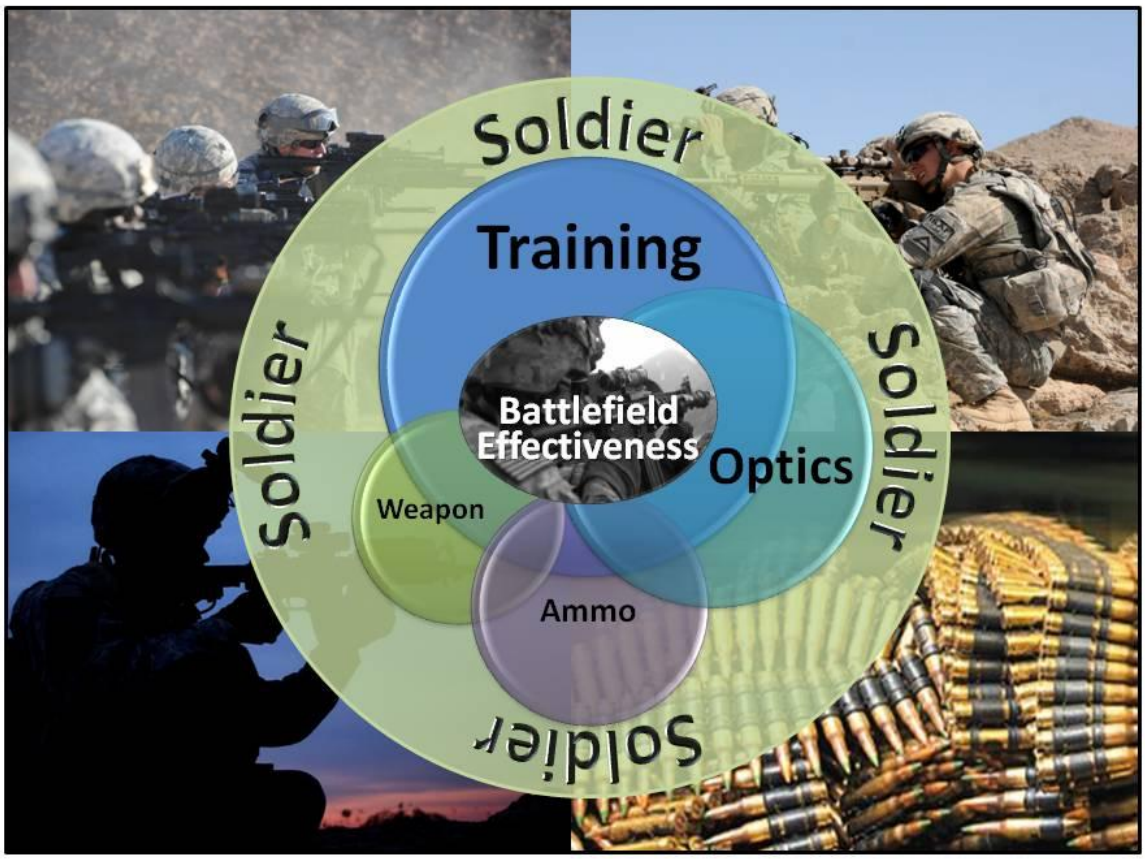
DUAL PATH STRATEGY SERIES:
PART III – SOLDIER BATTLEFIELD EFFECTIVENESS



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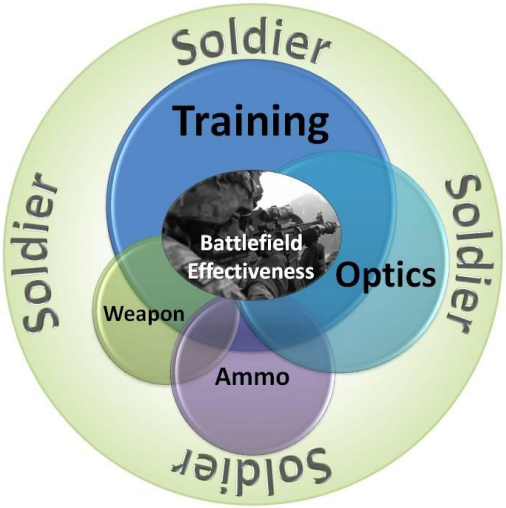
Editor's note: This feature is the third installment in PEO Soldier's "Dual Path" series. The Dual Path is PEO Soldier's strategy to provide Soldiers with a service rifle that is even more effective, accurate and reliable than the current family of M16/M4 individual weapons. The strategy pursues a rigorous M4 improvement program while simultaneously challenging industry in a carbine competition to deliver an entirely new weapon system that can outperform the combat-proven M4. The articles are intended to educate and inform readers regarding the significant considerations relevant to the search for a new service rifle.

Soldier Battlefield Effectiveness

The Army uses a simple framework to outline the complex discussion of Soldier effectiveness on the battlefield:

Soldier + Weapon + Ammo + Optic + Training = Battlefield Effectiveness

This framework reflects that no one thing accounts for how effective a Soldier is in engaging the enemy. Unfortunately, many discussions on the topic narrowly focus on the weapon platform and its corresponding ammunition. While these elements are important, they still represent just pieces to the overall puzzle. According to Col. Doug Tamilio, Project Manager Soldier Weapons, Picatinny Arsenal, N.J., the components of battlefield effectiveness in order of increasing importance are: weapon, ammunition, optics, training, and the Soldier.



"While the whole is greater than the sum of its parts, every component here plays an invaluable role," said Tamilio. "If you pulled any one aspect out of the equation the effectiveness of the Soldier is greatly reduced, which is why the Army takes a holistic approach when it comes to Soldier lethality."

Clearly, the Soldier is key to the story. What is his mindset? Is his morale high or low? Is he tired, cold, wet and hungry, or is he fired up? Does he feel like an accepted member of a tight unit or is he isolated? Most importantly, is he confident? The variables are nearly endless and they all contribute in one way or another to how a Soldier will perform on the battlefield. To contain the scope of this paper, therefore, we will set aside a discussion of the Soldier to focus instead on weapon, ammunition, optics, and training, in that order. This intent of this paper is to give the reader a greater understanding of the complex nature of a Soldier's battlefield effectiveness. By providing background on each of the topics referenced above, we feel that the layperson should come away with a new understanding and greater appreciation of just how complex the matter truly is, even before taking into account the human factor.

