IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF ILLINOIS

CALEB BARNETT, et al., Plaintiffs, v. KWAME RAOUL, et al., Defendants,	Case No. 3:23-cv-209-SPM **designated Lead Case
DANE HARREL, et al., Plaintiffs, v. KWAME RAOUL, et al., Defendants,	Case No. 3:23-cv-141-SPM
JEREMY W. LANGLEY, et al., Plaintiffs, v. BRENDAN KELLY, et al., Defendants,	Case No. 3:23-cv-192-SPM
FEDERAL FIREARMS LICENSEES OF ILLINOIS, et al., Plaintiffs, v. JAY ROBERT "J.B." PRITZKER, et al., Defendants.	Case No. 3:23-cv-215-SPM

DECLARATION OF MICHAEL MUSSELMAN

I, Michael Musselman, declare as follows:

1. I am at least 18 years old and have personal knowledge of the statements contained in this Declaration.

2. The statements contained in my expert report that I co-authored in this case, dated May 10, 2024, and attached hereto as **Exhibit 1**, are true and accurate.

3. If called to testify at trial in this case, I would testify to the matters set forth in my expert report provided in the above-captioned cases. My testimony would be consistent with all of the statements in the report, which included a complete statement of all opinions expressed, the basis and reasons for such opinions, the facts and data considered by me in forming said opinions, discussion about and identification of my qualifications as an expert witness (including any publication I may have authored in the previous 10 years and any cases during the previous 4 years where I may have testified as an expert at trial or by deposition), and a statement of compensation paid to me for study and testimony in this matter.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on September 13, 2024 within the United States.

s/ Michael Musselman
Michael Musselman
Declarant

EXHIBIT 1

JOINT REPORT OF EXPERT WITNESSESS JEFFREY EBY AND MICHAEL MUSSELMAN

BACKGROUND/QUALIFICATIONS

Jeffrey Eby

I, Jeffrey Eby, served in the United States Marine Corps from June of 1982 through November of 2010. I spent 17 years as an enlisted infantry Marine before receiving a Commission to Chief Warrant Officer-2 in February 1999. I retired as a Chief Warrant Officer-5, as the senior infantry weapons officer in the Marine Corps, serving under the Deputy Commandant for Plans Policies and Operations inside the Pentagon in November 2010. As an Infantry Weapons Officer, I served as an expert advisor at the Infantry Battalion level (900 Marines), Infantry Regimental Combat Team (10,000 Marines), as well as the advisor to the Deputy Commandant of Plans, Policies & Operations as the Infantry Advocate for all manning, training, and equipping efforts in support of the Marine Corps (175,000 Marines). During this time, I served in 4 combat deployments to Iraq for a total of 27 months. I was one of 44 infantry weapons officers among 175,000 Marines when I was commissioned in 1999, retiring as one of the 101 infantry weapons officers among 175,000 marines in November 2010. The growth of the infantry weapons officer program escalated in 2003 from 44 to 101 as operations Iraqi freedom and Enduring Freedom in Iraq and Afghanistan continued.

Marine Corps Infantry Weapons Officers, titled Marine Gunners, are considered the USMC's experts on small arms within ground combat. The job of the Marine Gunner is to train Marines on the care, cleaning, and employment of all individual and crew served weapons (2 rifles[1], 3 sniper rifles, 2 grenade launchers, 4 different machine guns, 2 mortar systems, 4 rocket systems, 2 anti-tank missile systems, a 25mm bushmaster cannon, tank main gun capabilities, artillery capabilities, all associated day and night aiming systems, laser pointers and illuminators, as well as all breaching techniques using ballistic, mechanical or explosive methods) within the ground combat forces. Marine Gunners are tasked to develop training programs for weapons, both individually and in combination of systems, and then to advise commanders on the best selection and employment of various weapons systems that will cause the most effective opposition for our enemies.

