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TECHNICAL NOTE 108: RAPID SEMIAUTOMATIC FIRE AND THE ASSAULT RIFLE (FIRING RATE VERSUS ACCURACY)

This Technical Note is based on a paper that I prepared in 2000 when I was a Lieutenant Colonel in the U. S. Army Reserve Command. I believe that it may have value to some of our many law enforcement and military customers, so I have decided to reprint it as a Technical Note. As with all of ArmaLite's Technical Notes, all rights are reserved.

Mark Westrom

CONTENTS

FORWARD

In "Marksmanship, McNamara, and the M16 Rifle; Organizations, Analysis, and Weapons Acquisition," James L. McNaugher focused on the political infighting surrounding acceptance of the M16 as the Army's standard service rifle. While the history of the organizational struggle itself is interesting, McNaugher's unusually clear summary of the central struggle within American marksmanship circles, i.e. the argument over the relative merits of *accuracy* of small arms fire versus *rapidity* of fire, is more important. This controversy has afflicted American small arms doctrine since the first repeating rifles entered American service. The debate strengthened as the services considered adoption of the M16, the first assault rifle used by the US military.

McNaugher reviewed the controversy clearly, but he stopped short of resolving the issue. The purpose of this paper (Originally published in 1984 as Sustained Fire and the Assault Rifle) is to present a framework for evaluating the differences between the contending small arms doctrines, and to apply the implications of this framework to modern warfare and weapons. In addition, this paper provides test results and training models that clarify the proper use of the assault rifle. While a brief historical review of the issues is presented, the reader is urged to obtain a copy of McNaugher's paper.

The supremacy of the rifle in combat was once undisputed, just as the supremacy of the sword and long bow was in their times. Most casualties in modern battle, however, are produced by blast or shrapnel. Some authorities conclude that the usefulness of the rifle is on the wane, and that the tank or artillery pieces are the deciding weapons of modern war.

There is, however, a difference between casualty production and victory. It's indeed possible for artillery or armor to win or lose a battle, but artillery cannot enforce the decision of its shrapnel, and armor is vulnerable without supporting infantry. Only a soldier can take and hold ground. When he closes with the enemy, the artillery of both sides must cease firing and await the outcome of the battle. As long as the foot soldier's primary weapon is the rifle, it remains the deciding weapon in combat. In today's more limited struggles, ("Operations Other than War") small unit actions and individual weapons are even more important.

If the rifle remains the final weapon of modern combat, it follows that efficient training in its use remains crucial to the success of the force. Marksmanship is the skill of employment of small arms. Its emphasis, even in an age of tactical atomic weapons, can be ignored only at the peril of the soldier's cause. The question is: What marksmanship skills are important today?

I. THE HEART OF THE CONTROVERSY: SPEED VERSUS ACCURACY

Since the advent of repeating small arms, American military theoreticians have been divided over the merits of *speed* versus *accuracy* of fire. This doctrinal debate is generally divided into two camps. The first is composed of those who advocate a "one shot, one hit" school of precision marksmanship that emphasizes the efficient use of ammunition. This doctrine was established in the mid nineteenth century when relatively accurate rifled arms were first produced in large numbers. The single-shot design of these arms, coupled with the small supply of ammunition available to the soldier, required accurate fire to produce maximum damage to an opposing force. In other words, fire superiority was established by the accuracy with which that ammunition was fired.

The other side of the debate is composed of advocates of another theory based on a different set of tactical assumptions, which holds that fire superiority is best established by producing an overpowering "volume of fire." Volume alone would assure that an opponent was either hit or intimidated to the extent that he was rendered ineffective. According to this theory, modern battle conditions prevent the use of effective aimed fire. An extreme view of this theory holds that precisely aimed fire plays little part in modern combat, and that small arms casualties are caused more by the random collision of bullet and target than by the conscious effort of the firer.

Acceptance of one theory or the other is more than an academic exercise. Training methods, small arms design, and small unit tactics all depend in part on the marksmanship theory chosen. A brief review of the development of American small arms doctrine will provide an idea of the factors leading to the current state of the small arms controversy.

II. MARKSMANSHIP DOCTRINE: FORCES FOR CHANGE

Until the mid-nineteenth century, armies were armed mainly with relatively inaccurate smooth-bored muskets. Without the stabilizing spin imparted to the bullet by rifling (spiral grooves cut into the rifle bore) muskets tended to be short-range weapons.

In addition to the relative inaccuracy of smooth bored muskets, both the tactics and the other military equipment in use at the time reduced the tendency to use precisely aimed fire. First, the lack of effective communications required opposing forces to form into compact formations basically unchanged since antiquity. Commands from higher to lower levels of the fighting force had to be conveyed by banner, bugle, whistle, messenger, and voice. Firepower was usually delivered in volleys. Hundreds of closely spaced combatants firing muskets charged with black powder produced casualties in the opposing ranks (replaced quickly, if not enthusiastically, by the ranks behind). The firing also produced opaque clouds that obscured visibility and reduced the control of the force. The fog-like clouds of smoke could become thick enough to conceal the movement of combatants and, simultaneously, nearly made it impossible to fire on specific targets. The climax of the battle normally awaited the direct contact of the forces, maneuvering in a manner now seen only on the parade ground, and by close combat with the bayonet.

Until the advent of fuzed projectiles and sophisticated sighting, survey, and communications, artillery was employed in the direct fire mode. Light, horse drawn artillery was often positioned in *front* of the infantry that it supported. Gunners sighted over their tubes using rudimentary sights, if any, and fired directly into the mass of the opposing forces. The artillery piece was thus a large musket or shotgun. Early explosive projectiles could create casualties more effectively as their shrapnel mowed the battlefield. The same clouds of smoke that could prevent precise aiming of small arms also interfered with the artillery unless the wind was blowing in the right direction. In the end, the power of nineteenth century artillery did not eliminate massed troop formations.

The advent of rifled muzzle-loading arms and more efficient bullet shapes may have altered the casualty figures, but they weren’t able to change the basic tactics of the forces engaged. The methods of control of the fighting force had not changed, and mass formations continued in use.

The tactical situation began to change, however, with the general issue of breech loading rifles using self-contained cartridges. Breech loading rifles were faster to load and fire than muzzle loaders, and were more accurate. The tighter engagement of the bullet in the rifling provided improved accuracy. It was a short but important step to the effective repeating firearm, which was not practical before the invention of self-contained cartridges.

Although muzzle-loading rifles predominated, the American Civil War (or War of Aggression Against the South, depending on the reader’s perspective) marked the first widespread use of breech-loading rifled arms. The Civil War also saw repeating rifles used on a scattered basis, use of improved projectiles and fuzing by the artillery, which also benefited from rifling, and even the first machine-guns. Massed troop formations weren’t eliminated, but the seeds for their demise were already beginning to be sown.

Marksmanship was raised to an art in the US Army after the Civil War. At last it was possible for riflemen to engage opposing massed forces at distances in excess of 1000 yards, the goal being to reduce the opponents' numbers before they were within bayonet range. The longer range of the rifle compared to the smooth-bored musket provided a tactical advantage. A rifle with longer range provided the firer with an advantage over an opponent using a shorter-range rifle. Considerable efforts in training and development were spent to increase the effective range of the rifle. Rifle sights became more sophisticated and precise in order to squeeze maximum benefit from accurate rifle cartridges. In the U.S., the Indian Wars of the late nineteenth century did not provide a true test of infantry tactics, but precision rifle fire came to be valued as a primary source of the combat effectiveness of the force. Limitations of ammunition supply, the long-range engagements possible on the plains, and the single-shot construction of the rifles used at the time encouraged the most careful use of each cartridge.