Weapons

The individual weapon is the primary system utilized by the Infantryman for carrying out his mission to destroy the enemy. The effectiveness and performance of this one system is integral to success, which is often the difference between life or death. To be effective, weapons must be reliable, accurate, ergonomic, and able to leverage all the enablers that can impact performance.

M4 Carbine

In post combat surveys conducted by the Maneuver Center of Excellence at Fort Benning, more than 90 percent of Soldiers interviewed rated the M4 as an effective weapon system, a mark that reflects well upon the performance of the system overall in light of the many demands placed upon it.

Reliability

For the Soldier, reliability is simply, "when I pull the trigger, it fires." A rifle's range and lethality matter little if the rifle will not fire when a soldier needs it to. For the M4's part, engineers have worked hard to ensure the system meets the Soldier's standard. Through a continuous improvement program, the Army has incorporated more than 90 performance-related design improvements to the M4 since it was first fielded. Any future carbine must be able to at least match or exceed the M4's reliability performance on this point. However, with any small arms weapon system, stoppages are bound to occur, which is why Soldiers are trained to work through these situations. Working through stoppages is a basic Soldier skill that is developed in initial training and mastered through follow-on training and operational experience.

For the Army's upcoming carbine competition, the weapon reliability testing will be extensive. Hundreds of thousands of rounds will be fired in a multitude of scenarios with both laboratory precision and "Soldier in the Loop" user evaluations. Reliability testing also includes a wide range of extreme environments from -60 degrees Fahrenheit to 160 degrees, solar radiation, drop tests, shock tests, vibration, fouling, dust, mud, ice, water, submersion, salt fog, humidity, sustained rate of fire, lubrication, toxic fumes, chemicals, and even fungus growth tests and more. The reason for such rigorous testing is to ensure the Army has a weapon that can perform reliably in all environments.

Accuracy and Dispersion

Many factors contribute to the accuracy of an engagement with no one factor affecting accuracy more than the human element (*e.g.,* Soldier and training). However, there are a multitude of factors that affect accuracy beyond shooter performance to include: sight adjustment, weapon condition, barrel temperature, ammunition, and environmental factors such as heat and wind. The weapon itself controls the repeatable delivery of a round, which is referred to as dispersion.

One measure of dispersion is "Minute of Angle" (MOA), which is the measurement (in fractions of degrees) of a ballistic round's deviation from its initial heading. Technically, one MOA is equal to about 1.05 inches at 100 yards (~91.4 meters) of distance. To simplify, let's work with 1 inch at 100 meters. Since MOA is a linear function, at three hundred meters, the spread would be equivalent to about three inches. So for a sub 1-MOA system like the M110 sniper rifle firing at a target 600 meters away, the rounds would be expected to strike within a circle with a six-inch diameter if no other factors affected the dispersion of the weapon. Other weapon systems are not necessarily as precise. For example, the M107 .50 Caliber Long Range Sniper Rifle is a 2.5 MOA system. At 1,000 meters, the rounds would fall

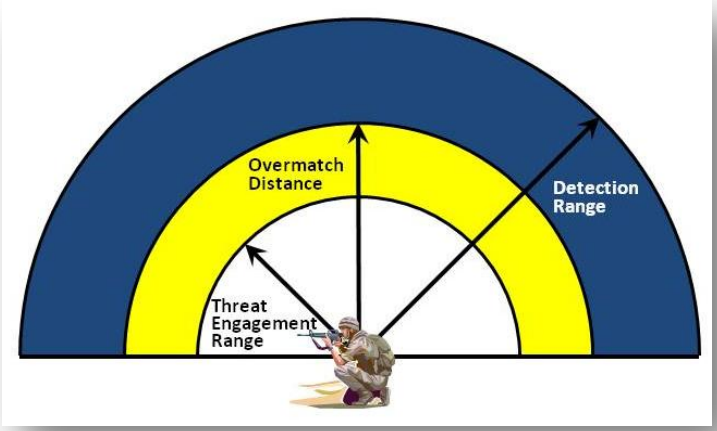
within a 25-inch circle, which is why the system is intended for targeting large equipment at greater ranges rather than personnel.

A weapon's dispersion is dependent on the weapon's design. Generous internal tolerances may result in a weapon performing under extreme environmental conditions, but at the sacrifice of accuracy. Tight tolerances may deliver greater accuracy, but reduced performance under extreme conditions.

Range

The maximum effective range of a weapon system is also a key element as it represents the potential for how far out a Soldier can effectively engage the enemy. This is also critical as it affects a Soldier's ability to leverage an overmatch advantage. Doctrinally, this means that a Soldier will look to engage the enemy at a range that is greater than the range at which they can be engaged by enemy fire (typically 20 percent). According to FM 3-22.9, Rifle Marksmanship M16/M4 Series, there are three ranges of concern. First, there is the detection range, which must be well beyond the effective range of the weapon system. This provides the Soldier time to prepare to engage the enemy at the farthest possible ranges. The next band is the range overmatch distance, whereby friendly Soldiers can engage the enemy, but the enemy cannot engage the Soldiers. The final band is the threat engagement range where enemy personnel can target friendly forces.

Optimally, friendly forces will engage as the enemy enters the range overmatch area. This advantage is short lived however, since a quickly approaching enemy can move through this area in seconds. For example, according to *The Encyclopedia of Land Warfare in the 20th Century,* the effective range for AK-47 fired on semi automatic is 400 meters. The effective range for an M4 Carbine is 500 meters. The 100 meter difference provides a decisive range overmatch capability so long as Soldiers are proficient at hitting targets at the 400-500 meter range, which is why extensive marksmanship training is so critical.