Michael Musselman

I, Michael Musselman, served in the United States Marine Corps from June of 1985 through July 1st of 2015, spending 18 years as an enlisted Marine serving in the infantry as a 81mm mortarman, Fire Direction Chief, Forward Observer, Platoon Sergeant, Battalion Master Gunner for the 25mm Bushmaster chain gun and coaxial medium machinegun, I received my Commission as Chief Warrant Officer 2, Marine Gunner in February of 2003. During which

---

[1] The US Army Weapon Systems Handbook 2020-2021 Weapon Systems Handbook 2020-2021 (army.mil) does not use terms such as "service, assault, nor battle" when defining the basic issued rifle in the hands of combat units. The simple term 'rifle' is sufficient, as indicated within this reference on pages 142, 144, 180, 208, 209, 320, 354, 372, 376, 382, 388, 390,

time, I studied ballistics while stationed at Quantico, Virginia, worked with numerous police departments on consulting with their firearm training personnel, to include Chicago PD, Illinois State Police, Naperville PD, Boston PD, New York PD, Virginia State Police, and several other agencies, started the Marine Corps Combat shooting team, to focus on different methods of weapon handling ang target engagement. I retired as a Chief Warrant Officer 5 Marine Gunner for the 1st Marine Division at Camp Pendleton , California responsible for the overall tactics and policies regarding all small unit weapons systems for 24,000 Marines within the first Marine Division as well as the first Marine Expeditionary Force, I planned and executed six division level live fire exercises, which incorporated several different weapon systems to include, M4, M16A4, 60mm and 81mm mortars, M249 light machinegun, M240 Medium machinegun, M2 .50 cal Heavy machinegun, all anti-tank missiles and rockets, demolitions and explosives, 155mm Artillery, M1A2 Main Battle Tank, all aircraft both fixed wing and rotary wing rockets and bombs all within close proximity of Marines conducting ground maneuvers. I made five combat deployments to Iraq and Afghanistan which my role was ensuring the Marines were using the most effective use of weapon and targeting systems to engage enemy combatants with direct fire and indirect fire, and also trying to determine the cause of injuries inflicted by the enemy on US service members in order to develop better training and tactics. I personally rewrote the entire manual on 25mm Bushmaster Chain gun Gunnery and qualifications. I served on several Marine Corps rewrite teams changing infantry doctrine, tactics and procedures concerning small, medium and large caliber weapon systems.

OPINIONS

It is our understanding that Illinois restricts as “assault weapons” any:

A. semiautomatic rifles that accept detachable magazines and have one or more of the following features:
   i. a pistol grip or thumbhole stock;
   ii. a protruding grip that can be held by the non-trigger hand;
   iii. an adjustable, folding, thumbhole, or detachable stock;
   iv. a flash suppressor; and
   v. a shroud attached to the barrel or that partially or completely encircles the barrel, allowing the bearer to hold the firearm with the non-trigger hand without being burned, but excluding a slide that encloses the barrel.

B. Semiautomatic rifles that have a fixed magazine with the capacity to accept more than 10 rounds.

C. semiautomatic pistols that accept detachable magazines and have one, multiple, or all of the following features:
   i. a threaded barrel;
   ii. a second pistol grip or another feature capable of functioning as a protruding grip that can be held by the non-trigger hand;
   iii. a shroud attached to the barrel or that partially or completely encircles the barrel, allowing the bearer to hold the firearm with the non-trigger hand without being burned, but excluding a slide that encloses the barrel;

iv. a flash suppressor;
v. the capacity to accept a detachable magazine at some location outside of the pistol grip; and
vi. a buffer tube, arm brace, or other part that protrudes horizontally behind the pistol grip and is designed or redesigned to allow or facilitate a firearm to be fired from the shoulder.

D. Semiautomatic pistols that have a fixed magazine with the capacity to accept more than 15 rounds.

E. semiautomatic shotguns that have any one of the following features:
i. a pistol grip;
ii. a fixed magazine with the capacity of more than 5 rounds; or
iii. the capacity to accept a detachable magazine.