European experience also revealed the value of long range marksmanship. During the Turko-Russian War of 1877-78, Russian divisions of ten thousand men were reduced to four or five thousand by intensive Turkish fire that began at distances above 2400 yards. At St. Privat, during the Franco-Prussian war of 1870-71, the advancing Germans lost six thousand men to rifle fire in thirty minutes as their distance narrowed from 1500 to 600 yards.

"The history of the development of weapons and tactics shows an interesting process of self- adjustment". As a result of the increased effectiveness of rifle fire, American officials concluded that American Infantry needed to be equipped with entrenching tools to avoid the Russian experience of having to dig for shelter with their bare hands.

The late nineteenth and early twentieth century was a period of intense development in all technologies, including military science. The advent of the self contained cartridge led inevitably from the single shot rifle to magazine-fed designs capable of much higher rates of fire. The higher rates of fire brought concerns that soldiers would fire their ammunition carelessly, depleting their own supply and that of the supply trains as well. Riflery techniques of the period strictly controlled the firing rate of the men of a unit. Almost all of the repeating rifle designs tested or adopted by the US Army from the 1860s until the 1930s included a "magazine cut-off." This device prevented the cartridges in the magazine from feeding into the chamber, and forced the rifle to be used as a single-shot. In an emergency, the cut-off was switched to allow the soldier to fire the ammunition in the magazine. This conservative attitude changed slowly. Many authorities shared the opinion that "We must be careful to look on the breech loading rifle not as a rapid-firing, but as a rapid loading arm,"

The situation changed slowly. After the turn of the century the board of officers appointed to evaluate the M1903 rifle recommended that "the regulations should require it to be habitually used as a magazine gun, and that single loading should be permitted only under exceptional circumstances". The 1903 rifle included a magazine cut-off until the end of production in 1943, but was seldom used except during drill or competition.

The development of effective area fire weapons provided the first challenge to the use of massed formations and the precision fire techniques developed to counter that mass. The application of breech-loading technology and effective recoil damping mechanisms to artillery increased the firing rate of that arm. The addition of increasingly effective fuzing and better explosive fillers to the increased rate of fire resulted in a much more deadly artillery park. Good maps, survey techniques, and wire communications allowed the artillery to largely abandon its direct fire role and shift to indirect fire techniques. These techniques allowed the artillery to fire from positions out of the direct fire of the opposing force, and allowed the engagement of land forces from miles away, out of sight of the battery. The development of nitro-cellulous based ("smokeless") propellants allowed the development of effective self-powered machine-guns. The combination of machine-guns, improved artillery, and the communications with which to control these weapons at dispersed locations signaled the demise of massed troop formations. The early French campaigns of World War I amply taught the armies of the world that such massed troop formations were no longer militarily sensible.

The static warfare of the trenches didn't alter the perceived need for precision marksmanship, despite the short distances often existing between the opposing trenches. Instead, changes in marksmanship doctrine were stimulated by a WWI development that was intended to overcome that immobility of trench warfare: the tank.

The application of a mobile, protected gun platform to battle did not eliminate trench warfare in WWI. German blitzkrieg tactics of World War II, however, took the Infantry out of the trenches and forced them to adopt mobile tactics and motor vehicles to move quickly. The target array presented to the WWII infantryman was substantially changed from that facing the nineteenth century infantryman.

No longer were massed forces presented as a large, convenient target. Such massed targets were too desirable a target for artillery. If possible, WWII forces used armored troop carriers to move quickly from protected positions to attack positions. The goal was to move close to the defending enemy, and force the defending artillery to lift its fires to avoid hitting its own forces. The rapid movement to contact also reduced casualties from machine-gun fire. Infantry was now presented with fast moving targets at close range. Submachine guns, another development of WWI, served as volume fire weapons at close range, but the standard infantry arm of most combatants was still the bolt action, repeating rifle.

The German Army was the first force to be armed with an intermediate class of weapons that was to challenge the precepts of traditional marksmanship theory. The "Sturmgewehr," or assault rifle, was born. The Sturmgewehr 44 produced by the Germans was an automatic rifle with a 30 round magazine capacity, and was capable of both semi-automatic and automatic fire. It fired a 7.92 x 33mm cartridge that was more powerful than the pistol cartridges fired by submachine guns, but less powerful than those fired in the standard rifle. The Sturmgewehr established the definition of an assault rifle: a rifle intended for use at the shorter combat ranges of the modern battlefield, capable of rapidly firing a cartridge of reduced size and recoil. The use of the reduced power cartridge was considered practical because of the prevalence of short engagement ranges, and the use of automatic fire provided the means for firing a large number of shots at a rapidly moving target in a brief period. Traditional marksmen, still used to more precise firing techniques, were not impressed.

In the period after WWII the Russians, who had gained a healthy respect for the Sturmgewehr 44, adopted a similar cartridge, the 7.62 x 39mm. A Russian assault rifle, the AK-47, was adopted for general issue in the late 1940s, and is now the most widely used firearm in history. The Western countries were slower in switching to the assault rifle.

The US Army was largely equipped with semi-automatic rifles during both the Second World War and the Korean War, while the opposing forces were equipped with bolt action rifles. The success of the M1 rifle (the Garand) during the wars made it difficult to persuade the responsible authorities that another rifle, and another riflery concept, were needed. The smaller M1 carbine (which fired a .30 caliber cartridge closer to the pistol cartridges used in submachine guns than it was to the intermediate sized cartridge used in the Sturmgewehr 44) provided fast, short range firepower, especially when modified to the automatic M2 version. The availability of two rifles bracketing the assault rifle class reduced the pressure to produce an assault rifle, and the general use of manually operated rifles by the Communist bloc during the early 50's further reduced the need for change.

The American reliance on accurate long-range rifle fire was seriously challenged after the Korean War. Research by the Operations Research Office (ORO) of Johns Hopkins University concluded that the rifle is used most frequently at ranges within 300 yards, and that the fire of even expert riflemen is satisfactory in battle only within 100 yards. The authors stated that "exposure was the chief factor responsible for the distribution of hits." This study, and others, indicated that weapons firing cartridges of reduced recoil (as used in the Sturmgewehr) could be employed without a reduction in combat effectiveness. At the same time, it was determined that soldiers in combat fired most shots without using their rifle sights. This discovery led some to conclude that improvements in traditional marksmanship offered little potential for increasing the effectiveness of small arms fire. Perhaps new mechanical methods of delivering firepower would provide a better way to increase hits.

The first mechanical approach included the use of automatic fire. This proved ineffective with the weapons available at the time because the heavy recoil of the ammunition carried the rifle off target. Another mechanical approach was to create a pattern of bullet strikes that would compensate for shooter error: a "shotgun" approach. Various methods were tried, including multiple projectile (salvo) cartridges and controlled-dispersion weapons that fired a burst of cartridges into a useful pattern. Subsequent tests showed that both .22 caliber duplex and .30 caliber triplex ammunition were more effective than cartridges bearing a single projectile, and a 7.62mm duplex round was ultimately standardized in the U.S. as the M198. Extensive experimentation with controlled-dispersion rifles in the 1950s and 60s failed to produce a successful design.

Other attempts to increase the hit rate involved shooting on ranges that duplicated battle conditions better than traditional target style known-distance (bullseye) ranges. Silhouette targets were placed at various ranges to simulate the battlefield dispersion of targets. Later versions of these "Trainfire" ranges had automatic targets that fell when hit, and counters that kept score automatically. A snapshooting course called "Quick Fire" attempted to answer the need for fast, instinctive shooting at short range. Both methods were received suspiciously by traditional shooters, who viewed them as useful additional training but felt that they merely expanded on traditional marksmanship skills.