Ranges of Concern

The range of a weapon system relies heavily on the ammunition the weapon fires and the length of the barrel. Systems that utilize 5.56mm ammunition typically cite ranges of 500 – 550 meters for point targets while U.S. weapon systems that fire 7.62x51mm typically cite ranges closer to 800 meters for point targets. The spiral grooves inside a rifled barrel impart spin to the round. The spin stabilizes the round which provides accuracy, though it doesn't necessarily increase the average range of the system. All things being equal, longer barrels may allow more of the propellant's energy to be transferred to the projectile, resulting in greater range. However, depending on the velocity loss from shortening a barrel it may or may not have an impact on the range of the weapon system. A 20 inch rifle does not have a longer effective range than a 16 inch barrel simply because it is longer. Modern cartridges have and are being optimized for shorter barrels. Faster powders can reach a more complete burn in shorter barrels. Regardless of the range potential for certain weapon platforms, the human factor must be considered. Studies have shown that Soldiers can only consistently hit a human-size target more than 300 meters

away 50 percent of the time or less on a qualification range. The numbers are significantly lower when a Soldier is operating in high stress environments.[1] Therefore, whether a Soldier is firing a 5.56mm system with an effective range of 500 meters, or a 7.62mm platform with an effective range of 800 meters, what really matters is whether he or she has the skill to hit the target to begin with. Taking the human factor into account, one could argue that the "real world" effective range of a 5.56 system is similar to a 7.62mm weapon platform because the range potential of both platforms significantly exceeds the average Soldier's marksmanship ability. This is not to say that well-trained Soldiers such as U.S. Army Snipers are not fully capable of firing small arms to their maximum potential.

The value of having a system capable of increased range not only depends upon the skill of the operator, but it also depends upon the operating environment. In urban or restrictive terrain, for example, most line-of-sight ranges are significantly less than a weapon's range potential. In more open terrain, the engagement range increase. For example, according to Lt. Col. Henthorn, in operating environments like Iraq, 80 percent of engagements are less than 200 meters. While in more distributed environments like Afghanistan, only 50 percent of engagements are less than 300 meters.

"A Soldier must be able to engage the threat he's faced with – whether it's at eight meters or 800," said Lt. Col. Henthorn, small arms division chief, Maneuver Center of Excellence, Ft. Benning, Ga., "Squads need a diverse capability that allows them to maximize their effectiveness in any operating environment."

Ergonomics and Design Features

Beyond reliability, accuracy and range, there are a host of attributes that contribute to how a Soldier effectively employs a weapon. Overall size will make a big difference in terms of handling and mobility.

Typically, a heavier weapon is more durable as a result of its ability to withstand the physical stressors and heating of the barrel by the explosive forces of the rounds. However, the Soldier needs to also be able to easily maneuver the weapon while moving through buildings, confined spaces, and in and out of vehicles. Often, the weight differences can be substantial. For example, a loaded 5.56mm M4 Carbine weighs in at just over 8 lbs. Meanwhile, the 7.62mm M14 Enhanced Battle Rifle weighs 16.6 lbs loaded – more than double the M4's weight.

How the Soldier reacts to the weapon when it is fired is also paramount. If a weapon's recoil is too intense for the operator (which can be the case at times with heavier weapons), he or she may not be able to keep the weapon on target, resulting in missed shots and wasted ammunition. Larger recoil also tends to foster an anticipatory flinch in the shooter that can be difficult to control. Rate of fire and capacity will also affect the Soldier's sense of the weapon. Burst and automatic modes enable the Solder to send more rounds down range, but at the sacrifice of precision accuracy.

Simplicity is also an important feature on many different levels. Simpler systems are easier for Soldiers to train on, clean, and maintain in the field. Simpler systems also have fewer parts that can break and have lower logistical support requirements.

[1] COL Robert Radcliff: "Improving Soldier Lethality" NDIA Small Arms Symposium, May 2008 "http://www.dtic.mil/ndia/2008Intl/Radcliffe.pdf"

A Series of Tradeoffs for General Purpose Needs
Ultimately, Army service rifles must be general purpose in nature and embody a series of tradeoffs that balance optimum performance for a wide range of possible missions in a range of operating environments. With global missions taking Soldiers from islands to mountains and jungles to deserts, the Army can't buy 1.1 million new service rifles every time it's called upon to operate in a different environment. Further, the service rifle needs to work well in the hands of Soldiers from the 5th percentile females to 95th percentile males in terms of body size and composition. Inherent in a system's ergonomics are the significant design tradeoffs of caliber and barrel length.

"Larger 7.62mm systems deliver higher energy rounds at longer ranges, but are heavier, use heavier ammunition, and have greater recoil, which makes putting subsequent rounds on target difficult in the close fight," said Tamilio. "Smaller 5.56mm systems are lighter, have less recoil, improved controllability, and lighter ammunition, but deliver lower energy rounds at range. Actually, weapons that are too light can have significant recoil that makes it difficult to maintain on target."

Rather than trading off characteristics, some may suggest simply increasing the variety of platforms in a squad. While it's beneficial to have a mix of capabilities, too much system diversity reduces a unit's ability to cross level magazines and ammunition in a fire fight. On a much larger scale, standardization between units and among allies facilitates logistical support.

Ultimately, the "best" weapon for an operator with a unique target set will not be the same weapon as the best weapon a large Army facing a wide range of targets.

AMMUNITION

"When all the factors of marksmanship do come together, it is ammunition that ultimately comes in contact with the enemy," said Lt. Col. Jeffery Woods, product manager, small caliber ammunition, PEO Ammo, Picatinny Arsenal, N.J. "Of significance is ammunition's ability to engage a wide range of targets effectively."

M855A1 Enhanced Performance Round

Considering the global mission demands it faces, the Army requires a staggering amount of ammunition. Joint Munitions Command manages plants that produce more than 1.6 billion rounds of ammunition annually for training and combat.[2] The Army currently employs a 5.56mm round for its 1.1 million M16/M4 weapon systems, as well as for the M249 Squad Automatic Weapon. Larger caliber 7.62mm rounds are used in the M240 series of medium machine guns, the snipers' M24 and M110 systems, as well as the M14 Enhanced Battle Rifle (EBR). The M2 Machine Gun and the M107 Long Range Sniper Rifle make use of .50 caliber rounds.
When it comes to ammunition's effects, the Army stays away from the imprecise term "knockdown power," which is the reference most people have in mind from years of exposure to Hollywood images where the laws of physics simply do not apply. People don't fly backwards through the air when shot. From a scientific perspective, the ratio of target mass to bullet mass is too extreme to result in such

[2] Joint Munitions Command. "Frequently Asked Questions" <http://www.jmc.army.mil/JMCFAQ.aspx> (19 Jan 2011).

dramatic effects. In a study performed by Battelle Labs and documented by the Federal Bureau of Investigation (FBI), the force of impact of a 9mm projectile at muzzle velocity is equivalent to dropping a one pound weight about six feet. The force of impact of a .45 caliber projectile is equivalent to dropping a one pound weight 11.4 feet[3]. Once fired, a bullet travels at supersonic speeds and crushes its way through soft tissue, which promptly gives way. Unlike the blunt force of a hammer or a bat, a bullet from a handgun or rifle penetrates soft tissue, leaving even less force to actually push an object.

