# Impact & Lethality Testing

## Hypervelocity Gun Range Facilities

ARNOLD ENGINEERING DEVELOPMENT CENTER
An Air Force Materiel Command Test Center

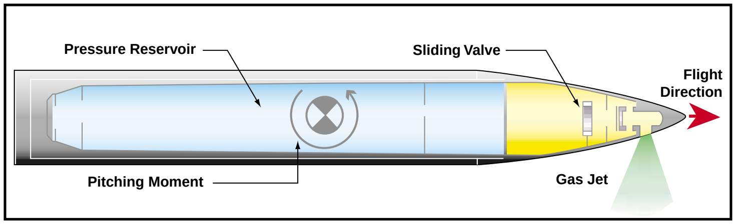
# Range G-Largest 2-Stage Light-Gas Gun

Since 1963 AEDC has conducted more than 7,000 hypervelocity ballistic range shots in its Hypervelocity Gun Range facility. The Range G launcher is a two-stage light-gas gun that launches projectiles into a 10-foot-diameter, 929-foot-long instrumented tank. The environment within the tank can be maintained at pressures from 0.2 torr to 1.7 atmospheres.

A major launcher upgrade in 1994 greatly increased the size of all of the launcher components, including the launch tube diameter, which was increased from 2.5 to 3.3 inch. The massive Range G launcher is now the largest routinely operated two-stage, light-gas gun system in the nation. The upgrade was designed to provide a launcher that generates an unequalled "soft launch" (minimized acceleration loading) that permits the launching of extremely high-fidelity missile simulations at hypervelocity speeds.

The 3.3-inch-diameter launch tube is typically used to support one-fourth scale testing (projectile and target one-fourth size of full-scale system). As missiles have grown more complex, the fidelity of the simulations has become more important. As a result, in 1995 AEDC embarked on a development effort to provide an eight-inch-diameter launcher that could test near-full-scale missile systems. Fortunately the primary driver components of the gun installed during the 1994 upgrade were capable of operating at much more severe conditions than normally experienced using the 3.3-inch-diameter barrel. The eight-inch barrel was fabricated from thick-walled pump tubes from an obsolete gun and then connected to the existing driver system. The eight-inch launcher is now operational and has successfully demonstrated as unprecedented capability to test very large high-fidelity missile simulations at hypervelocity speeds.

*An AEDC Machinist prepares to load a gasjet projectile into the breech of the four-inch-diameter launch tube.*

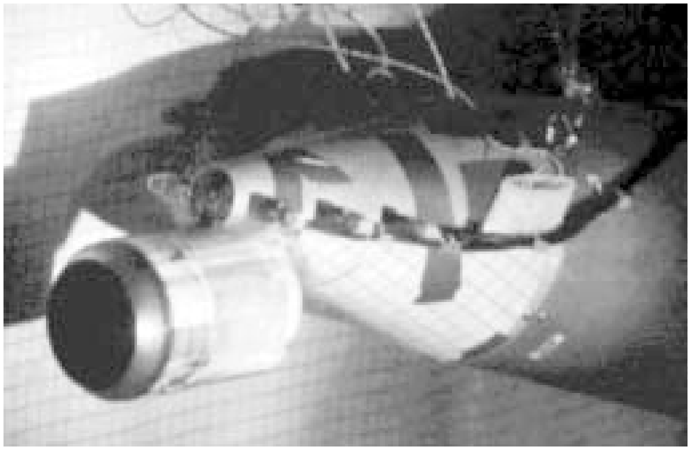



*Gasjet technique.*

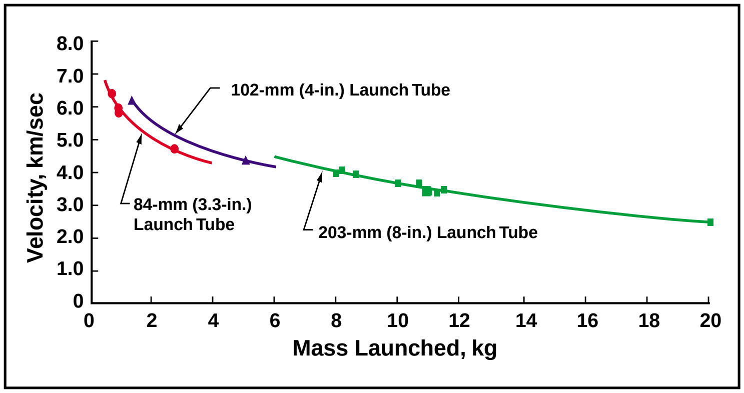
In 1997 the versatility of the Range G facility was enhanced even more with the addition of a four-inch-diameter gun barrel. The facility now has the capability of conducting tests with any of the three interchangeable barrels (3.3, 4.0 and 8.0-inch).

The primary challenge in designing projectiles for gun-range lethality testing is to develop a geometrically-scaled projectile that matches, with sufficient fidelity, the axial and radial mass distribution of the actual missile, yet possesses adequate integrity to withstand the acceleration loads experienced during gun launch. Recent upgrades using 2-D and 3-D finite element analysis software (FEAMOD) coupled with AUTOCAD, the AEDC launcher code, and the graphical user interface tools of PATRAN provide a seamless design path that permits AEDC engineers to analyze proposed projectile designs in a simulation of the dynamic environment of launch. The analysis simulates stress wave propagation through the projectile body, characterizing by color schemes, stress concentrations which exceed material yield. With marginal areas identified, design changes are incorporated which minimize the probability of projectile failure during launch.