The potential of smaller, reduced recoil cartridges was being considered at the same time. The British candidate for the NATO service cartridge in the early 1950s was a .280 caliber round. The issue was not new, having been raised in the 1930s as the US Army briefly selected the .276 Pedersen cartridge for use with whatever semi-automatic rifle then under development was accepted for service use. Tests at that time indicated that the shooter could carry more ammunition, fire faster, and obtain more hits than a shooter using the standard .30 caliber cartridge.

While the Soviets switched to the AK47, the US Army was attempting to replace the M1 with a lighter rifle, but one that had the same range and lethality of the M1. It was eventually replaced with the M-14, which was basically an improved M1. The M-14 was a well made rifle equipped with a 20 round magazine and capable of automatic fire. It was a rifle that suited the traditional marksmen in authority, but was not a true assault rifle. Although the M-14 was intended to replace the automatic M2 carbine, M3A1 submachine gun, and M1918A2 Browning Automatic Rifle as well as the semi-automatic M1 rifle and carbine, the heavy recoil of the 7.62mm NATO cartridge it fired made control of automatic fire difficult.

The first assault rifle of the U.S., the M-16, was adopted during the Viet Nam War. That war exposed U.S. forces to close range combat against forces using the AK-47 assault rifle. The adoption of the M-16 was opposed on several grounds. First, it was not a "rifleman's" rifle. It was an ugly thing that didn't appear capable of great strength or accuracy, and initial tests seemed to confirm the appearance. Its light recoil did not provide the impression of power that firers were used to. What appeared to be flimsy construction did not provide much confidence to the user. It was introduced to combat before the design was fully proved out, and early shortcomings of the rifle in combat gave it a poor reputation that is still being lived down.

Other objections to the M-16 came not from its design, but from the implications of its use. The US Army still continued to teach its soldiers that they were to hit their targets with single shots, and supporters of precision marksmanship didn't feel that the M-16 had either the range or accuracy that was required in battle. The cartridge employed, the 5.56mm, was familiar to shooters as the .223 Remington. Its supposed vulnerability to deflection by wind or underbrush was of considerable concern.

Ironically enough, thirty years after the adoption of the M-16, it largely won over the most traditional of shooters: target shooters. As a result of improvements developed by various Army teams, the M-16 has virtually replaced the M-1 and M-14 in competition. Despite the late-developing understanding of the M16's inherent accuracy, the conflict over accuracy vs. volume of fire continues.

Supporters of increased fire volume noted the results of tests conducted after the Korean War to support the shift to the assault rifle. Traditional marksmanship training in the Army was continually reduced as the Army adjusted to the idea that the training might very well not produce results that justified the time and money invested. The "system" seemed to be accepting the premise that the automatic fire capabilities of the M-16 would make up for the decreased marksmanship skills of the soldier.

Advocates of the precision marksmanship and the volume fire schools of marksmanship continue to argue the relative merits of their theories, with little acceptance of the underlying assumptions of the other side. The extreme advocate of precision fire may agree with the nineteenth century writer who held that "the limit of profitable individual fire is reached when the shot-group becomes equal to the object in either direction." In other words, when it becomes possible to miss the target. An extreme view of the ORO studies may be that even extensive marksmanship training can produce no significant improvement in results. As in most complex issues, the truth is probably somewhere in the middle.

The result of the current state of the controversy is a somewhat confused idea of what the role of the individual firearm is on the modern battlefield, how the soldier should be trained for it, and what the rifle for such a battlefield should look like. Modern tactics, for example, suggest that the opportunity for careful engagement of an individual target will be unusual. Training programs, however, do not properly teach what to do otherwise.

In exploring the issues involved, this paper will differentiate between three types of small arms fire:

Slow Fire, in which each shot is individually, precisely aimed in an effort to produce a hit on a particular target.

Rapid Semiautomatic Fire, in which a series of shots fired with distinct trigger pulls is directed at a target to produce a hit.

Automatic Fire, in which a string of shots is fired with a single pull of the trigger. Automatic fire is usually associated with machine-guns. The purpose of automatic fire is not necessarily to hit an opponent, but may be intended to merely pin him down, harass him, or retain freedom of movement for the friendly force. The three shot Burst Fire mode of the M16A2 rifle is a variant of Automatic Fire.

Automatic fire and rapid semiautomatic fire are often referred to together as volume fire, or assault fire techniques.

The difference between slow fire and rapid semiautomatic fire is in the intention to fire a series of shots in rapid semiautomatic. The principles of marksmanship (position, breath, sights, trigger control, etc.) are the same, but may be employed with different relative emphasis. The goal remains the same: to produce a hit.

Slow, precise firing techniques were employed with manually operated repeating rifles, not only because of their design but also because of other factors that will be discussed further. Volume fire techniques are possible with modern assault rifles. It's this new capability of the assault rifle that has forced the small arms doctrine dispute into focus.

III. A MODEL OF FIRING SPEED

The findings of a test can be strongly biased by the design of the test itself. In other words, a researcher can prove anything he wishes by cleverly designing a test tending to prove it. Even when a final result is not planned in advance, the results may be influenced by the innocent assumptions made in designing the test.

If a researcher defines rapidly delivered firepower at 25 meters or less as important, his test is likely to conclude that a submachine gun is superior to an M1 rifle. On the other hand, if he decides that the ability to deliver accurate hits at 1000 meters is important, he may conclude that a large caliber bolt action rifle is the optimum design. The conclusions of the authorities on both sides of the volume versus accuracy controversy of marksmanship are flavored by similar conscious or unconscious value judgments.

The skill of a shooter is often represented by a score achieved on a “bullseye” target. Each bullet falls within one of a series of concentric rings, each ring bearing a value. Adding the values of all of the shots provides the score. A shooter may be said to have done well if, for example, he accumulated 98 out of 100 points possible on a certain type of target. This type of scoring rewards the efficient use of each round of ammunition. This measure may be easy and understandable in competition, but it may not be *tactically* efficient. Another measure of effectiveness with small arms may be in order, such as hits per pound of ammunition and weapon, or hits per unit of time. This paper will concentrate on the relationship between the *firing rate* and the resulting *hit rate*.

It’s useful again to note the elements of the tactical environment of the nineteenth century that encouraged a reliance on accurate rifle fire. First, the soldier had only a limited supply of ammunition, not rapidly replenished from supply trains that were themselves supported by a limited production base. The firearms that were available were manually operated, perhaps single-shot. The enemy approached in a slow, compact formation for purposes of control. Long range artillery posed little threat. It was practical to engage the opponent from long range in the hopes of inflicting casualties early and discouraging his further advance. Long range marksmanship skills were profitable in this type of situation, and the longer the range of engagement the better.

The modern battlefield is radically different. In modern warfare neither side wishes to open fire at too great a range. It’s difficult to see the opponent in the first place, and early fire is likely to result in a heavy artillery or mortar barrage or in a swift mounted attack. Before engaging him with small arms, modern infantry wants to get close enough to the enemy that his opponent’s indirect fire weapons cannot be employed. At such close ranges, the level of damage that can be inflicted quickly may be more important than the number of casualties possible in the long run. When two platoons of men meet in a forest, for instance, it’s the side that hurts the other the most in the first few moments that is likely to survive as a fighting force.

