TWGSS/PGS:

Combat Vehicle Gunnery Training Takes a Great Leap Forward

by Brigadier General Philip L. Bolté, U.S. Army, Retired

"Gunner! Sabot! Tank!"

"Identified!" I responded, somewhat rustily, to the tank commander's fire command.

"Up!" shouted the loader.

"Fire," from the TC.

I had indexed the ammunition, lased to the target, and laid the crosshairs, almost like old times.

"On the way!" I announced as I fired. There was a blast and my sight was obscured. The obscuration caused me to miss the tracer, but I saw the impact of the long rod penetrator on the target tank.

It all seemed real, but in fact I was in a maneuver area at Fort Hood, attending a demonstration of the TWGSS/PGS, acronyms for the Tank Weapon Gunnery Simulation System and Precision Gunnery System, designed for the Abrams tank and Bradley Fighting Vehicle, respectively.

Watching the demonstration, my mind went back over the years I had been associated with tanks and gunnery training. To "date stamp" me, I remembered the Cedar Run Range combat course at Fort Knox, where we student officer tank commanders had to respond to a balloon simulating an air attack by climbing out of the M4A3E8 Sherman turret and standing on the back deck to fire the .50 caliber machine gun. I remembered commanding a tank training company at Fort Knox later, when M48 tank crew trainees fired subcaliber rounds at small targets a few yards away to get the feel of laying the tank gun, making sure the final lay was always in the same direction to eliminate the effects of backlash. I remembered that a smart M60 gunner knew he could increase his chances of a hit with an inert HEP practice round by using the telescope, which allowed for projectile drift, rather than using the computer, which did not. I remembered the laser gunnery range used in the 1st Armor Training Brigade that allowed gunners to track moving targets and fire, but not much else. And I thought of the M1 tank Conduct of Fire Trainer that places great stress on the tank commander and gunner as they engage computer-generated targets in rapid succession.

Each generation of training devices was a step in the right direction, and each capitalized on new technologies, but none by itself met the standards of realism that the armor community wanted. Institutional trainers using computer-generated displays are effective, but the environment is an artificial one. Gunnery devices attached to a tank have been useful and provide a degree of realism to a crew in that soldiers use their own tank, but firing procedures are not complete.

Subcaliber devices have benefits, but they require at least small firing ranges and leave out many of the required crew duties. Also, each system that provides a partial replication of tank gunnery procedures has always included drawbacks that result in some degree of negative training.

At last, it seemed as if all the crew duties were accommodated, with the exception of the loader actually loading a round of ammunition. Dummy rounds can be loaded for additional loader training. The simulator cable, in fact, was routed outside the barrel to keep the breech free of obstructions.

The realism of the TWGSS was awesome. Here was a crew, using its own tank under field conditions, and any error in executing firing duties was reflected in a miss. Targets were at real ranges. There was blast and obscuration. Not only was I impressed, but, more importantly, the young tank crewmen, brought up on video games and computer technology, were enthusiastic about what they were experiencing.

My experience with the Bradley and the PGS was similar. Here I fired both the 25mm automatic cannon and the TOW missile. Again, the realism was almost unbelievable. I *saw* the TOW missile heading for the target and *saw* the hit.

The Requirement

Technology has opened new possibilities in the past two decades to greatly improved training devices for tank crews. Laser substitutes for actual rounds, video disk training devices, and computers have all been incorporated in devices to train tank gunnery. At first, each device filled a particular void, but as technology broadened the horizons of those responsible for developing requirements for gunnery trainers, and tank crew training systems themselves, the potential to duplicate reality began to be realized. Generally, in tank crew training, two paths were followed, dictated by the limits of technology, cost, and imagination. Separate devices were developed to train gunnery and to conduct tactical training.

MILES was developed and fielded to bring greater realism to tactical training. Using laser projectors and detectors, MILES provides a means of inflicting real-time casualties on opposing forces. The result has been a major step in providing realism in tactical training.

Various gunnery training devices were developed for both the Abrams tank and Bradley Fighting Vehicle, culminating in the 1980s with a Conduct of Fire Trainer (COFT) for each weapon system. The COFTs provide

At left, a crew installs the TWGSS system to an M1A2 at Fort Hood. It takes 20 minutes. Above, a crew reviews the after-action record that is stored on a laptop computer.

