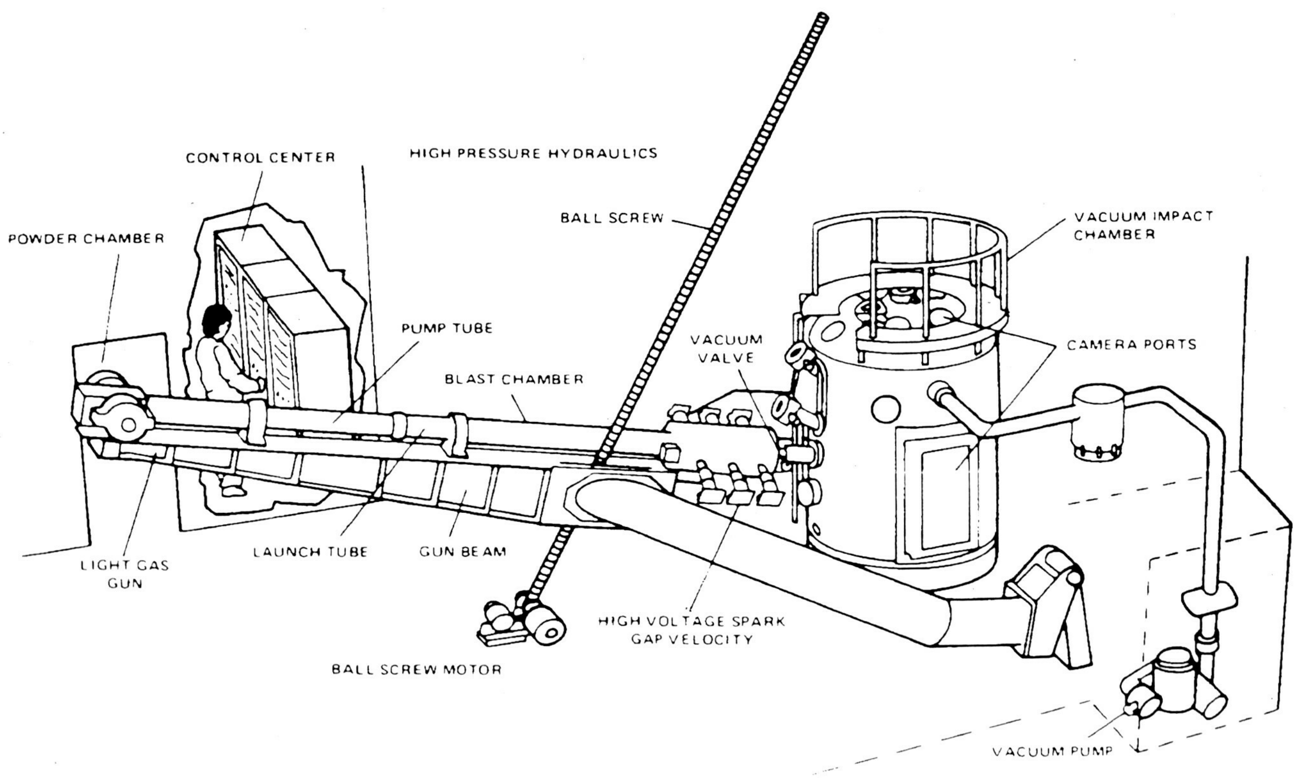
Utilizing its 0.30 cal light-gas gun and powder gun, the AVGR can launch projectiles to velocities ranging from 0.5 to nearly 7 km/sec. By varying the gun's angle of elevation with respect to the target vacuum chamber, impact angles from 0° to 90° with respect to the gravitational vector are possible. This unique feature is extremely important when examining crater formation processes.

The types of projectiles that can be launched include spheres, cylinders, irregular shapes, and clusters of many small particles. The projectiles can be metallic (i.e. aluminum, copper, iron), mineral (i.e. quartz, basalt), or glass (i.e. pyrex, soda-lime). For example, soda-lime spheres can be launched individually for sizes ranging from 1.5 to 6.4mm (1/16 to 1/4 inch) in diameter; in groups of three for sizes ranging from 0.2 to 1.2mm; or as a cluster of many particles for sizes ranging from 2 to 200-μm.