THEORY

The number of hits that a shooter obtains is obviously dependent on both his firing rate and his accuracy. A series of graphs will serve to illustrate some of the relationships involved.

There is a direct relationship between shots fired and hits possible:

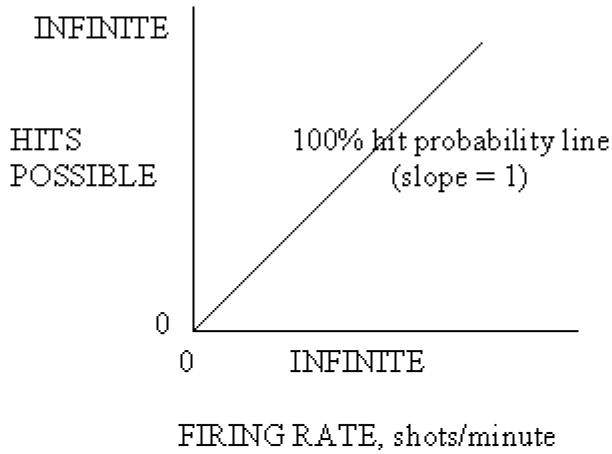


FIGURE 1, HITS POSSIBLE VERSUS SHOTS FIRED

It's similarly apparent that the accuracy of each shot of a series of shots is also related to the rate of fire (this curve is representative only, and is not based on experimental data):

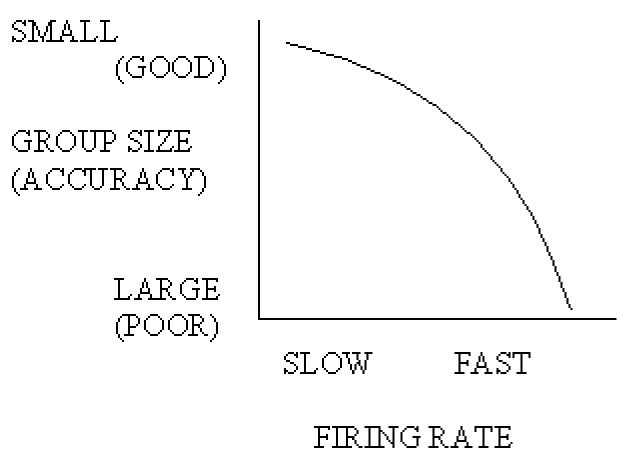


FIGURE 2, ACCURACY VERSUS FIRING RATE

The interaction of accuracy and total shots fired produces a curve that displays the relationship between shots fired and the hits obtained in a given time period. Figure 3 shows the general form of the hit rate curve expected:

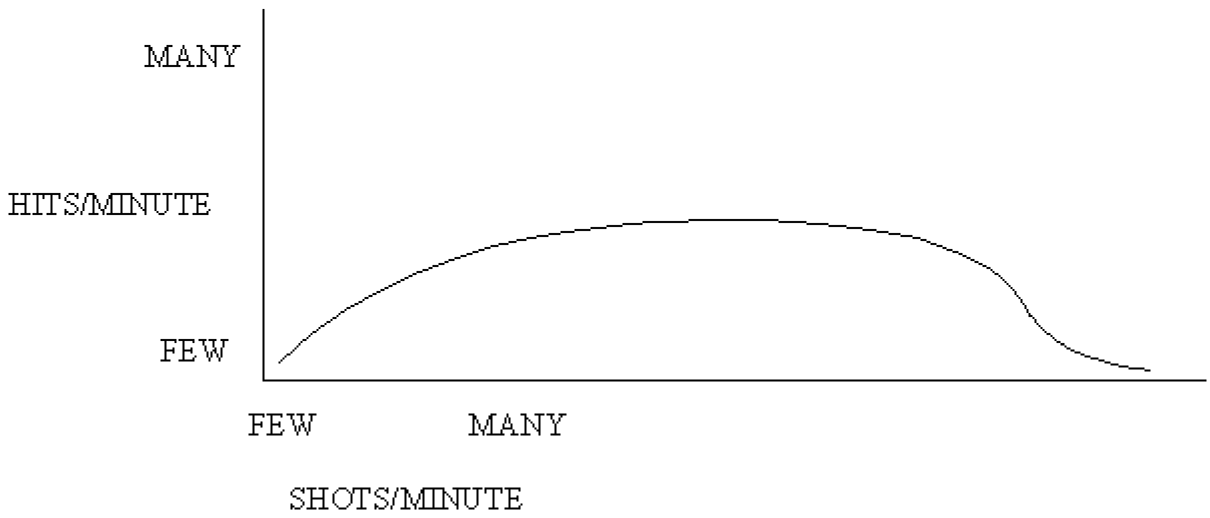


FIGURE 3, HITS VERSUS SHOTS FIRED IN A GIVEN TIME PERIOD
(THE SHOT RATE CURVE)

Consider a soldier armed with a weapon with an endless supply of both ammunition and targets. He may fire a single shot in a given time period (i.e. one minute) and have a certain chance of hitting the target. He may also choose to fire two shots in that minute. The two shots are apt to be aimed less accurately than a single shot because of the time allowed, but *the probability of achieving at least one hit is increased because two shots were fired*. The efficiency of ammunition use may have declined, but the probability of achieving at least one hit has risen. With each additional shot in that minute the accuracy of each shot will tend to decline, but the number of hits expected in the minute will continue to rise. Eventually the shooter is firing so fast, and the shots are so wild, that the number of hits starts dropping. The various theories of efficiency of marksmanship appear at different places on the curve thus generated, and their logic and usefulness can be evaluated from a standpoint that means more than a traditional percentage score.

This concept is by no means new. It is, as the saying goes, intuitively obvious to the casual observer. One Nineteenth Century writer noted that "as rapidity of fire increases, a point is soon reached beyond which the percentages of hits decrease...but up to that point at which carelessness or hurry in aiming causes an excessive decrease in the percentages, the *whole number* of hits may increase" (emphasis added).

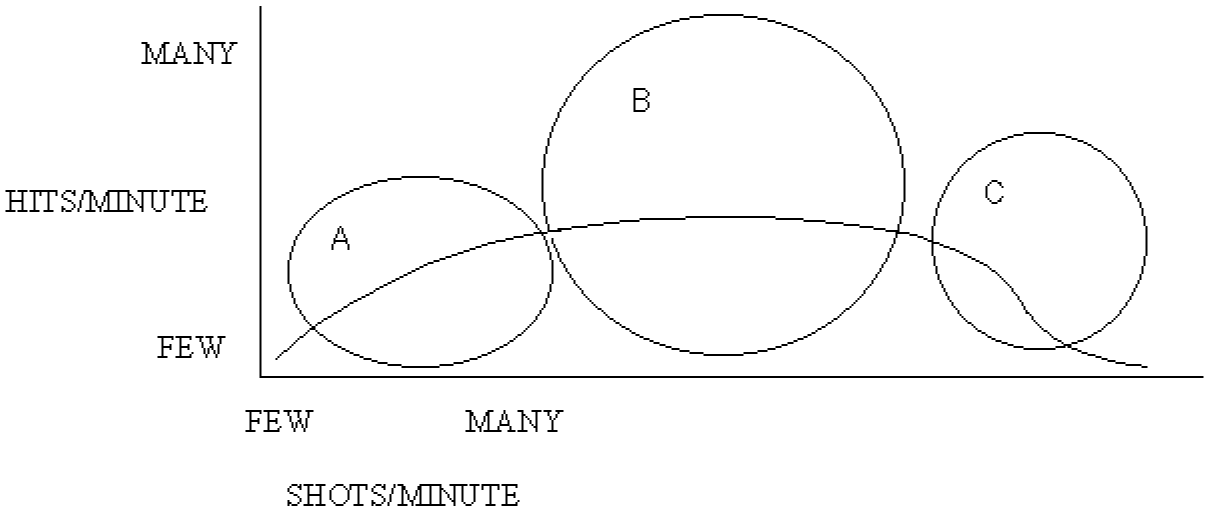


FIGURE 4, AREAS OF INTEREST

The area of the curve at the far left of figure 4, region A, provides the most efficient use of ammunition, and it would appeal to the traditional marksman and his slow fire techniques. It's also useful to the contemporary soldier who has a limited supply of ammunition, and who thus may depend on total casualties for his survival more than he can depend on short run damage. A sniper, who may only have one shot at a wary or distant target, also needs to operate in this region of the curve. Even in a modern, fast moving war, important or distant targets will appear that need to be engaged accurately.

