Laser Counter Rocket, Artillery, and Mortar (C-RAM) Efforts

By Michael Libeau

Mortars and rockets are common weapons confronting U.S. troops abroad. Insurgents fire the inexpensive projectiles into populated areas, intending to kill or injure service members and to inflict physical damage. While kinetic solutions like guns and missile interceptors are used to counter rockets and mortars, laser counter rocket, artillery, and mortar (C-RAM) systems present a promising solution to counter these challenging threats in the near future.

Scientists and engineers at the Naval Surface Warfare Center, Dahlgren Division (NSWCDD) have been researching, developing, testing, and evaluating laser C-RAM systems through collaboration, modeling and simulation, and experimentation. The Joint Technology Office (JTO) and the Directed Energy and Electric Weapons Program Office (PMS 405) sponsored the first year of these initiatives in 2007. Consecutive and current work has been sponsored by the Office of Naval Research (ONR) Expeditionary Maneuver Warfare and Combating Terrorism S&T Department.

Background

In preparation for the development of a laser C-RAM system, an understanding of the vulnerability of rockets and mortars to laser energy was crucial. Engineers from NSWCDD and the U.S. Army Space and Missile Defense Command (SMDC) collaborated on laser C-RAM efforts. Engineers analyzed the RAM threat and examined a variety of targets, accessing RAM vulnerabilities to laser energy by utilizing theoretical, numerical, and experimental work. They then developed theoretical models that captured the physics of the laser-induced failures of targets containing high explosives (HE). Additionally, NSWCDD engineers enhanced lethality simulations using a tool called the Effectiveness Toolbox to model engagements of RAM targets with laser energy. Figure 1 shows a screen capture from the Effectiveness Toolbox.

The resulting simulations included results from a laser atmospheric propagation model and a thermal model to determine the effect of the laser energy on the target. The simulations also incorporated target trajectories necessary for modeling the changing laser conditions on the target resulting from the engagement of a ballistic target. Subsequent to modeling these effects, live testing was performed. Figure 2 shows the lasing and destruction of a RAM target during live testing.

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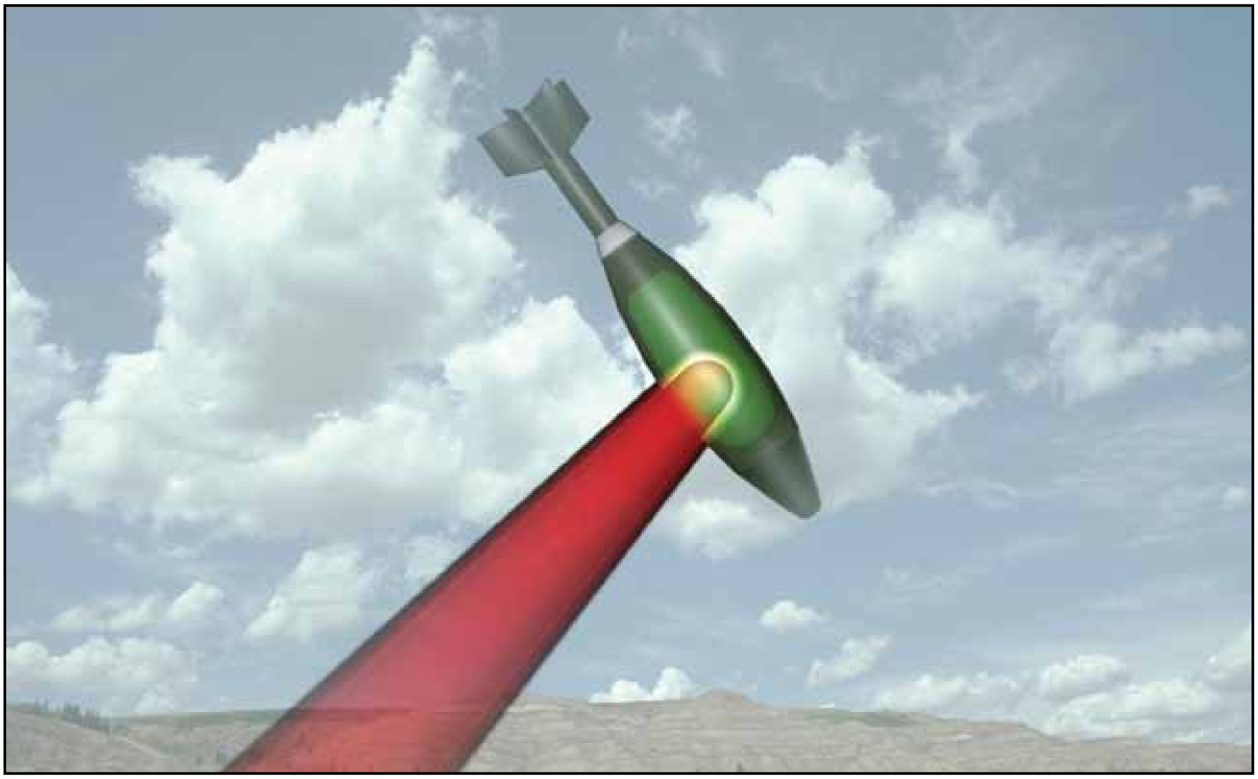