The increasing demand for lethality test capabilities that comply with "Live Fire" engagement scenarios continue to be met by innovative techniques designed to control projectile flight dynamics. During fiscal year 1997, a cold-gas, jetting technique for pitch inducement was refined to a level of reliability that the technique has become a standard for lethality testing. Using up to 2,000 psi of argon gas, stored within the projectile body, a predictable thrust vector is developed as the gas escapes through an orifice located in the side of the projectile nosetip. Release of the gas is initiated at launch by an inertia activated valve system. Pitch amplitude at impact is controlled by variations in initial gas pressure and flight distance to target.



*Typical collision of missile simulation projectile against simulated enemy missile.*




*Demonstrated capabilities of the three interchangeable launch tubes of the Range G launcher.*

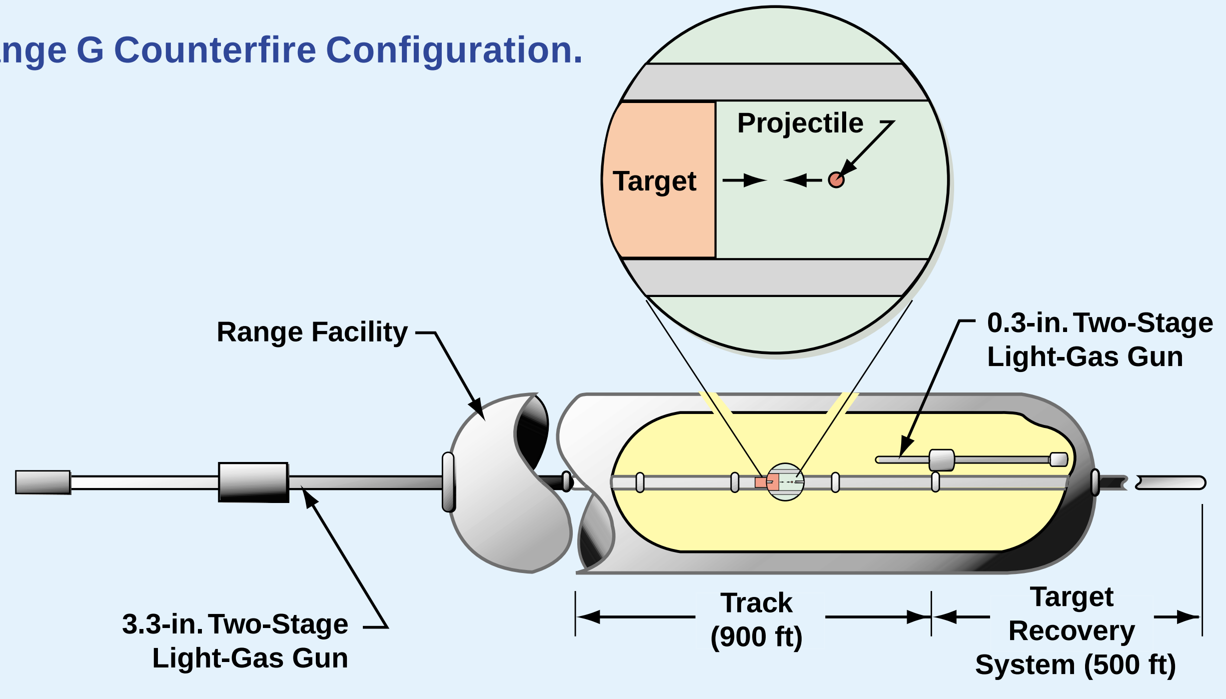
*Jetting action of gasjet projectile is shown as the projectile exits the launcher muzzle.*

*An AEDC engineer poses with a projectile which was launched in the AEDC Range G eight-inch launcher.*


*Multi-plate target and post-test recovered target following counterfire impact at 12.2 km/sec.*


*Pretest "semi-infinite" aluminum target and post-test recovered target following counterfire impact at 12.2 km/sec.*

**Range G Counterfire Configuration.**



# Hypervelocity (7-15 km/sec) Impact Test Capability

High-speed impact testing has been limited to speeds less than seven km/sec by performance limitations inherent in the two-stage light-gas guns which are generally used to accelerate impact models. Since space debris encounters and extoamoshperic kinetic-energy-weapons intercepts occur at much higher velocities (approaching 17 km/sec), considerable risk has been associated with extrapolating existing impact-test lower-speed results during design of various space systems. For several years, AEDC has been actively engaged in developing the counterfire technique to increase the velocity at which impact studies can be conducted. In the counterfire technique, a target model is launched at up to seven km/sec from the 3.3-inch-diameter range launcher. The target flies down the Range G track to an "impact zone" near the end of the range test tank. At the appropriate time as determined by a fully automated, computer-based sequencing system, a second 0.33-inch-diameter launcher, located at the end of the range test tank and aimed in a direction opposing the Range G launcher is fired such that its small projectile impacts the target model in the "impact zone." Since the small, counterfired projectile is traveling at speeds of up to 8.5 km/sec, the resultant impact occurs at relative velocities exceeding 15 km/sec. Following the impact event, the target model proceeds down the track into the recovery system at the end of the track, and the target model is recovered intact for post-test analysis and evaluation.

In fiscal year 1994, four counterfire impacts were generated with two of the target models being successfully recovered.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