On the other hand, a soldier who chances upon another opponent, or group of opponents, may not care how much ammunition remains at the end of a minute. He cares whether *he* remains at the end of the minute. Clearly, his interests lie with producing as much damage as possible in the time available. He can worry about resupply later. This man would employ rapid semiautomatic fire to operate in the higher parts of the curve, region B, where casualties are produced fastest.

Areas of the curve to the left produce maximum casualties per unit of ammunition. Areas at the top of the curve produce maximum casualties per unit of time. The area of the curve where hits per minute starts to drop off, region C, represents less efficient use of both ammunition and time, and represents increasingly ineffective firing technique *unless intended as suppressive, area fire*.

EXPERIMENT

A small experiment in firing rate was conducted by members of the 205th Military Intelligence Group in Frankfurt, Germany in 1984. Shooters were provided loaded magazines and limited time in which to fire at fixed, conventional bullseye targets from the prone, unsupported position. The rounds fired and actual times were recorded, so that scores could be related to firing rate. Firing was surprisingly effective at extremely fast firing rates. The following average scores were produced:

Intended Firing Rate	Average points/sec	Average points/shot	Actual firing rate shots/min
Unlimited (slow fire)	1.37	7.38	11.59
30 shots per minute	4.56	6.89	39.65
40 shots per minute	5.55	6.46	51.71
60 Shots per minute	6.26	5.77	66.60
120 Shots per minute	7.29	3.56	125.30

As expected, *accuracy* (measured in points per shot) decreased as the firing rate increased. *Effectiveness* (measured in points scored per second), however, increased even as the firing rate was increased to the rate of one shot each half second.

The approximately ¼ increase in actual firing rate from approximately 40 shots per minute to approximately 50 shots per minute resulted in almost a ¼ increase in effectiveness. In other words, the increased firing rate produced an affordable gain in effectiveness. Effectiveness improved less with further increases in firing rate.

The fastest firing rate, 125 rounds per minute, for instance, still provided an increase in score over the 66 shot per minute rate. The 1/6 or so increase in score required a doubling of the ammunition expenditure. While the test doesn't appear to have been fired fast enough to enter area C of the curve, the law of diminishing returns is clearly evident.

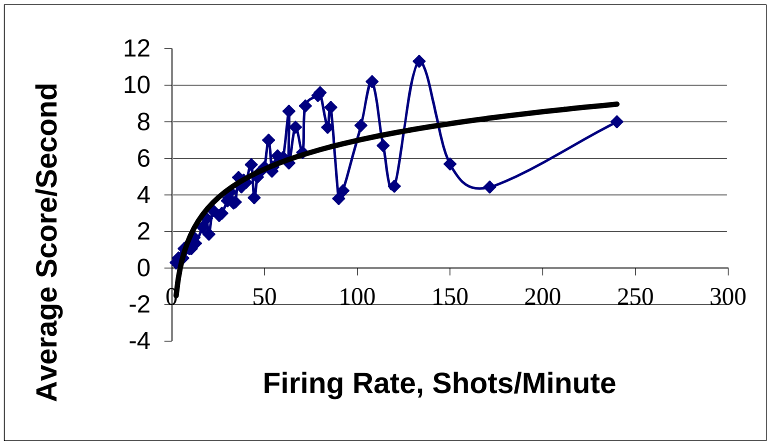


FIGURE 5, POINTS PER SECOND VS. FIRING RATE

A plot of the data generated during the test shows a steady climb in points per second, with increasing spread until about 65 shots per minute. Thereafter, the data swings wildly and increases in score become smaller.

Mathematically smoothing the data produces a curve very similar to that of Figure 4. Areas A and B of Figure 4 are clearly evident on the curve. (The slope of the curve differs from that of Figure 4 because it is distorted by the scale of the horizontal axis. The negative area of the graph is a result of the smoothing calculations.)

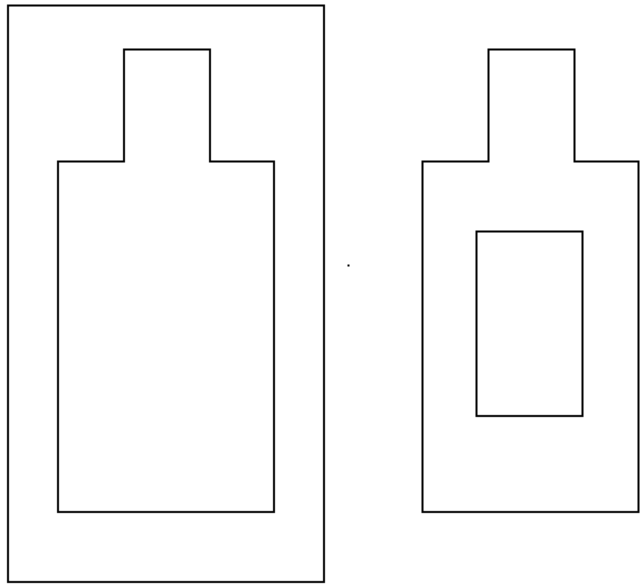
The Frankfurt test was conducted with each shooter firing at a single, stationary target from the prone position. It is most applicable to a defensive scenario. The small number of shooters (30) and small number of trials per shooter (5) means that the thorough analysis isn't possible. Nonetheless, it provides an intriguing hint at the relationship between firing rate and hits.

MODEL

Even a precisely aimed shot is not guaranteed to hit. There is only a probability, better or worse depending on the aim. In discussing the various types of fire and the different areas of the curve, it's useful to consider a simple model that recognizes the probabilities involved, and allows a common vocabulary for discussion.

First, remember that the shots fired are being fired as a group. The dispersion of this group may be regarded as creating or defining a "window."

When the rifle is aimed properly, the target is superimposed on or in the window. The chance of hitting the target depends upon how large the window is compared to the size of the target. If the target occupies one fifth of the window, the firer can expect to fire five shots, on the average, to hit the target. The smaller the window is compared to the target, the higher the probability of a hit (Ph).



Ph less than 1 Ph = 1

FIGURE 6, THE TARGET AND THE WINDOW

In battle, the target attempts to throw off or enlarge the window by running, dodging, and generally not cooperating to produce the kind of sight picture that assists in good shooting. In addition, the target attempts to make himself smaller or invisible by hiding behind terrain, vegetation, or armor. His attempts to make the window larger and himself smaller combine to reduce the probability of a hit.

No single curve will define the tradeoff between rate of fire and rate of hits for all conditions. A number of environmental, weapon, and firer characteristics may produce changes to the curve. What all curves have in common, however, is the same general shape, with a fairly broad, flat top.