Abrams and Bradley crews with highly effective training. Through the use of computers and instructor monitoring, crews can be faced with a wide variety of scenarios and challenges. Targets can be stationary or moving over varying terrain, the firing tank can be moving or stationary, weather conditions can be changed, fire control systems can be degraded, and the pace of engagements can be changed. The systems offer a true final exam before a crew proceeds to live firing. But the environment, although realistic in many ways, is artificial. The crew is in a simulator with computer-generated images. The crewmen are not in their tank, and they know it.

As early as the 1970s, while the Abrams tank was under development, the U.S. Army armor community was seeking a gunnery training device that could be applied to the tank itself. What the Army wanted was an eye-safe laser simulator, a strap-on device, that could be used for precision and degraded mode gunnery training on unit vehicles in all terrain and weather conditions.

In a search of industry ideas, the Army program manager for training devices (PM TRADE) contacted the Swedish company Saab for a report of its newly developed laser simulator BT41. The resulting "Hit/Kill Study" compared various methods for providing precision gunnery training to crews to sustain their skill levels between live fire opportunities.

In 1982, two Saab simulators were acquired by the Army for engineering tests at Fort Knox. These were later used in an Armor Center Concept Evaluation Program (CEP) in conjunction with the newly developed TWGSS concept. In 1984, the Infantry Center at Fort Benning acquired additional BT41 systems for a CEP associated with the PGS requirement for the Bradley Fighting Vehicle. Here the requirement was to simulate both gun and missile systems in training crews. With system requirements further defined, in 1986 an additional CEP was conducted at Fort Hood using these systems, as well as other simulators, including MILES. The main purpose was to evaluate the transference of gunnery skills from simulation to live fire. As the U.S. Army continued its progress toward the eventual acquisition of a solution to the TWGSS/PGS challenge, Saab was meeting with success with foreign armies. In 1988, the German Army selected Saab systems to meet its similar requirement. In September 1992, the U.S. Army selected the new generation Saab simulator, BT46, to meet its TWGSS/PGS requirement. British selection of the same system followed two months later. Thus, the major NATO armies were following a similar path for combat vehicle gunnery training.

A procurement contract was subsequently awarded to Saab. The Army approved an acquisition plan to procure 2,000 systems for the Abrams and Bradley by the year 2001, with the first unit equipped in 1995. The systems are eventually to be fielded at 25 locations. In addition, procurement and fielding is now planned for Marine Corps Abrams tanks. To date, the program is on schedule and within programmed cost, and the equipment exceeds required performance standards.

When the U.S. Army's 1st Armored Division deployed to Bosnia, it quickly became apparent that Abrams and Bradley crews would be unable to maintain weapon system proficiency in the environment there. The Army diverted delivery of more than 60 TWGSS/PGS systems to the deployed force, which should solve the problem.

It is significant to note that TWGSS/PGS also meets the U.S. Army's Tactical Engagement Simulator (TES) requirement by combining a precision gunnery and maneuver capability with provisions for extensive after-action review.

System Description

TWGSS/PGS is an eye-safe laser simulator strap-on device that provides precision and degraded mode gunnery training, using unit vehicles, in all terrain and under all weather conditions. The system requires the vehicle crew to perform all gunnery tasks under field conditions, except actual ammunition loading, and provides accurate firing results. These are available immediately and for after-action review (AAR). Similar in concept, the TWGSS and PGS have common or generally similar components. In the following paragraphs, the TWGSS is discussed in detail, with major differences of the PGS discussed later.

TWGSS consists of three subsystems: the firing system, the target system, and the training data retrieval system.

The firing system, mounted on the tank, includes four main elements: the transceiver unit; the tracer, burst, obscuration simulator; the vehicle interface assembly; and the remote system interface. Other components include the control panel, loader's panel, and turret position sensor. The included target system, comprised of target processor, four retro reflectors, and four hull deflectors, allows the tank to participate in two-sided engagements, as well as independently assessing engagement results.

The transceiver unit, mounted in the main gun muzzle, uses conditionally eye-safe laser transmitters. A transmitter simulates projectiles in real time

with the correct ballistics and dynamics of real ammunition, based on actual firing tables, thereby allowing precision gunnery training. The tracer, burst, and obscuration system simulates in both the gunner's primary sight and auxiliary sight the effects of rounds fired with the main gun or coaxial machine gun. Tracers are simulated with realistic burn times and zooming effects. Bursts on the target or on the ground are simulated, with the size determined by the type of ammunition and range. Obscuration is shown for main gun ammunition and can be programmed by the instructor from 0 to 5 seconds.