Based on the weapons expertise we have acquired and that was expected of our specific rank in our service to the USMC, and the supporting documentation cited herein, we will opine on the capabilities that are expected of weaponry used in military combat and how virtually none of the firearms that Illinois has restricted falling into the above-described categories are even used by militaries, let alone meet those standards that the military demands. Specifically, in sum:

1. Beyond certain semi-automatic-only .50 caliber special application rifles and the M14 which has been converted to a M39 Enhanced Marksman Rifle (EMR), we are unaware of a single military in the world, let alone any branch of the U.S. military, that uses any semiautomatic-only rifles for general combat purposes.

2. We are unaware of a single military in the world, let alone any branch of the U.S. military, that uses pistols that meet the above description. The pistols that are used by military personnel do not serve any combat purpose; rather they are a last-line of self-defense for certain limited personnel.

3. While the military does employ shotguns, including semiautomatic ones that have a pistol grip and a fixed magazine with the capacity of more than 5 rounds (We are unaware of any shotgun used by the military that has the capacity to accept a detachable magazine), shotguns have no significant combat tasks to perform.

4. It is our understanding that, in defining "assault weapon" for rifles/handguns, Illinois does not distinguish between those that use centerfire ammunition and those that use rimfire ammunition. In other words, rifles/handguns that use rimfire ammunition can be "assault weapons" under Illinois law. Firearms using rimfire ammunition, regardless of their configuration, are not used in the military for any purpose, let alone combat. Rimfire ammunition generally comes nowhere near the power desired of ammunition used in combat. We are unaware of any rimfire ammunition ever used by any military, in the U.S. or otherwise; at least not in the 20th or 21st centuries.

RIFLES

The last general purpose issued semi-automatic only rifle for U.S. forces was the M1 Garand, which ceased service in 1957 when it was replaced by the select fire[2] M14 rifle with a 10-20 round detachable box magazines. In 1962, the M14 was replaced with the M16 series rifles , which are still in use today. In sum, no common service rifles have been semi-automatic only since 1957, which was the last time the US fought against a peer opponent.[3]

Following combat against the Chinese army in Korea in 1950, the military services realized that a higher volume of rifle fire was necessary against 'peer' opponents than what could be achieved from the slow firing, slow to reload, and difficult to manage recoil of the M1 Garand chambered in the larger .30-06 cartridge, or the older bolt action M1903 Springfield rifles in common use throughout the military.

Fighting against a peer opponent requires a choreographed response during an engagement. The infantry usually meets the opponent by receiving gunfire from an entrenched or hidden force (historically we in the USA are the 'moving' force, attacking a prepared 'defending' force). The infantry rifleman requires a high volume of accurate fire to 'suppress'[4] an opponent into position. Think of suppression as an action that prevents the enemy from rising out of prepared positions to shoot at US forces. Sufficient suppression prevents enemy action and is measured by overwhelming the enemy's ability to return fire for the duration of friendly force firing. These are not precision aimed fires, as it is very unlikely that an enemy is visible to the approaching US forces as you would see in historical photos of the Civil War or World War I. These are not long duration fires either, as the attack develops and is executed rapidly, generally taking less than 2-3 minutes overall.

The riflemen need an extremely high volume of sufficiently accurate shots that will allow time for the 3-man machine-gun teams to be moved forward to the point of contact, mount their weapons onto tripods to support the engagement, locate the target areas, select an engagement criterion[5], initiate firing shots and to refine their impact areas (of bullets) sufficient to continue suppressing the enemy. The machineguns suppressing the enemy positions allow the rifleman to slow down their rate of fire, preserving ammunition, cooling down the weapons, allowing leaders

---

[2] A selector lever on the common general purpose rifle has three settings: Safe, Semi-Automatic, or Full-Automatic

[3] See **Exhibit 1**, FM 3-0 Operations, 01 October 2022, page x, defines a peer opponent as an adversary that contests the joint force in all domains through several methods: Information warfare, Preclusion, Isolation, Sanctuary and Systems warfare. FM 3-0_WEB_Working.pdf (army.mil)

[4] Field Manual 3-34.2, Combined-Arms Breaching Operations: "Suppression is a tactical task used to employ direct or indirect fires on enemy personnel, weapons, or equipment to prevent or degrade enemy fires and observation of friendly forces."