According to the FBI, "a determined adversary can be stopped reliably and immediately only by a shot that disrupts the brain or upper spinal cord." If a round does not strike the central nervous system, incapacitation will only result from circulatory collapse resulting from massive blood loss. This takes time. The FBI study states that "there is sufficient oxygen within the brain to support full, voluntary action for 10-15 seconds after the heart has been destroyed."[4]

Despite the fact that studies have long concluded that shot placement is the most critical factor in stopping a subject, some firearms writers continue to argue for a system that can deliver a "one-shot stop." However, according to Lt. Col. Henthorn, the reality is that Soldiers never fire one bullet anyway.

"In the close fight, Soldiers don't pull the trigger once and then evaluate and then pull the trigger again," said Henthorn. "Instead, Soldiers in combat pull the trigger two, three, or four times and then reevaluate. The single bullet mantra just does not apply in real world combat because Soldiers know that you rarely get a second chance in a firefight to come out on top of an engagement."

General Purpose Rounds

During the course of a Soldier's patrol, he may face a variety of threat situations. He could be working a checkpoint that is approached by enemy combatants in a vehicle. He could be engaging in a fire fight with insurgents clad only in soft garments. Or he could be facing an enemy taking cover behind walls or doors. To be effective in all scenarios, a Soldier needs to have true "general purpose" rounds in his weapon magazine that are accurate and effective against a wide range of targets.

"Naturally, some ammunition types will perform better than others against specific targets," said Woods. "Armor piercing rounds will do well against hard targets whereas other rounds may give up hard target performance for soft target effectiveness. Yet, after testing and measuring combat performance, the Army concluded that only one general purpose round was more effective that the current 5.56mm M855 to defeat the wide range of targets faced by Soldiers and that's the new the M855A1 Enhanced Performance Round."

In summer 2010, the Army began fielding stocks of the M855A1 Enhanced Performance Round (EPR) to units in Afghanistan. The new round is the result of years of Army research and testing. The M855A1 is identical in weight to its predecessor, but different in construction and materials. The new round exposes a harder and sharper steel "arrowhead" penetrator that extends beyond a copper jacket. The jacket is now "reverse drawn" and formed from the back of the bullet up to the penetrator. The lead slug inside the jacket has been replaced by a copper slug, and a new flash reduced propellant provides higher velocity.

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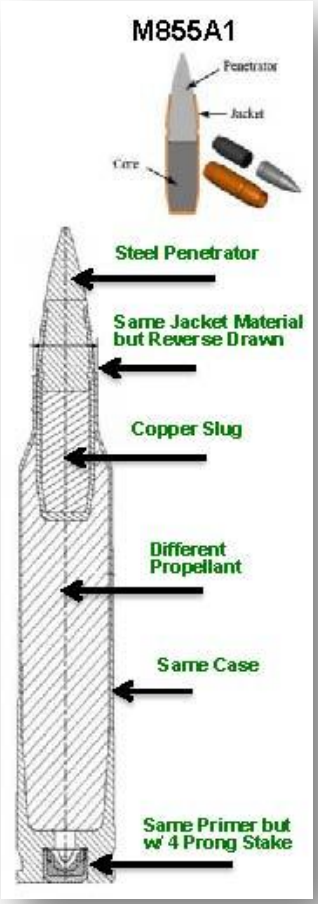
[3] Goddard, Stanley: "Some Issues for Consideration in Choosing Between 9mm and .45ACP Handguns," Battelle Lab, Ballistic Sciences, Ordnance Systems and Technology Section, Columbus, OH, presented to the FBI Academy 2/16/88, pages 3-4

[4] Patrick, Urey W., "Handgun Wounding Factors and Effectiveness," Federal Bureau of Investigation, Firearms Training Unit, July 1989. p. 8.



"The M855A1's performance is dramatic," said Woods. "Compared to the older M855 round, the new round delivers improved hard-target penetration, more consistent performance against soft targets and a significantly extended range of these desired effects along its trajectory. With the lead portion eliminated, the round also has a reduced environmental impact."

From a performance perspective, the M855A1 can penetrate 3/8 inch mild steel at ranges exceeding 350 meters, compared to just 160 meters for the M855. In fact, Army Research Laboratory tests demonstrated that the M855A1 even outperformed the 7.62mm M80 ball round, which does not have a steel penetrator, against hard targets within the effective range of the M4/M16 weapon systems. The M855A1 provides consistent expected performance against soft targets, too.

A significant difference between the older M855 round and the new round is that the M855A1 does not rely upon yaw for its effects. As a bullet travels along its trajectory, it does not fly perfectly straight. It actually wobbles slightly as it spins resulting in variable changes in both pitch (up and down) and yaw (left to right). The yaw of the M855 round can cause it to turn as it enters soft tissue, break into discrete components of penetrator and slug, and transfer its energy to the target. Yaw-dependent rounds achieve different effects on the target depending upon the angle of yaw of the round when it hits the target. There is the possibility that if the round happens to hit a soft target "straight on" at the instant of impact, the round could pass through and fail to transfer its full energy to the target. As the M855A1 is not yaw dependent, it provides the same consistent performance against soft targets every time, regardless of yaw angle or whether in close quarters or longer-range engagements. Essentially, the new M855A1 EPR delivers the best potential soft target performance of the older M855 every time it's fired.

Caliber

Much has been written about the "bigger bullet" debate. Before the 5.56mm M16 Rifle was introduced in the 60s, Army Soldiers were armed with the 7.62mm M14 Rifle. Earlier service rifles such as the M1 Carbine and M1 Garand also fired larger rounds. One of the primary benefits of a larger round is greater range. It's not necessarily a faster round, but once the propellant accelerates the mass, the laws of physics allow for the object in motion to remain in motion longer, therefore the 7.62mm round can travel farther than a round with less mass. The round's accuracy over distance is also less affected by environmental factors such as wind.

Larger rounds do come with tradeoffs, however. Bigger rounds result in larger recoil profiles, more weight for Soldiers to carry, and a potential reduction in lifelong reliability and durability of the weapon platform. Larger caliber ammunition requires that you build a stronger system, which often equates to increased weight. Weapons with greater recoil and more weight also demand a higher performance from Soldiers who need to control the weapon and keep it on target. After all, a miss with a bigger bullet is still a miss.