For both guns, projectiles are typically encased in a sabot (a plastic carrier) to align, support and protect them during their passage through the gun barrel (launch tube). Since the launch tube is rifled, the launch package [sabot and projectile(s)] exits the barrel with both an axial and angular velocity. The resulting centrifugal force separates the sabot from the projectile(s) leaving the projectile(s) in free flight. The projectile(s) pass through a velocity chamber and then into the target vacuum chamber. The velocity chamber uses a set of photomultiplier tubes, light sheets, cameras and counters to detect and record projectile passage (and ultimately determine velocity). At the entrance to the target chamber there is a valve-like device, which deflects the trailing gun gases after projectile passage. The result is a very clean target impact with minimal propellant debris. The target chamber is roughly 2.5 meters in diameter and height and can accommodate a wide variety of targets/mounting fixtures. The chamber can maintain vacuum levels below 0.03 torr, or can be back filled various gases to simulate different planetary atmospheres. Impact events are typically recorded using high-speed video or film.

AVGR PERFORMANCE SUMMARY

Guns (barrel diameters):	0.30 cal (7.6mm) Light Gas Gun & Powder Gun 1.76 cal (44.7mm) Air Gun
Projectile velocity (m/s):	2,500 to 7,000 (LGG) 500 to 3,000 (PG) 10 to 900 (AG)
Projectile size (mm):	0.002 to 6.4 (LGG and PG) 6.4 to 44.7 (AG)
Test chamber pressure (atm):	0.00003 to 1
Test chamber temperature:	270K (ambient)
Test gas:	Air, N2, CO2, Argon, arbitrary
Imaging options (frames/sec):	500 or 1000 (NAC high speed video) 5,000 to 10,000 (NOVA 16mm film, 400 ft roll) 35,000 (Cordin 35mm film, 36 exp. strip)
Maximum viewing window:	0.7 x 1 m

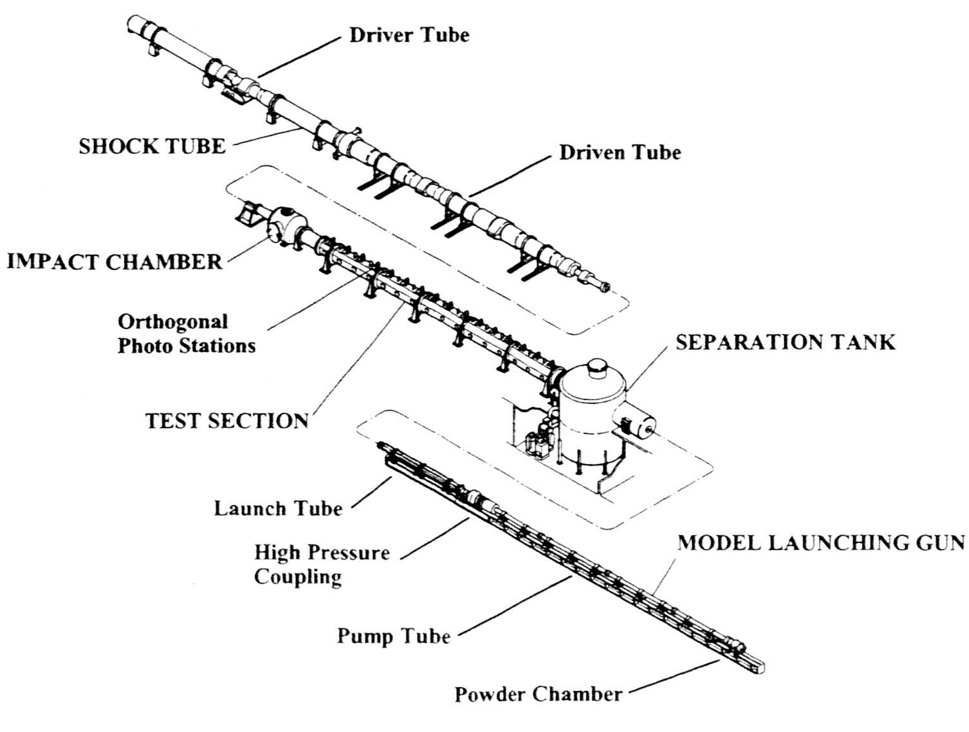


HYPERVELOCITY FREE-FLIGHT FACILITIES

The Hypervelocity Free-Flight (HFF) Range at Ames Research Center (ARC) currently comprises two active facilities: The Aerodynamic Facility (HFFAF) and the Gun Development Facility (HFFGDF). Both facilities were constructed in 1964 and are located in Building N-237.