Both slow and rapid semiautomatic techniques have their purpose. It’s reasonable to consider what factors will tend to drive a shooter up or down the curve, and to decide how the modern combatant should operate.

RIFLE

First, the characteristics of the firearm must be examined. The mechanism employed will obviously determine the maximum rate of fire of the weapon. The advantage of a semi-automatic rifle lies in the fact that it allows the firer to shoot faster, producing a higher curve than possible with a bolt action rifle, and producing a higher possible hit rate.

Rifle configuration will also affect the firing rate. A poorly designed stock can cause the rifle to slip off of the shoulder upon firing, requiring additional time to recover for the next shot. Magazine capacity determines how much of the available time the firer spends reloading the weapon. Well-designed sights, notably aperture or low magnification optic sights, can increase the firing rate by reducing the time required to lay or re-lay the firearm on target. A good trigger, that is to say a trigger that is relatively light and free of distracting movement or roughness, will not necessarily increase the firing rate, but will distract the shooter from other aspects of firing less than a poor trigger. It may minimize the effect of errors in trigger manipulation.

The accuracy of the rifle may dictate the area of the curve that is most effectively employed. A relatively inaccurate rifle is obviously a poor candidate for use as sniper rifle, and may be better employed at short range and firing at a faster rate.

The skill and discipline of the firer himself obviously determines the height to which the curve may rise. It's reasonable to expect that the better shooter will exhibit a curve with a steeper slope in the single shot region (A), a higher rapid semiautomatic fire region than a poorer firer (B), and a delayed drop in firing efficiency in area C.

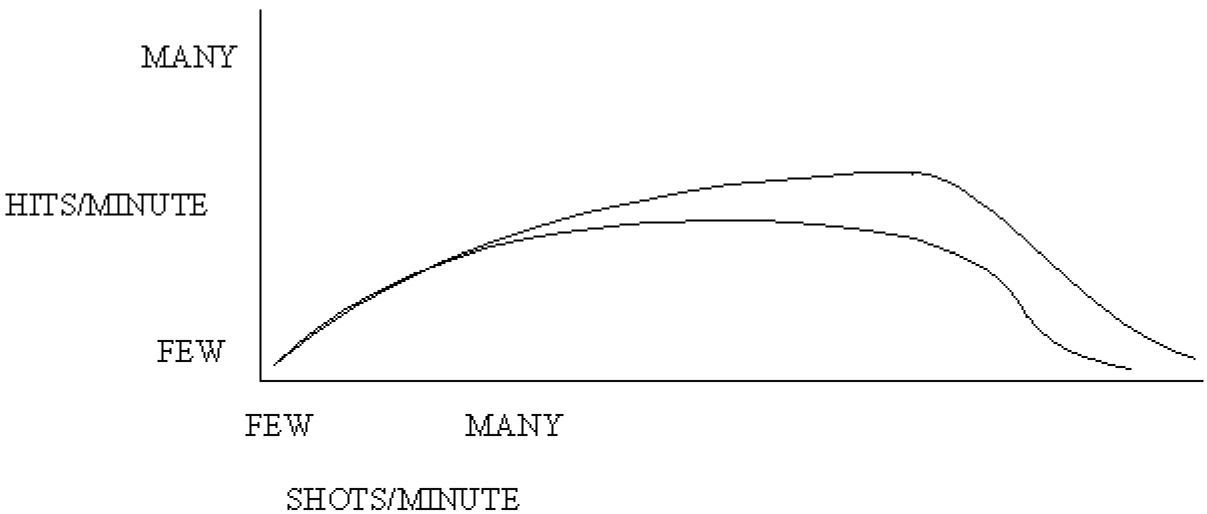


FIGURE 7 EFFECT OF TRAINING OR EXPERIENCE

Repeated testing has indicated that the casualty production capacity of the best shooters may not be greater than that of the worst under conditions of stress.

AMMUNITION

The ammunition used has a major bearing on the hit rate curve, not only because of its accuracy, but because its recoil has a major effect on the firing rate. The 7.62mm NATO cartridge has a long-range accuracy advantage over the 5.56mm cartridge, but the heavy recoil of the ammunition results in a dramatically reduced firing rate. At the shorter ranges typical of modern combat, rifles firing the 5.56mm round regularly achieve a significantly greater hit rate than does the longer range 7.62 round. In one major test, firers using 5.56mm fired 73 shots at 100 yards and obtained 69 hits. Firers using the 7.62 round obtained 58 hits with 66 shots. Lighter recoiling cartridges thus have an advantage at the higher firing rates of region B, and the traditional, powerful rifle cartridges have an advantage in region A.

TERRAIN AND TACTICS

Terrain and tactics combine to influence the choice of firearm doctrine. If ranges are long, the firer will tend to want to open fire as early as possible, using precision fire techniques to inflict damage. If the opponent has weapons with which to retaliate, such as artillery or mortars, or if he can button up in armored vehicles and rush the firer's position, it would be foolish for the firers to reveal their battle positions too soon. In this case it may be more sensible to wait until distances narrow, and engage with rapid semiautomatic fire techniques. A single, wary target may present the opportunity for only a single shot and thus require precision, while the previously illustrated fast moving opponent at close range dictates the use for volume fire. Neither technique of fire is appropriate in all conditions.

SUPPLY

Last, the logistical situation may determine which firing technique is appropriate. If ammunition is plentiful and the tactical situation requires producing a maximum number of casualties in a short time, rapid semiautomatic fire (assault rifle) techniques may be best. On the other hand, if ammunition is in short supply, the survival of the force may be best ensured by making every shot count and thus inflicting more damage in the longer run.

Unfortunately, a soldier can only carry one primary weapon into battle. The weapon carried cannot be expected to fill all roles perfectly, but must have qualities that make it as useful as possible under the battle conditions that can be reasonably expected. Modern battle techniques, battlefield conditions, and a rational understanding of the abilities and limitations of the typical soldier are leading an increasing number of nations, both major and minor, to shift from traditional heavy rifle calibers to smaller calibers and associated assault rifles. Even as this significant shift goes on, however, few agencies are questioning the basic precepts of marksmanship by which the new rifles will be used.

Traditional techniques of slow fire are well established, both in the military establishment and in the ranks of the worlds target shooters. Automatic fire is well known, if not necessarily well employed. Detailed consideration of the possibilities of rapid semiautomatic fire with modern rifles is harder to find, although the simple underlying theory is implicitly accepted by most exposed to it. It appears that the possible battlefield benefits of properly applied rapid semiautomatic fire should lead to further study of its parameters, and to an effort to train soldiers to get the best results from it.

IV. THE IMPLICATIONS OF RAPID SEMIAUTOMATIC FIRE

Small arms training, equipment, and tactics have been developed on a base of precision and automatic fire techniques. The potential values of properly controlled rapid semiautomatic fire have not yet been rigorously verified by test. Fortunately, rapid semiautomatic fire poses no problems that have not been addressed already.

TACTICS:

The worries of Nineteenth Century commentators, who anticipated that the soldier would use a rapid-firing weapon to do just that, thereby expending his whole supply of ammunition, were not totally unfounded. Studies of Korean War engagements revealed that the supply of ammunition for automatic weapons was quickly depleted, but that ammunition for the rifle generally sufficed until resupply was effected. Conservation of supplies on hand, as well as indications of its inferiority to semiautomatic fire, dictates that automatic rifle fire should be employed only at night, during short-range engagements (within 25 meters or so), or by designated automatic riflemen.