The performance of a 5.56mm round to a 7.62mm is somewhat comparable, especially when reviewing the performance metrics of 7.62mm M80 Ball with the 5.56mm M855A1. To say that the one round is better than the other depends ultimately on the target set and the range. For example, a talented squad Designated Marksman (DM) firing 7.62mm M80 ball ammunition through a M14 EBR has the potential of incapacitating an enemy combatant without body armor at 700 meters. However, using that same weapon and ammunition, the DM couldn't match a Rifleman's ability to incapacitate a combatant taking cover behind intermediate barriers such as a car door at 300 meters with M855A1 ammunition. The reason is simply that M80 ball ammunition doesn't have a steel penetrator and it suffers from the same performance inconsistencies due to yaw angle as the M855, but to a larger degree.

"All things being equal, bigger is better," said Lt. Col. Henthorn, "However, things are never equal and technology advances are virtually erasing the performance differences of the 5.56mm vs. the 7.62mm ball round. In the near future, once the EPR updates get incorporated into the 7.62mm round there will be another significant jump in performance that we will be able to put into the Soldier's hands."

OPTICS, SENSORS AND LASERS

Though their significance is often overlooked, optics, sensors, and lasers are true combat multipliers in that they allow for quicker engagements, increased probability of a first round hit, and better accuracy to make a force more lethal. After all, if you can't see what you are shooting at, it doesn't matter what size weapon or ammunition you are shooting, you will not be effective.

M68 Close Combat Optic

"Sensors, lasers, and optics are not only tools for better shooting, they are also tools for knowing when not to shoot by providing positive identification," Lt. Col. Christopher D. Schneider, product manager for soldier maneuver sensors. "Minimizing collateral damage begins with knowing what you are shooting at."

Optics have been standard on U.S. Army service rifles since shortly after September 11, 2001. In fact, the Army recently passed a milestone having purchased its 1,000,000th M68 Close Combat Optic (CCO) in 2010. Allocations for the various types of optics differ depending on unit make up. About 85 percent of M4 Carbines are issued with a CCO. The remaining weapons are issued with the four-power M150 Rifle Combat Optic, while M240 machine guns are issued with the M145 Machine Gun Optic. If for any reason the primary optical sight becomes inoperative, all M4s and M16s have an integrated Back-up Iron Sight that provides an immediately available capability adjustable to 600 meters.

CCO
The CCO provides the Soldier armed with an M16 series rifle or M4 Carbine with an optical red dot sight. The sight enhances target acquisition speed, allowing Soldiers to engage targets up to 300 meters with both eyes open to maintain situational awareness. The sight has no magnification and can be used with all current night vision devices.

The CCO presents only a single red dot aiming point for the Soldier to consider, rather than the two points presented by iron sites, which was the standard sighting mechanism for centuries. Soldiers rate the CCO as an effective optic and regularly comment on the sight's effectiveness for close quarters combat.

"The red dot system eliminates the need for a Soldier to align the front and rear sights and switch focus between the two," said John Heinsohn, product director – sights, Product Manager Individual Weapons, Picatinny Arsenal, N.J. "The CCO requires less training than iron sites and eliminates uncertainty and a potential point of failure. Once the system is properly zeroed, using it is as simple as putting the red dot on center mass and pulling the trigger."

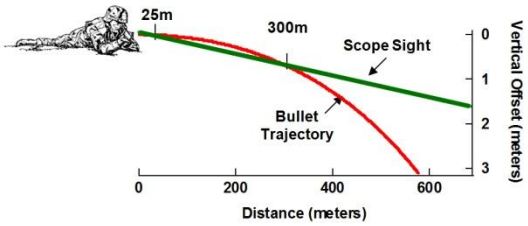
At ranges beyond 300 meters, a valuable tool in the optics arsenal is the **M150 Rifle Combat Optic (RCO**). The sight is a battery-free 4x magnified optic for use on M4/M16/M249 weapon systems. The RCO provides greatly enhanced target identification over non-magnified views and is typically assigned to small unit leaders as well as squad designated marksmen. In the Marine Corps, all infantry personnel use the RCO. The sight increases the probability of a first-round hit and can be utilized for reflexive fire in close quarter battle to long-range engagements with proper training. Enhanced capabilities provided by the RCO include range estimation, which, along with the bullet drop compensated reticle, provides accurate target engagements out to 800 meters. Soldiers rate the RCO as an effective optic and regularly comment on the sight's ruggedness.

M150 Rifle Combat Optic

Proper Employment
Proper utilization of optics is just as vital to a Soldier's performance on the battlefield as the four fundamentals are to firing a rifle. CCO training is incorporated into Army basic training while RCO training is provided by New Equipment Training (NET) Teams using a train the trainer method.

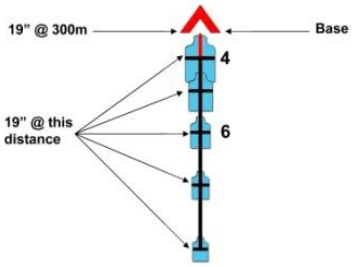
Mounting and zeroing optics are critical first steps. Zeroing means that the sight is aligned with the weapon system so that the point of aim matches the point of impact to the best extent possible. Any error in the zeroing exacerbates itself as range increases. For example, a margin of error based on an incorrect 25 meter zero of 1 inch using an RCO equates eight inches off at 200 meters, 12 inches off at 300 meters and 20 inches off at 500 meters. Conditions such as temperature, altitude, and angle of fire will also affect point of impact. For example, Soldiers who zeroed their weapons at sea level would benefit from re-zeroing their weapons if they are operating at 5,000 feet.

Zeroing errors do not begin to take into consideration other factors such as human error, ammunition, or weapon inaccuracies. A Soldier must also train on correct eye relief and sight alignment to ensure proper shot placement. More often than not, an enemy will not remain fixed in place, but will be on the move. Therefore a Soldier must also know how to lead a target by adjusting for slow and fast movements. Wind will also affect the trajectory of a round and must be taken into account. For example, a 10 mile-per-hour full-value wind moves a 5.56mm bullet from about ½ of an inch at 25 meters to about 15 inches at 300 meters.