HYPERVELOCITY FREE-FLIGHT AERODYNAMIC FACILITY

The Hypervelocity Free-Flight Aerodynamic Facility is a combined Ballistic Range and Shock-tube Driven Wind Tunnel. The HFFAF consists of: a model launching gun (light-gas or powder); a sabot separation tank; a test section (with 16 orthogonal shadowgraph imaging stations); an impact/test chamber; a nozzle; and a combustion-driven shock tube (see figure below). The primary purpose of the facility is to examine the aerodynamic characteristics and flow-field structural details of free-flying aeroballistic models. For this mode of traditional aeroballistic testing, each of the shadowgraph stations can be used to capture an orthogonal pair of images of a hypervelocity model in flight along with its associated flow-field. These images combined with the recorded flight time history can be used to obtain various aerodynamic coefficients C_D, $C_{L\alpha}$, $C_{m\alpha}$, $C_{mq} + C_{m\alpha}$. In addition, several high-speed thermal-imaging cameras can be used to measure the global surface temperature distribution of a model at different points along its flight path. This information can be used to evaluate the aerothermodynamic response of actual heat-shield materials. For very high Mach number (i.e. M> 25) simulation, models can be launched into a counter flowing gas stream generated by the shock tube. The facility can also be configured for hypervelocity impact testing. In this mode, a light gas gun is used to launch impact particles (typically spheres or cylinders) at target materials mounted in the impact chamber. A fourth mode of operation is shock tunnel testing. For this type of testing a fixed, instrumented model is mounted in either the impact chamber or at one of the shadowgraph stations in the test section. The combustion driven shock tube is used to generate a short duration reservoir of high-temperature, high-pressure test gas for expansion through the nozzle and over the test article.



Most of the research effort to date has centered on Earth atmosphere entry configurations (Mercury, Gemini, Apollo, and Shuttle), planetary entry designs (Viking, Pioneer Venus, and Galileo), and aerobraking (AFE) configurations. The facility has also been used for scramjet propulsion studies (NASP) and meteoroid/orbital debris studies (Space Station, and RLV). At this time, the shock tube is in "stand-by" mode and is not operational.

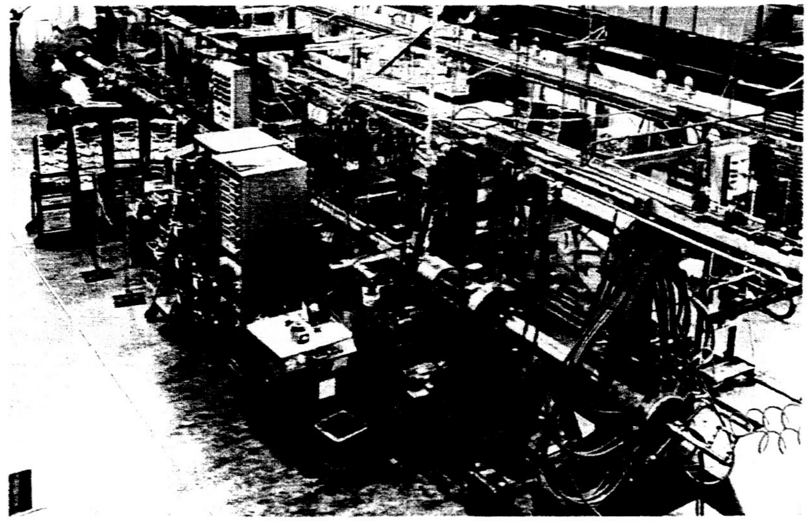
HYPERVELOCITY FREE-FLIGHT GUN DEVELOPMENT FACILITY

The HFF Gun Development Facility consists of: a light-gas gun; a sabot separation tank; a flight tube; and an impact chamber. This facility is used primarily for gun performance enhancement studies. In particular, operational parameters and hardware configurations are adjusted and/or modified in an effort to increase maximum velocity (and/or launch mass capabilities), while maintaining acceptable levels of gun barrel erosion. The facility operates in a manner similar to the HFFAF with the primary difference being a shorter flight path, 38ft (11.6m) as compared to 114ft (34.7m). The HFFGDF utilizes the same arsenal of light-gas guns to accelerate particles ranging in size from 1/8 inch (3.2mm) diameter to 1 inch (25.4mm) diameter to hypervelocity speeds. Particle velocity is measured using several, photomultiplier-tube-based time of arrival stations. Several of the outputs can be used to trigger flash x-ray channels.