[5] Engagement criteria of Machineguns relate to fires in respect to ground (plunging, grazing), target (frontal, flanking, enfilade) or gun (fixed at one target point, searching near to far, traversing left to right)

to determine the next available actions (call in mortars or artillery, send in tanks or armored vehicles, call in air delivered strikes, or even to start disengaging if the contact conditions are not favorable to friendly forces).

Many studies were conducted by the US Army during the 1950s and 1960s to determine if semi-automatic firing rifles were sufficient for future ground combat. One study evaluated "flechette" rounds versus single projectiles per trigger pull, determining that flechette rounds had a higher casualty rate compared to single shots.[6] Another study evaluated a mix of weaponry from smaller 5.56mm projectiles to heavier 7.62mm projectiles, determining squads armed with low impulse 5.56mm weapons were superior to squads armed with 7.62 weapons in target effects, sustainability of effects, and overall effectiveness[7]. In all instances, automatic fire for short durations (2 min or less) against multiple targets provided significant increased hit probability vs semi-automatic fire. The end result of these and similar studies was the elimination of semi-automatic only rifles in consideration for future military service rifles.

By the early 1960's, the US Military had moved to select-fire M16 variant weapons because of the two decades of studies and experiments. The initial M16 rifle had three selection settings available: safe, semiautomatic and fully-automatic. The M16A2 variant was modified to provide a 'burst of three rounds' setting instead of fully automatic to save ammunition, increase hits on target, and prevent the weapon from overheating while firing fully automatic. The training programs in the 1960s were not well developed to support the difficult action of shooting fully automatic, which was made more difficult by the much higher recoil of the heavier bullets in use before the M16 series weapons came along. The cartridge that the U.S. military uses in all its M16s, as do all NATO countries today, the 5.56x45mm NATO, is considered among, if not *the* weakest of all centerfire rifle cartridges. Using it relatively mitigates the punishing recoil of full auto fire with larger calibers, which improves accuracy of suppressive fire at a target area.

The methodical warfare practices from the Civil War until after Vietnam had US forces executing a type of defensive warfare up until the mid-1980s, in which infantry moved from one defensive position to the next, dug fighting-holes and awaited an enemy attack (WWII was fought like this by most Infantry across the Pacific Island-hopping campaign and in Europe). In the 1980s, all U.S. ground forces changed to Maneuver Warfare, which had much less use of fighting-holes and saw US Forces in the offensive predominantly. Automatic, unaimed fire to suppress enemies' defensive position became the normal engagement behavior during training against the more dangerous peer level threats.

---

[6] Project Salvo I, conducted by the US Army Operations Research Office, published in 1959 conducted experimentation using multi-dart "flechette' type projectiles, automatic fire vs semi-automatic fires with a measurement of increased/decreased casualties metrics against cardboard targets. Automatic fires provided a 60% increase of casualties over single rounds fired. Smaller, lighter weapons provided a 50% increase effectiveness against the M1 Garand used as a baseline.
[7] Small Arms Weapons Systems (SAWS) conducted by the US Army Combat Developments Command Experimentation Command at Fort Ord, CA, published in May 1966. See **Exhibit 2**.

The only reason that U.S. Forces have employed semi-automatic rifle fire during the last 60 years of combat is due to our fighting non-peer enemies over this duration (Low Intensity combat in Iraq, Afghanistan, criminal behavior in Panama, or Police Actions in Vietnam). Semi-auto fire engagements made sense in those situations where we were not facing well trained, well-armed opponents, but instead outnumbered our opponents at the point of contact, and the opponents lacked training, equipment, aerial support, or reinforcements, making fully-automatic fire unnecessary.