Bullet trajectory and scope pointing

While target movement is a key factor, so is the movement of the projectile itself as it travels through space. Bullets do not travel in a straight line like a ray of light, rather they fly along an arching trajectory due to gravity, which pulls down on the projectile throughout its flight. When M4/M16 sights are zeroed, they are typically set for 25 meters and 300 meters as the projectile's path is a match at those distances. This is especially true for iron sights and the M68 CCO. In this scenario, at 200 meters, the projectile is actually traveling higher than any straight line path. To incorporate the physics of the bullet's flight into a Soldier's marksmanship requires training and close attention to the range estimation, especially at longer distances. At the squad level, laser range finders are issued to grenadiers carrying the M320 Grenade launcher, but a properly trained Soldier can use his RCO to determine a range estimate as well.



RCO reticle showing bullet drop compensator for range estimation

"Due to the nature of a bullet's travel, range estimation is an extremely valuable skill," said Heinsohn. "Using the reticle of the RCO, a Soldier can calculate a rough range estimation and align the bullet drop compensator properly. The width of the stadia lines equate to 19 inches, the approximate width of a human torso. Lining up the enemy with a matching stadia line will give the Soldier an approximate range."

Sensors and Lasers Extend Human Capability

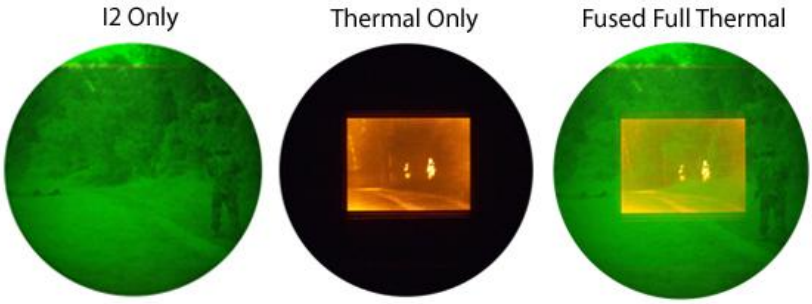
"Technology accessories have greatly extended a Soldier's capability to engage the enemy regardless of environmental conditions," said Schneider. "For years, infantry Soldiers have used image intensification technology to see at night, then came thermal sights. Now we layer the two technologies together for unprecedented capability."

The current image intensification (I2) platform is the **Monocular Night Vision Device (MNVD), AN/PVS-14,** which is issued to nearly every Soldier. The MNVD amplifies ambient light and very near infrared energy to enable night operations out to a range of 150 meters. The system is designed for use in conjunction with rifle-mounted aiming lights. The device mounts on the head or helmet and incorporates an infrared (IR) illuminator.

Monocular Night Vision Device (MNVD), AN/PVS-14

Moving beyond image intensification are thermal weapon sights that reveal infrared signatures undetectable to the naked eye. The **AN/PAS-13 Thermal Weapon Sight (TWS)** family enables the Soldier to detect and engage targets, day or night, in all weather and in most low visibility conditions. These devices can be mounted onto a weapon rail and operate to the maximum effective range of the

weapon. The TWS family comprises three variants: light, medium and heavy. There are typically six TWS systems issued to each light infantry platoon.



Merging image intensification with thermal vision technology, engineers have developed the **Enhanced Night Vision Goggle (ENVG) AN/PSQ-20** as a single, helmet-mounted passive device. The pairing of the technologies complement one another and balance out the limitations of each. The ENVG combines the visual detail in low light conditions that is provided by image intensification with the thermal sensor's ability to see through a significant amount of smoke, fog, dust, as well as a certain degree of foliage cover.

"The thermal capability makes the ENVG useful during the day as well," said Schneider. "For example, if an insurgent approaches a checkpoint with a suicide vest or a hot weapon under his garments, a Soldier looking at him through the ENVG could pick up indicators that something is 'wrong' with the picture giving the Soldier a whole new level of situational awareness."

Having been equipped with the ability to see in many scenarios, Soldiers are also provided technology to target in multiple scenarios as well with the use of laser pointers that can be set to work in both day and night conditions. The Army began pushing out "**Multifunctional Aiming Lights (MFAL)**" in large numbers in 2007. The devices are designed to provide precision aiming in visible and infrared (IR) spectrums. During the daytime Soldiers can employ visible red dot lasers for targeting purposes, whereas at night, they can employ IR beams as they can only be detected with the use of night vision devices.

The MFAL family includes the **AN/PEQ-15 Advanced Target Pointer Illuminator Aiming Light (ATPIAL)** and the **AN/PEQ-15A Dual Beam Aiming Laser – Advanced2 (DBAL-A2)**. Issued to every Soldier, MFALs work in conjunction with the Soldier's MNVDs. The IR lasers emit a beam of IR light for precise weapon aiming, as well as a separate, IR-illuminating laser with adjustable focus. A visible red-dot aiming laser can also be selected to provide precise aiming of a weapon during daylight or night operations. Another powerful targeting device is the **AN/PSQ-23 Small Tactical Optical Rifle Mounted (STORM) Micro-Laser Rangefinder (MLRF)** enables determination of distant target and terrain locations with laser range-finding and digital direction finding.

All Soldiers, particularly infantry, carry a variant of the multifunctional aiming lights. Using their night vision devices, a Soldier equipped with an MFAL is fully capable of carrying out their missions at night. While the use of sensors and lasers does not automatically equate to enhanced marksmanship, they do provide an enhanced capability to the Soldier to bolster his situational awareness and increase his potential for delivering lethal fires in combat.

Fire Controls

From a systems growth perspective, sensors and lasers have significant potential. As an example of what will soon become available in the near term, the developmental XM25 Individual Semi-Automatic Airburst System employs a Target Acquisition / Fire Control (TA/FC) that can turn an average shooter into a marksman. The TA/FC allows the individual Soldier to quickly and accurately engage targets by producing an adjusted aimpoint based on range, environmental factors, and user inputs. The TA/FC integrates thermal capability with direct-view optics, laser rangefinder, compass, fuze setter, ballistic computer, laser pointer and illuminator, and an internal display.

XM25 with mounted Target Acquisition / Fire Control

Looking even further out, the Defense Advanced Research Projects Agency is leading an initiative for improved optics through its Dynamic Image Gunsight Optic (DInGO) program. The goal of the DInGO program is to develop a rifle scope that will turn every soldier into a marksman over the full lethal range of combat rifle, allowing accurate engagement of targets by automatically making all of the ballistic adjustments needed to hit the target. The government's solicitation asks industry to overcome the limitations of current scopes that are optimized for a single target range and introduce a reticle error at long range limits. The new DInGO scope will allow for a wide field of view at close quarters as well as sufficient magnification to hit moving targets farther than a quarter mile away. Scope designers will also compensate for bullet drop and moderate winds.