The vehicle interface assembly is the link between TWGSS and the tank. It receives and distributes power, monitors and injects signals to and from the fire control system, monitors weapon status for use in the after-action review, registers the turret/hull relationship, and injects sound into the intercommunication system.

The remote system interface uses satellite data to determine the position of the tank, updating the position every 50 meters. The information is stored on the memory card for use in the after-action review. The unit is made up of two components, the antenna that receives satellite signals and the assembly that determines vehicle position.

The entire TWGSS assembly can be mounted on a tank in 20 minutes. The target system, which can be mounted independently on targets, includes four retro detector units, four hull defilade detector units, and the target computer unit. It determines whether a projectile hits or misses the target. If the target is hit, the system simulates the effect the projectile would have on the vehicle. The effect is indicated with strobe lights and sound cues in the intercommunication system. Each round is individually evaluated, with no consideration of cumulative effects. If there is a hit, based on the received coordinates and a random generator incorporating actual vulnerability to the round fired, the unit determines whether it is a no-kill hit or a weapon, mobility, or catastrophic kill. It then triggers the appropriate visible and sound signals.

The training data retrieval system includes equipment necessary to perform the after-action review of TWGSS training. It is used to evaluate the effectiveness of tank weapon firing engagements, whether in a tank weapon gunnery exercise or in a tactical training environment. The system consists of a laptop computer unit and memory cards.

Here, the TWGSS system is mounted on a Marine M1A1 at Camp Lejeune, N.C. The Marines use the system for both tactical and gunnery training.

Each TWGSS tank has a memory card installed at the beginning of an exercise. Using the TWGSS control panel, the crew or instructor downloads information such as ballistics and target templates, as well as ammunition allowances, obscuration times, etc. The memory card then stores the data on training events for use in the after-action review. Three days of data can be recorded on one card.

The laptop computer unit provides the centerpiece of the after-action review. Each memory card is loaded into the computer, and graphics for gunnery or map views can be displayed. Gunnery results are also available in the map view so that gunnery and maneuver training results can be integrated. For firing engagements, crew member names and vehicle type are displayed, along with detailed data on time, motion, engagement ranges, hit points, and damage assessment.

PGS is essentially the same system as TWGSS. It is designed for compatibility with both the 25mm chain gun and the TOW missile system. For the 25mm gun, wide misses can be measured for area fire evaluations. TOW missile engagements can be simulated out to the 3,750 meter maximum range of the missile system.

As noted earlier, a number of gunnery training devices have been introduced in the last two decades, each offering advantages, generally related to realism, over other devices. Continued proliferation of such devices, however, is not an acceptable solution to the training challenge. Thus, it is important to examine how TWGSS/PGS fits into the overall training environment.

Most important are the relationships of the Abrams and Bradley conduct of fire trainers (COFT) and MILES with TWGSS/PGS. COFT and MILES are both widely fielded and have proven to be effective training systems.

The Abrams and Bradley COFTs, like TWGSS and PGS, are similar in nature and provide excellent gunnery training. Crews can be faced with a wide variety of scenarios and firing engagement challenges over a short period of time, making the use of COFTs efficient. They have been used since introduction to prepare crews for live fire from their vehicles. Nevertheless, training experts have recognized the missing bridge between the COFT full simulation and live fire with full-caliber ammunition. Fielded subcaliber devices, while contributing to training, lack realism and include at least a degree of negative training.

While live firing of full-caliber ammunition is critical to full-up training, the cost of ammunition, the availability of ranges, and safety restrictions are, among other factors as well, severe limitations. TWGSS/PGS can be especially useful for night firing training where live fire at night may be restricted because of the proximity of civilian communities. At Grafenwöhr, the U.S. Army's major training area in Germany, night firing has been curtailed, but TWGSS/PGS can provide

the means to conduct night training, including gunnery, without disturbing the local population.

TWGSS/PGS provides the missing bridge between COFT training and live fire. The system is flexible enough to offer a range of simulated gunnery training that provides a smooth transition to live firing. Realism can be achieved, with the operational tempo of live fire, without the need to travel to distant ranges and fire service ammunition.

TWGSS/PGS can perform gunnery in four progressive modes: tracking training, scaled gunnery, panel gunnery, and combat gunnery.

Tracking training teaches crews to lay on targets and track moving targets using the actual vehicle fire control system.