Against a peer threat, which all US Forces prepare for every day, fully automatic fire is critical. It is rehearsed repeatedly. The U.S. Forces do not prepare for future fights against non-peer threats, therefore will always be ready to use fully automatic fire against determined peer level threats in all environments. All US Forces are prepared to engage against a peer threat, at which point, the constant training exercises have focused on providing sufficient accurate suppression with full auto firing selection from service rifles. At the time of this writing, the USMC has issued the M27 rifle to all infantryman, which comes with a safe, semiautomatic, and fully automatic settings (but not burst-fire). The US Army has just authorized a product improvement to the M4 series rifle to revert back to fully automatic fire in lieu of burst-fire. The US Army will issue the XM7 rifle with select fire settings of safe, semi, and fully automatic to those front-line units that will not receive the M4 PIP (product improvement program). These changes are a recognition of the value of fully-automatic fire in preparation for future peer-level conflicts.

This has been confirmed by testing. A study by the US Army Operations Research Office on Operational Requirements for an Infantry Hand Weapon provides: "*…Recent ORO investigations in Korea have shed some light on this subject by indicating quantitatively the comparative importance of aimed and unaimed fire as related to offensive and defensive operations.* ***Generally, aimed fire plays a more important part in defense than unaimed or volume fire, whereas in the offensive, the reverse is true….***"[8]
None of the weapons banned by Illinois are remotely sufficient to handle the military's requirements for weapons it uses against peer level countries, as they lack the necessary volume of fire (burst or automatic fire) to suppress an enemy long enough to bring other heavier weapons/assets to bear upon the enemy.

PISTOLS

No general-purpose force in the U.S. Army or Marine Corps has a tactical task against an enemy that requires a pistol as the solution. Pistols are supplied to soldiers/Marines who man crew-served weapons (mortars, machineguns, rockets, missiles) so they may have a personal protection weapon available should their primary weapon become inoperable. Pistols are issued to Staff Non-Commissioned Officers (enlisted ranks of E-6 and above), and to Officers (O-2 and

[8] Operational-Requrements-For-An-Infantry-Hand-Weapon.pdf, Technical Memorandum ORO-T-160 Operational Requirements for an Infantry Hand Weapon by Norman A. Hitchman, entered into the Library Army War College, Carlisle Barracks, PA on 19 June 1952 with the Operations Research Office conducted by the 10 of 111 (pdf). Originally classified "Secret" but now declassified. Pages 5-6. See **Exhibit 3**.

above normally) as these personnel have the primary task of leadership and management of forces, not directly engaging the enemy. Pistols lack sufficient velocity to ensure bullet penetration and expansion required to stop an attacker in a military context, where assailants are often wearing body armor or are far away before the attacker can cause harm.

SHOTGUNS

In the rare instances that they are used in theater, shotguns are generally limited to use by special operations forces for ballistic breaching methods of shooting off hinges or doorknobs for urban entry (like a civilian SWAT team uses a battering ram). Military Police use shotguns (generally pump-action) for guard duty or riot control purposes. Front-line combat forces, however, have limited use for any shotguns outside of police actions. General purpose forces tend not to see the value in using the shotguns available to them, due to shotguns' slow reload time, limited range, and bulky ammunition requirements, not making them worth carrying into combat.

MAGAZINES

It is our understanding that Illinois restricts as "large capacity ammunition feeding devices" any device that is readily detachable from the firearm that delivers ammunition into a firearm that has a capacity of, or that can be readily restored or converted to accept, more than 10 rounds of ammunition for long guns and more than 15 rounds of ammunition for handguns. While it is true that, with few exceptions such as sniper rifles, the military *exclusively* uses "large capacity ammunition feeding devices" as Illinois defines them, Illinois's definition includes magazines with capacities significantly lower than anything the military would use.