It's useful to stop here to address the issue of three shot bursts. As noted above, automatic fire with the M-16 is more effective than semiautomatic only within *25 meters*. This suggests that it's employed best in room to room or trench fighting. At such close ranges the goal must be to make a few feet of space uninhabitable for the enemy. *A three shot burst is ineffective in this role,* first because three shots don't spread out very far, and second because a stressed shooter will often release the trigger so fast that only one or two shots are fired. Since the M16A2 trigger mechanism doesn't reset when released, the soldier will tend to fire a ragged series of one, two, or three shots "bursts."

Current battlefield conditions dictate the employment of rapid semiautomatic fire. Its use by riflemen will in turn require changes in other tactical measures. Adoption of close range rapid semiautomatic fire to engage fast moving, opponents will increase the need for the opponent to move even faster, armor himself better, and employ more or better supporting fires to reduce the effectiveness of rapid semiautomatic fire.

TRAINING:

Shooting, like any skill, is performed by applying basic techniques properly. The techniques of slow fire have been thoroughly developed in training and competition since the Civil War by both military and civilian shooters. These techniques have formed the basis of the firing techniques that are taught to American soldiers today.

By contrast, rapid semiautomatic fire techniques are seldom taught. There is no defined course of fire, target, or training standard. We don't know how to train it, and we don't know when we're doing it well. There is little likelihood that rapid semiautomatic fire will be well applied on the battlefield.

The basics of military rifle marksmanship as currently taught in the US Army are referred to as the four key fundamentals: steady position, aiming, breath control, and trigger squeeze.

While these fundamentals are generally taught as tools for firing precise, single shots, they have been related to rapid semiautomatic fire in the 1989 edition of FM 23-9, M16A1 and M16A2 Rifle Marksmanship. *This is the first time rapid semiautomatic fire has made its way into Army doctrine*.

Oddly enough, a substantial body of knowledge concerning rapid semiautomatic fire has been built up by the same shooters who object to faster firing rates the most: traditional target shooters. The rapid semiautomatic fire techniques that produce the best results on the target range might be worth transferring to the soldier.

The basics of rapid semiautomatic fire technique have been well developed by target shooters for use in competition. The "National Match Course," is a conventional target match that includes several events which require the shooter to assume position, fire ten sustained shots in as little as 60 seconds, and reload somewhere in the middle. In addition, the prestigious "Infantry Trophy Team Match" rewards teams of shooters who best use rapid semiautomatic fire techniques to deliver a maximum number of hits from the greatest range possible. The fundamentals of this competitive event relate directly to rapid semiautomatic fire in combat.

Although military marksmanship training doesn’t ordinarily include a rapid semiautomatic fire event, the continued use of the National Match Course and Trophy matches has served to continue the awareness of the techniques required. What are the additional techniques required to engage a moving target on the dynamic battlefield, and how should they be trained?

In classic target shooting, the shot fired is followed by a *follow-through* phase, a moment during which the shooter absorbs the recoil of the weapon, and recovers as closely as possible to the shooting position he held just before the shot. Follow through is used in sports from discus throwing to Judo to shooting, and is intended to assure that the sportsman doesn’t halt his movement (or shot) early. In shooting, it also serves to make evaluation of the shot easier by providing hints in the form of the final resting position of the firearm.

In rapid semiautomatic fire, on the other hand, the shooter wishes to recover from recoil, return to firing position, re-acquire the target, and immediately commence the next shot. It is the recovery process that marks the difference between slow and rapid semiautomatic fire. Although service rifle shooters use a sustained firing rate, it’s explained in more detail in instruction manuals intended for pistol shooters. Crucial elements include:

1. Firing a string of shots requires extension of the basic factors used in firing slowly, with the addition of recovery and rhythm.

2. After the weapon fires it will be moved by the recoil of firing, and it must be recovered instantly to the position it occupied prior to the dislocating effects of recoil.

3. During recovery, from recoil, reestablish sight alignment without a focus shift.

4. The firer must immediately reestablish a positive, steadily increasing pressure upon the trigger. Summing the process up, "the shooter should make every effort to keep his

arc of movement at a minimum, continue positive trigger pressure, maintain sight alignment, and shoot with a definite rhythm."

Errors of trigger control are increased in rapid semiautomatic fire. Hoping to maintain a given tempo of fire, or trip off a shot just as the sights center on the target, the firer will tend to jerk the trigger. The predictable result is that shots tend to drift low and, in the case of a right-handed rifle shooter, to the right. Left-handed shooters jerk the shots low left.

The essential element in a rapid semiautomatic fire training effort is not time, because by its nature rapid semiautomatic fire is done quickly, but rather the ammunition allotted to it. We don't yet know the most effective method of teaching rapid semiautomatic fire skills, but it's reasonable to expect that several hundred rounds per shooter will be required in training rapid semiautomatic fire skills. Much of the training can be done with inexpensive .22 caliber semiautomatic training rifles.

Range based marksmanship training is only the beginning of the individuals training for combat shooting. Once the basic marksmanship skills have been developed, they have to be translated to conditions under combat. Too often, the relationship of marksmanship training to effective combat employment of small arms fire is forgotten.

It's important to note that nothing in the rapid fire techniques proposed in this paper allow a reduction in training in the basic marksmanship principles as now taught. Rapid semiautomatic isn't a substitute of good marksmanship training: it is an extension of it to a more effective mode of fire.

TRAINING REALISM

Oddly enough, the worst marksmanship training possible is performed when firing blanks. Trainees frequently run through maneuvers firing blanks wildly, without properly employing good marksmanship technique. Aiming, fire control, and fire distribution are normally ignored because shots are fired with "just blanks". Soldiers like the rattle of automatic fire, and will expend blanks on it eagerly.

Despite the fact that M-16 blank adapters will safely trap a bullet fired from a ball cartridge, soldiers are often prohibited from aiming at opposition forces during training as a safety measure. Soldiers are frequently required to deliberately fire misses.

The significance of such neglect of basic fire discipline should not be ignored. The soldier who fires his weapon on full automatic in training because it's fun must be expected to do the same in combat because it's habit. A soldier trained to miss will do so instinctively.

Fortunately, the problems can be cheaply addressed with the kind attention of the supervising NCO and a few therapeutic push-ups. The attentions of trainers should be directed to the details of fire discipline on a continual basis if rapid semiautomatic fire is to be successfully employed. A few principles must be strongly reinforced:

1. *All* shots must be aimed through the sights.
2. All shots must be fired *semiautomatically*, unless the tactical situation or assignment properly requires automatic.

3. Training must *reinforce the fundamentals*. Even blanks must be fired with the fundamentals applied.

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RIFLE DESIGN:

Few subjects are likely to stir the emotions of an Infantryman more than the design of his rifle. The issue is complicated because rifle design is a compromise of cost, weight, reliability, accuracy, and other factors. No one rifle will be best in all situations, but an Army can only field a limited number of small arms designs. Some factors that lend themselves to effective rapid semiautomatic fire are already known from competitive experience.

First, the cartridge and rifle design must obviously be accurate enough to meet the requirements placed on it in combat. This is not a simple issue at all. Combat conditions on the modern battlefield indicate that the ability to hit a target about 18 inches wide at 300 meters is sufficient, but even this is debated. Some authorities have suggested that a large shot group, an inaccurate rifle, was actually desirable because it allowed better coverage of the target area. Others feel that the better the accuracy of the rifle, the better the likelihood of a hit. The accuracy required of a rifle and cartridge combination lead directly to the costs of the final product. All other factors being held constant, it’s more expensive to build an accurate rifle than a less accurate one. The accurate rifle also tends to be heavier because of weight retained on the barrel, and can be more prone to malfunction due to tighter tolerances ordinarily employed in the search for improved accuracy.