In the scaled gunnery mode, targets can be placed at close-in ranges, but the system can be set so that longer ranges are simulated. Thus, using one-half scale, a target placed at 500 meters will appear to the crew and the fire control system to be at 1,000 meters. This mode allows the use of areas restricted in size, such as many local training areas.

The panel gunnery mode allows crews to prepare realistically for situations similar to those faced on typical live fire ranges. TWGSS/PGS provides an accurate assessment of the quality of performance of the crew.

Because of safety restrictions associated with live fire, in the combat mode the crew is faced with situations more real than those faced on live fire ranges. Gunnery tasks must be accomplished, with the exception of actual ammunition loading, just as they must be in combat. Targets react as they do in combat. It is this mode, of course, that can be used in two-sided exercises, with the firing vehicle vulnerable to fire from opposing target vehicles.

MILES has provided the Army with the ability to train realistically in two-sided maneuvers. How does the TWGSS/PGS fit with MILES? This is an important question, for much of the cost of TWGSS/PGS is associated with qualities that are similar to MILES.

Fortunately, the answer to the question is that TWGSS/PGS is compatible with MILES. Thus Abrams tanks equipped with TWGSS and Bradley Fighting Vehicles equipped with PGS are able to participate in maneuvers with, for example, dismounted troops or HMMWVs using MILES components. The TWGSS/PGS transceiver transmits MILES firing information after a completed TWGSS/PGS simulation in order for the laser target interface device (LTID) and MILES target systems to function. MILES information is transmitted at the impact point of the simulated round. TWGSS/PGS equipped vehicles use the retro reflector mounted strobe lights to simulate hits instead of the yellow lights of MILES.

What this all means is that Abrams and Bradley crews can participate in MILES-based exercises using TWGSS/PGS instead of add-on MILES components. It means that Abrams and Bradley crews, in addition to gaining the tactical training of a MILES-based exercise, can practice their gunnery skills at the same time. Thus, there is much less difference between training and the reality of combat.

TWGSS/PGS has been adopted for the Abrams and Bradley, but it is equally applicable to other combat vehicles, such as the Marine Corps light armored vehicle (LAV).

On the subject of compatibility, not only is TWGSS/PGS compatible with MILES, but there is international compatibility. As mentioned earlier, the British Army and the German Army have both adopted Saab systems, as has the Swedish Army, and Saudi Arabia is procuring TWGSS/PGS through the U.S. FMS program. Other countries can be expected to follow. These systems, modified to meet certain national requirements, are all similar in operation and are compatible. International exercises will be greatly enhanced by this situation.

The potential for growth of any complex training system is important. The U.S. Army cannot afford to field a system that may become outdated in several years. At the aforementioned demonstration at Fort Hood, Saab included the application of its Gunnery and Maneuver Exercise (GAMER) system. GAMER is an add-on system that integrates the capabilities of existing systems such as TWGSS/PGS and MILES to provide realistic two-sided combat training at the small unit level in local training areas. A portable system that can be carried in a HMMWV and set up in an hour, GAMER's add-on components to existing systems use commercial components, including a laptop computer and mobile data cellular hardware. GAMER allows the integration of simulated artillery, mine fields, and obstacles into the play. It maximizes the capability of the small unit leader to plan, conduct, and review the training exercise. In effect, in about an hour, a local training area can be converted into a miniature National Training Center.

Summary

TWGSS/PGS is bringing to the U.S. Army a major improvement in its ability to effectively train combat vehicle crews in gunnery. Moreover, it provides training establishments and combat units the ability to integrate gunnery and maneuver training. The benefits include training time and cost savings, as well as greater realism in training. TWGSS/PGS is as close to live fire training as possible, without incurring the disadvantages and costs associated with such training.

Compatibility with the existing MILES equipment and interoperability with other nations' systems are benefits that enhance the attractiveness of TWGSS/PGS. It is a modern training system that offers current capability and growth potential for the U.S. Army of the twenty-first century.

Brigadier General Philip L. Bolté was commissioned in Cavalry from the U.S. Military Academy in 1950. He served in a number of cavalry units, including 3rd and 14th Armored Cavalry Regiments and the 11th Airborne Reconnaissance Co., and commanded the 1st Squadron, 1st Cav in Vietnam. He is a graduate of the Armor School, Canadian Army Staff College, and the Army War College. He retired in 1980 from his final assignment as program manager, Fighting Vehicle Systems.