HFF PERFORMANCE SUMMARY

Guns (barrel diameters):	0.28, 0.5, 1.0, and 1.5 cal (7.1, 12.7, 25.4, and 38.1mm) LGG 0.79, 1.74, and 2.40 cal (20, 44, and 61mm) PG
Model Velocity:	5,000 to 28,000 ft/s (1.5 to 8.5 km/s) LGG 1,500 to 6,500 ft/s (0.5 to 2.0 km/s) PG
Model Size:	0.125 to 1.5" (3.2 to 38mm) LGG 0.188 to 2.4" (4.8 to 61mm) PG
Model Mass:	5 to 200 gm (LGG) 10 to 400 gm (PG)
Maximum Reynolds Number:	2×10^6 /ft (6.5×10^6 /m)
Maximum Model Acceleration:	1.5×10^6 g
Test section pressure	0.03 to 760 torr (4 Pa to 0.1 MPa)
Test section temperature	270 K (ambient)
Test gas	Air, N2, CO2, arbitrary

ELECTIC ARC SHOCK TUNNEL (EAST)



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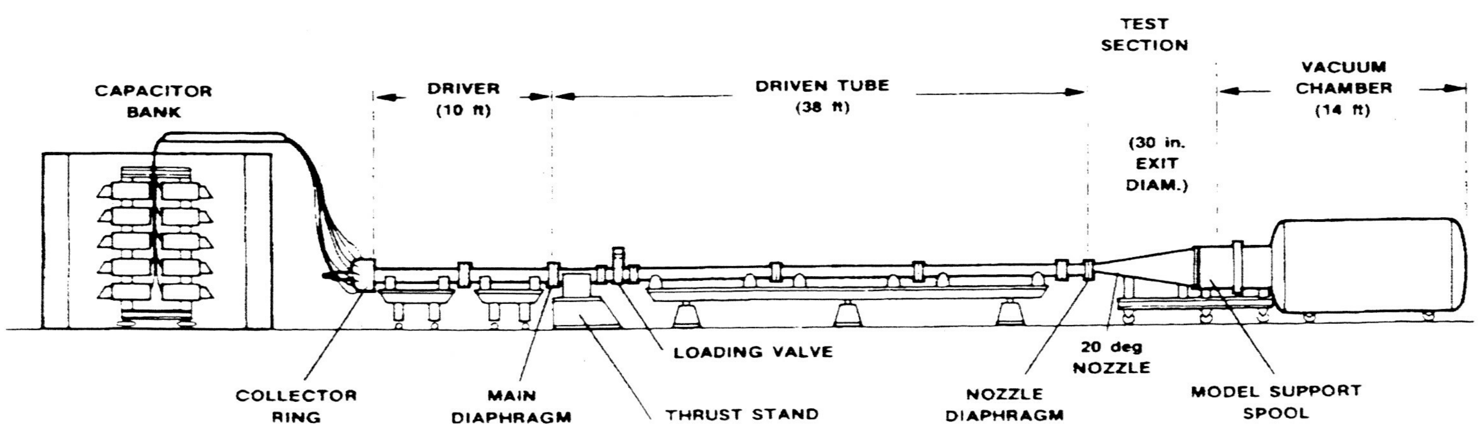
EAST PERFORMANCE SUMMARY

Shock Speed: 4-in Shock Tube	1 Torr hydrogen: 46 km/s
	1 Torr air: 20 km/s
Shock Speed: 24-in Shock Tube	1 Torr air: 5 km/s



THERMOPHYSICS FACILITIES BRANCH: SAFETY, ACCURACY, PROFESSIONALISM

The Ames Research Center Thermophysics Facilities Branch forges fruitful partnerships with organizations that need to completely, accurately and efficiently test concepts that use innovative materials and/or new design ideas.

We provide a variety of hyperthermal and hypervelocity environments from simulations of the heating of ascent and entry (Earth or other planetary atmospheres) to hypersonic flight regimes. Our goal: seamless integration of your material or flow characterization, model design, pretest planning, testing, and final report.

The Ames Thermophysics Facilities have a remarkable, comprehensive suite of highly adaptable world-class test hardware. When combined with our senior staff's extensive expertise and the wide range of test experiences, we offer a unique set of testing possibilities.

Full details can be found in the Test Planning Guide, available upon request by contacting:

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