Figure 1. Screen Capture from the Effectiveness Toolbox Showing the Laser Engagement of a Mortar Target

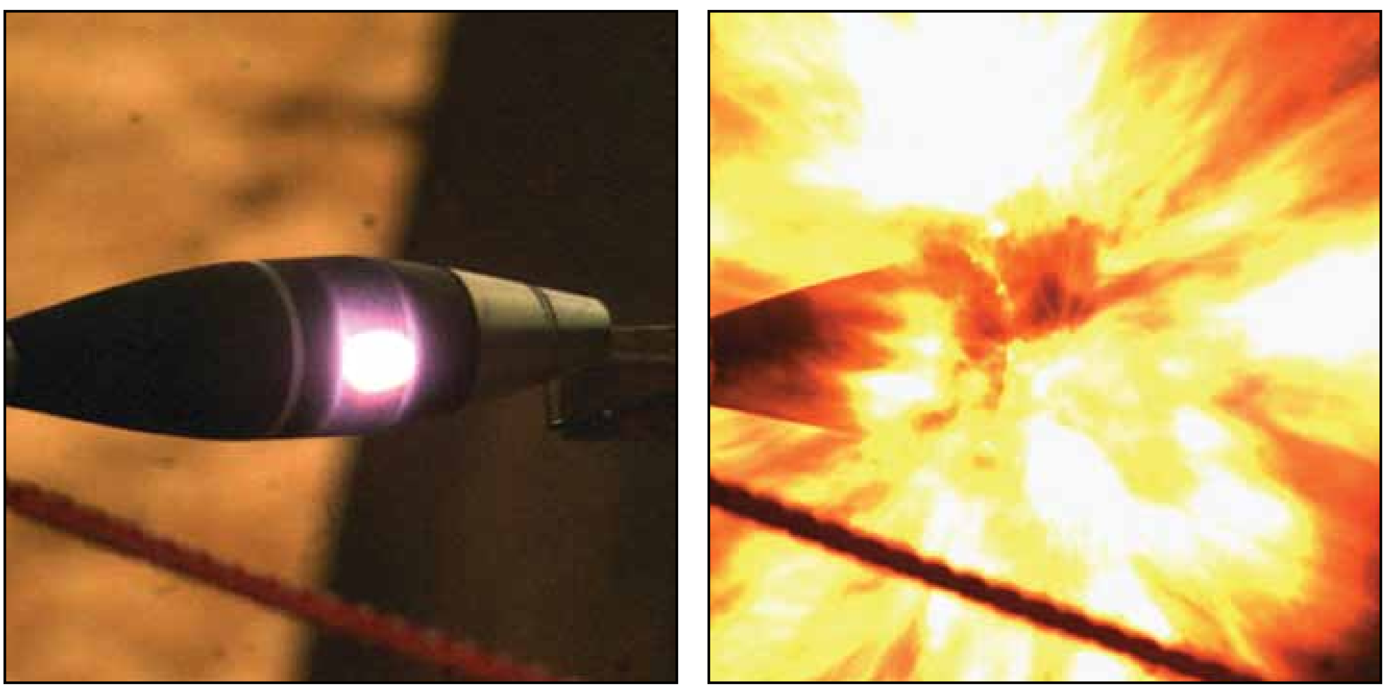

Figure 2. Explosive Target is Destroyed with NSWCDD's Fiber Lasers

NSWCDD engineers conducted two large experimental tests to determine the vulnerability of HE targets to laser energy using NSWCDD's High-Energy Fiber lasers. The first test was conducted jointly with SMDC. During these two tests, over 40 RAM targets were destroyed under different laser conditions, producing significant information on laser lethality. Researchers measured the failure times of multiple targets for different laser powers, spot sizes, incidence angles, and aimpoints. The experimental data yielded by the tests increased engineers' understanding of the vulnerability of targets containing energetic materials. This data was then used to benchmark predictive models.

Future tests are planned with additional HE targets to further the knowledge of RAM vulnerability. These tests are controlled and conducted carefully to ensure that good data is obtained. Accurate measurements of laser power on the target and the resulting target failure times must be made during the tests. To that end, NSWCDD engineers leverage Division-wide expertise in lasers and optics with its long history of explosives testing to achieve meaningful test results. NSWCDD personnel have been instrumental in improving techniques to measure the spatial profile of laser power on a target. The spatial distribution of laser power on a target is critical to understanding the target's failure. Figure 3 shows a laser beam's spatial power distribution measured during a test.