Few authorities today believe that an intentionally inaccurate rifle will improve hit rates. Even if it did, it’s probably more important to build the soldier’s confidence by providing him an accurate rifle. Few soldiers will eagerly engage in a risky activity like close combat if they don’t trust their individual weapon.

Much effort has been expended, especially in the United States, to produce accurate rifle sights. Accuracy in rifle sights has traditionally meant the ability of the firer to precisely zero the rifle, to align the bore and sight lines so that he hits the target reliably. This doctrine isn’t universal. Some armies have skilled shooters adjust all of the rifle sights in a unit. Others have skilled shooters fire each rifle and provide its user a small picture of where it hits, so that they can hold off accordingly.

Accuracy is only one characteristic of sights though. The speed with which they can be trained on a target, the ability to use the sights under poor light or weather conditions, and their ability to stand up to the rigors of a battle environment all are traded against the precision of aim. Sighting precision is reasonably considered sufficient when one unit of sight adjustment will not shift the bullet impact off the target at normal battle ranges. American designs since the mid thirties have tended to employ sights capable of being adjusted in one minute increments, which shift bullet impact one inch at one hundred yards.

In rapid semiautomatic fire, the emphasis is shifted from precision to the ability to rapidly engage targets, to rapidly recover from recoil and come back to the target. Aperture sights display a good compromise of accuracy, simplicity and speed of use, ruggedness, and flexibility under tough conditions. Optical sights can be even simpler to learn and use than aperture sights. Recent adoption of a simple unit power (1X) telescopic sight by Austria, the United Kingdom, and Germany confirm a shift towards telescopic sights.

It was noted earlier that rifle caliber and configuration had in impact on the useful firing rate of the weapon. In order to shoot faster, the rifle's configuration should be such that the weapon's muzzle doesn't climb during fire. The recoil of the weapon should be in a straight line into the shooter's shoulder so that muzzle rise is minimized. The rifle cartridge should produce as little recoil impulse as possible while remaining effective, or the rifle should have recoil damping mechanisms (buffers, muzzle brakes, etc.) to reduce the effect of recoil. The rifle should not be so light that it cannot be held stable or so that even a mild cartridge causes excess discomfort or disruption to the shooter.

Accurate shooting is a complex act. Any disruption of the act of firing tends to degrade shooter performance. In slow fire, disruptions may be worked through by sheer will power to deliver a successful shot. In rapid semiautomatic fire, on the other hand, there is insufficient time to work through problems. When the shooter is distracted by a bad trigger he is more likely to jerk a shot than if the trigger was "good." In spite of studies that show that poor triggers may have little effect on accuracy, competitive shooters have long concluded the opposite.

Numerous assault rifle designs are employed throughout the world. It's uncertain that the peculiar needs of a firearm tailored to rapid semiautomatic fire, whether it's a good trigger or new optical sights, are worth the expense involved. Nonetheless, the peculiarities and potential of rapid semiautomatic fire deserve closer attention as new designs are evaluated.

IV. CONCLUSIONS AND RECOMMENDATIONS

Today, the U.S. Military is generally conducting small arms training with much the same emphasis on single round accuracy that it did eighty years ago. Preliminary data suggests that a substantial increase in lethality can be obtained by increasing the firing rate of the line. The principles now taught are generally sound, and little additional training is needed to squeeze an important increase in effectiveness from our soldiers. Rapid semiautomatic fire is a simple extension of existing training, and its benefits are easily achieved by emphasis during training.

To make the best of Rapid Semiautomatic Fire we must:

1. Test the benefits of rapid semiautomatic fire. The data presented in this document is sparse in the extreme. It has never been systematically studied by the services.

Additional firing data needs to be gathered to learn the effect of training, position, tactical situation, and weapon design. Fortunately, the experiments aren't lengthy or difficult to conduct. The apparent flattening of the firing rate curve suggests that a rule of thumb rate of fire such as "50 shots per minute in the final assault" is adequate guidance. Lengthy testing to pin down exact numbers under a variety of scenarios might be interesting, but will probably not prove useful.

2. Raise the curve.

Once the issues related to the curve are understood, we should develop those talents, conditions, or actions that increase the hit rate, i.e. raise the curve. A number of possibilities appear useful

Aim every shot. The current edition of FM 23-67, providing doctrine for the M60 Machinegun, shows a machine gunner boldly firing the weapon from the hip. An M60 is too heavy to fire readily from the shoulder, so aiming every shot with this arm may be difficult. Nonetheless, advancing with a weapon firing from the hip must be regarded as an act of desperation or idiocy. The very fact that such an unsound technique is posted to the cover of a major document is a poor indicator of fire discipline.

Even machineguns must be sighted if at all possible. There can be no exceptions for blanks.

Make it a Tradition. Aiming every shot should not be a training imperative: it should be a tradition. Rifle cleaning provides an interesting example of a task that is raised to a tradition.

Many NCOs believe that rifles must be cleaned each day for three days after firing. Many units thus conduct multiple cleanings after firing.

This tradition dates back to the use of corrosive primers in small arms ammunition. When fired, the primers left a small deposit of salts in the grains of the barrel steel. These salts leached out of the steel over a period of days. If not carefully removed, the salts would absorb moisture from the air and encourage corrosion. The corrosion can literally take place overnight.

The government hasn't purchased corrosively primed ammunition since 1954, yet soldiers are still cleaning rifles for three days running.

The tradition of three cleanings has carried forward from 1954 because NCOs ingrained it in their subordinates, who in turn passed the tradition to their subordinates when they later became NCOs.

Establishing a tradition of aiming every shot rests properly with the NCO Corps. From the first day a soldier or Marine handles a rifle, he should be driven to bring the rifle to the firing position every time he pulls a trigger, whether in training or merely lowering the hammer to turn the rifle in to the arms room.

Support the tradition in training.

Current qualification courses provide the shooter one round with which to engage each target. This isn't tactically realistic. The current courses punish a shooter using rapid semiautomatic fire for even nearby targets.

In combat, the soldier is presented with a significant logistics issue: how to consume his basic load of ammunition with greatest efficiency. When presented with a distant target, he may need to fire several rounds to get a hit. If he does so, however, he may run low on ammunition. When presented with a threatening, nearby target later, he may be out of ammunition. He certainly must not decline to fire a second shot at that nearby opponent if the first shot is a miss.

This is just what the current qualification courses train the soldier to do. Current training teaches the wrong lessons. Each target is addressed by one cartridge. The correction to this is simple. Issue sufficient ammunition to allow for misses. Reward the shooter based on targets ultimately hit. Reward him further with a few points based on ammunition remaining. The highest scores obviously continue to go to the best shots, who both hit many targets and return with ammunition, but all are trained to engage.

Avoid burst or automatic fire. As previously noted, there is ample evidence proving that automatic fire is almost useless beyond 25 yards. It is essentially useful for room to room fighting or trench clearing. Three shot burst if largely useless for both close combat and longer range fighting. It is truly the worst of both worlds. Both automatic fire with the M-16A1 and Burst fire with the M-16A2 should be strenuously discouraged by the same NCOs who reinforce the act of aiming every shot. This is especially important during training with blanks, because soldiers enjoy automatic fire as a matter of play.

In summary, aiming assures maximum efficiency with each shot. Rapid semiautomatic fire assures maximum efficiency with each moment of contact. Combined, they offer a substantial increase in combat effectiveness with little change in resources or doctrine. The success or failure of these changes hinges on the skills of the supervisor most able to influence the soldier: his NCO.

 MARK WESTROM