The future of sensor technology lies also in its fusion with accessories that transmit the data back to common platforms and higher units where the information can be shared in real time with team members and commanders to improve situational awareness on the battlefield. Soon, Soldiers won't necessarily need to look through the scope to see what the gun sees. They will be able to view it through an eyepiece hanging from their helmet. Also in the works is "Liquid Lens" technology, which takes advantage of polymer lenses to add an 8-power magnification at the flick of a switch.

TRAINING

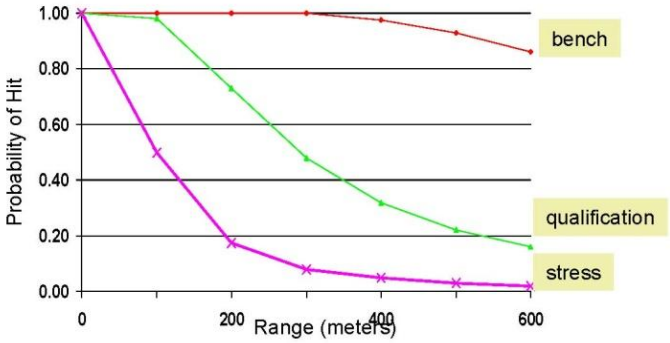
Of the multiple factors relevant to Soldier effectiveness on the battlefield, Soldier marksmanship represents the greatest variable. The weapon, the ammunition, and the optic are all manufactured devices with stable attributes and performance parameters, whereas a Soldier's ability to control those devices with precision is entirely dependent on the operator. Training is the only way to reduce the variability so that Soldier performance becomes more effective and more consistent over time. The more training, the less variability, the better the marksmanship.

U.S. Army Soldiers attached to 1st Infantry Division prepare to shoot at targets at a range in Kirkuk, Iraq, Dec. 1, 2010.

Shooting a weapon accurately is difficult. It takes a lot of physical dexterity to hold a weapon still, take proper aim, and squeeze the trigger without drawing the weapon off its intended mark. Service

members know firsthand how tough it is to shoot while clad in full military gear. An even smaller set of individuals, combat veterans, know that performing the same task in the face of enemy fire is extremely difficult.

Just how difficult? U.S. Army figures indicate that the probability of a hit under stress is under 20 percent at 200 meters, 10 percent at 300 meters, and 5 percent at 600 meters.[5] Large aiming errors are expected in combat considering extreme stress, unknown target locations, short target exposures, and multiple targets. To complicate matters, just because a hit is recorded, doesn't necessarily mean it was an incapacitating hit either.



Probability of Hit under Changing Conditions[5]

Unfortunately, training is not a "one and done" endeavor. Marksmanship is a perishable skill. As with any motor skill, it is important to frequently exercise the muscle memory that is critical for accurate reflexive fires. Frequent live-fire training is required for developing and maintaining expertise, whether the targets are at close quarters battle (CQB) ranges or at 200 meters and beyond.

Overhauling Marksmanship Training

In March of 2010, the Army instituted new guidance for its Basic Rifle Marksmanship (BRM) and its Advanced Rifle Marksmanship (ARM) programs that represent a complete revision of the marksmanship program. Army Research Institute studies in both 2008 and 2010 validated the new approach that increases both the amount of ammunition fired in training as well as the variety of firing positions and battlefield scenarios faced by the Soldier.

"Essentially, the entire emphasis of training has changed," said Maj. Aaron Crafton, Battalion S3 Officer in Charge, 2-29 IN, 197TH Infantry Regiment, Ft. Benning, whose office is the proponent for the Army's Rifle Marksmanship Field Manual 3-22.9. "The goal of our new program is to teach Soldiers how to '*fight* with a rifle' rather than to just 'shoot a rifle.'"

Maj. Crafton explained that the new program integrates lessons learned from years of warfare. The Army is moving away from the foxhole firing methods of old. Training is now based upon what Soldiers are seeing in the field – Soldiers shoot from the kneeling, shoot from the standing, and shoot from barricades. Gone also is the "1-shot-1-kill" mantra of legacy training whereby Soldiers were presented with 40 rounds to strike 40 targets. In recognition of battlefield realities, the new marksmanship program requires that some targets receive multiple hits for a "kill," which is why "controlled pairs" are being taught in the program. Another real-world aspect of the testing incorporates malfunction clearance, which is something that Soldiers need to be prepared for. In the old qualification procedures, "alibis" were allowed for Soldiers whose weapons experienced a misfire. Of course, the Army is still teaching center mass aiming, and the four fundamentals of shooting remain the same: steady position, correct aiming, breath control and proper trigger squeeze.

[5] COL Robert Radcliff: "Improving Soldier Lethality" NDIA Small Arms Symposium, May 2008 "http://www.dtic.mil/ndia/2008Intl/Radcliffe.pdf"

Comparison: The Old and the New Marksmanship

Legacy Marksmanship "Shoot a Rifle"	New Marksmanship "Fight with a Rifle"
➢ Soldiers taught to fear a rifle ➢ "Up & Downrange" on ranges ➢ 1 Shot-1 Kill as part of qualification ➢ Antiquated firing positions ➢ M68 CCO introduced in ARM 2 ➢ Malfunction=Alibi ➢ Magazine changes are an administrative function ➢ Endstate: A Soldier who could successfully engage 23 of 40 targets.	➢ Soldiers taught to be comfortable with a rifle ➢ 360 degree low-ready on ranges ➢ Some targets require multiple hits for a kill ➢ Combat-relevant firing positions ➢ M68 CCO introduced in BRM 2 ➢ Malfunction clearance is a part of the qualification ➢ Magazine changes are part of the qualification ➢ Endstate: A confident Soldier who continually assesses the situation he is presented with and acts decisively to not only engage targets but keep his weapon operational.
Legacy Basic Rifle Marksmanship (BRM) vs. New BRM 341 rounds fired vs. 370 rounds **Percent Increase: 8.5 percent**	**Legacy Advanced Rifle Marksmanship (ARM) vs. New ARM** 216 rounds fired vs. 360 rounds fired **Percent Increase: 66.6 percent**

BRM/ARM Marksmanship, 198th IN BDE, Command Sgt. Maj. Richard Weik

Training Regimen

Training begins with an introduction to the rifle. Soldiers learn all about its components and how to disassemble and reassemble the weapon, load, unload, clean, and everything else that comes into play when being introduced to a weapon for the first time. Afterwards, Soldiers are introduced to the four fundamentals of marksmanship.