Ongoing Laser C-RAM Initiatives

Recent advances in fiber lasers have increased the power outputs of these rugged, solid-state devices. Both government and contractor efforts are examining the application of commercial off-the-shelf (COTS) lasers and other electric lasers for application into advanced weapon systems. The Navy's Laser Weapon System (LaWS) Program, for example, is examining a laser system built around efficient fiber lasers. This is significant because a high-energy fiber laser system offers two critical advantages over gun and missile interceptor C-RAM systems. First, the laser has a great depth of magazine since it requires only electricity for operation. Consequently, unlike a gun system, which has a limited supply of ammunition, a laser system is limited only by its supply of electrical energy. Second, a laser system offers a cost per kill that is significantly lower than alternative systems because only electricity is being expended instead of gun ammunition or a costly missile interceptor. This low cost per kill also better matches the low cost of the RAM target being engaged.

High-Energy Fiber Laser C-RAM systems will provide significant advantages in defeating the RAM threat while augmenting existing C-RAM solutions. More importantly, laser C-RAM systems will help protect members of the armed forces from the inexpensive, yet often deadly threats posed by rockets and mortars.

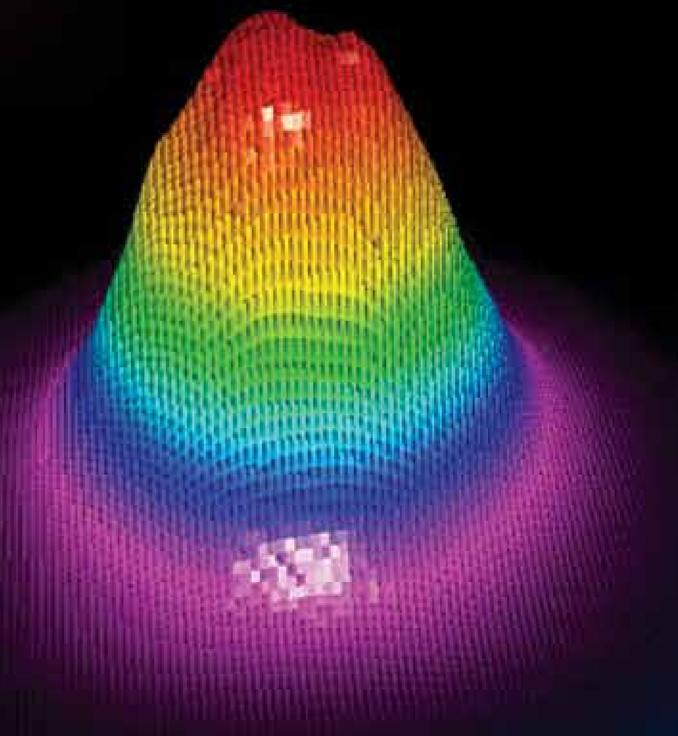

Figure 3. Laser Power Spatial Variation from a C-RAM Test