"The biggest myth is that a Soldier can add the best optic and best accessories in the world to a weapon and be a great shot, but if you don't know the basics on how you fire your weapon, you're never going to hit the target," said Staff Sgt. Juan Vega, marksmanship instructor, 2-29 IN, 197TH INF REGT. "The four fundamentals have held true for a long time. If something is going wrong with your shooting, it's going to be a problem with one of the fundamentals."

The hands-on introduction is followed by training with the Engagement Skills Trainer (EST) 2000, which is a large scale simulator the size of a large room. The EST 2000 is essentially a sophisticated video game with full-scale replica weapons that give Soldiers a better understanding of the fundamentals. In use since 2006, more than 900 of the simulators are utilized by Army, National Guard, and Reserve Soldiers. The simulator saves significant time and ammunition resources and can run hundreds of scenarios, from basic range zeroing and shot grouping drills all the way to shoot/don't shoot modules. The value of virtual marksmanship is that it allows a Soldier to conduct repetitive and reparative training leading to increased weapons proficiency, combat effectiveness, and ultimately, survivability on the battlefield.

Infantry trainees at Fort Benning also spend time on a special "LOMAH" range for their field fire training. LOMAH is short for "Location Of Miss And Hit." LOMAH is a projectile detection targetry system for small arms marksmanship training. The system detects the passage of supersonic projectiles passing through or by the target surface, presents multiple targets at the same time, and provides downrange feedback. The system tells the Soldier exactly where his rounds are going, thereby providing more information for the Soldier that will assist him or her in adjusting their marksmanship.

LOMAH is followed by the final BRM qualification test in positions learned so far – the prone supported, prone unsupported, and the kneeling. In all, Soldiers spend about 15 days on basic rifle marksmanship. Lasting between seven to 10 days, the ARM program held during the Advanced Individual Training is shorter than BRM, but more robust in terms of rounds fired. The most significant difference with the new ARM program is the training conducted around combat field fires. In this portion, Soldiers learn to shoot in the kneeling unsupported, barricade supported, and prone. In the testing portion, numerous targets require multiple hits to qualify for a "kill."

Once training is complete and Soldiers get to their assigned units, how often they get to fire depends upon how much ammunition they've been allocated and how the local commanders organize their training priorities. Some units range qualify their Soldiers more than the active duty requirement of two times per year, some less depending on the unit's primary mission. Ultimately, the bottom line for better marksmanship training is repetition, with the goal of producing Soldiers who can confidently perform on the battlefield regardless of the scenario or stress level.

"Training forms the basis and the muscle memory of shooting," said Staff Sgt. Vega. "When things go hot, Soldiers don't have to think, they go into automatic mode – battle drill shooting."

CONCLUSION: Underlying Complexity is Confidence

At the start of this exploration of Soldier battlefield effectiveness, we opened with the following framework:

Soldier + Weapon + Ammo + Optic + Training = Battlefield Effectiveness

A review of each topic area reveals significant complexity with each factor playing a major role in a Soldier's overall performance:

1.) **Weapons are the base platform for Soldier lethality.** The advanced state of small arms technology has provided the Soldier with tremendous capability. However, as with all mechanical devices, weapons are imperfect and designs can always be improved. Weapons must be reliable in any operating environment. They must be accurate and capable of engaging the enemy at overmatch distances. Weapons must also be relatively simple to maintain and sustain from a field maintenance and logistics perspective. Any carbine design must strike a balance between weight, size, and capability to enable all Soldiers to carry out a broad array of missions. The Army has incorporated significant improvements to the M4 Carbine and has now challenged industry in a competition to deliver a carbine that can outperform the M4A1.

2.) **Ammunition incapacitates when it hits its mark.** Ammunition must be reliable and provide consistent performance in terms of velocity, dispersion, and effects on target. Regardless of the size of a round, shot placement is the most critical component of lethality. The central nervous system must be struck to achieve a high probability of incapacitation otherwise an enemy may be able to counter attack, if only for a matter of seconds. To meet the needs of the larger Army, rounds must be general purpose in nature and capable of performing well against a wide range of target sets. Current ammunition development has provided increases in capability across the board. The Army's new M855A1 Enhanced Performance Round is a significant upgrade over the M855 in terms of hard target performance and soft target consistency.

3.) **Optics, sensors and lasers are combat multipliers.** Optics aid target identification and allow for quicker engagements and increased first-round hit probability. Sensors and lasers enable Soldiers to employ weapons in day, night, and degraded weather conditions. Yet, all devices require training as improper zeroing and employment will degrade effectiveness. The future of optics, sensors, and lasers will be the proliferation of systems that provide Soldiers with pre-calculated ballistic solutions.

4.) **Training represents the greatest variable in the Soldier effectiveness equation.** Shooting accurately under battle stress conditions is extremely difficult. Regardless of a Soldier's weapon, ammunition, or optic, to hit his mark he must properly execute the four fundamentals of marksmanship: steady position, aiming (correct site picture), breath control, and trigger squeeze. Applying lessons from the past decade of warfare, the Army has redesigned its marksmanship program with increases in both the amount of ammunition fired as well as the variety of positions and battlefield scenarios Soldiers train on. Marksmanship is a perishable skill and repetition is required to keep battle reflexes sharp.

Considering these elements in context reveals the truly complex composition of a Soldier's battlefield effectiveness. In light of just how effective the U.S. Army Soldier is, it is evident that Army's holistic approach to outfitting and training Soldiers produces results, though there is always room for improvement.

Doubtless, the Army will continue to pursue every advantage in its quest to make the Soldier the most effective he can be on the battlefield. This pursuit will result in the evolution of weapon systems, accessories, and tactics – anything and everything to ensure that U.S. Soldiers never find themselves in a "fair fight." The net effect of all the Army's efforts must be a well-equipped, well-trained Soldier who has faith in his gear, training, unit and Army. In the end, it is always the exceptional confidence of the U.S. Soldier that carries the fight.