A. Virtually all box magazines for M16/M4 rifles in the military use 30-round magazines. In rare instances, 20-round magazines will be used for select personnel performing specific, limited functions. We have never seen a magazine for M16/M4 rifles in the military that had a capacity of less than 20-rounds (and even those were rare). What's more, the only reason box magazines for M16/M4 rifles are generally 30-rounds, but not more, is only because decades of testing showed that magazines over that capacity were not sufficiently reliable to bet our lives on because they were too susceptible to feeding issues, due to losing spring tension (i.e., jamming). But for that limitation, the military would use much larger box magazines for M16/M4 rifles; proof of which is the decades it spent trying to do so with testing.

B. The U.S. military has adopted the Sig Sauer M17 as the pistol it issues to those select servicemembers who carry pistols. All box magazines for the Sig Sauer M17 pistol issued in the military have a capacity of either 17-rounds or 21-rounds. Those are the same capacity magazines that come standard with the Sig Sauer M17 pistol when sold to the general public (except in jurisdictions that have magazine capacity restrictions). That is not surprising since, as explained above, pistols in the military are used for the same purpose they are in civilian life: self-defense.

C. As explained above, it is our understanding that Illinois deems semiautomatic rifles that have a fixed magazine with the capacity to accept more than 10 rounds and semiautomatic pistols that have a fixed magazine with the capacity to accept more than 15 rounds to be "assault weapons." We are unaware of any semiautomatic rifle or pistol that the U.S. military, or any military in the world, uses that uses fixed magazines of any capacity.

AMMUNITION

The military has access to a variety of bullet designs that allow bullets to be selected to meet mission requirements. Bullets designed for the low impulse, buffered 5.56 x 45mm rifles of the M16 series, M4 series and M27 series rifles that are currently available are:

a. M855A1 Enhanced Performance Round: Considered the first environmentally friendly round as it is lead free. This bullet design has demonstrated more consistent performance in both soft and hard targets and increased accuracy beyond 300 meters. This bullet is now the primary bullet for US forces in combat.
b. M855: A 62 grain bullet designed with a steel penetrator to be used against body armor of combatants in the 1980's. Research by the US Army in the early 2000's identified this bullet to be 'yaw dependent' as well as speed dependent (at least 2500 feet per second) to have sufficient lethality upon the target. This shortfall led to the M855A1 Enhanced Performance Round listed above.
c. M193: A 55 grain bullet, lead core bullet without the steel penetrator designed inherent to the M855A1 or M855 bullets. This bullet was the primary bullet in use during the Vietnam War from the early 1960s until replaced as the primary service cartridge in the early 1980s.
d. M856: A 63.7 grain tracer cartridge to assist marking targets, identifying where shots are landing at extended ranges, and to assist with night firing prior to the issuance of night vision equipment commonly in place today.
e. M1037 Short Range Training Ammunition. Referred to as 'frangible' ammunition created from a frangible copper-filled polymer designed to lower ricochet beyond the target, or ricochet back towards the shooter. Usually used for ranges less than 100 meters when sensitive equipment or personnel are in the area.
f. Mk262 Mod 1: A 77 grain Open Tip Match ammunition used as an interim cartridge in the mid 2005-2012 time frame when M855 was determined insufficient against combat opponents (over penetration, under expansion) and until M855A1 was finalized in design and in full volume production.
g. M995. A 52 grain bullet with a tungsten carbide core for penetration of hard targets. Capable of penetrating 12mm (1/2") of rolled homogenous armor at 100 meters and light body armor at normal combat distances.

The military does not choose these bullets with self-defense in mind, but with what will best accomplish the military mission at hand. That calculus does not necessarily consider effectiveness against non-combatants who lack body armor or who are within close proximity, nor, in certain battlefield scenarios, concerns of bullets' over-penetration beyond the target, like a homeowner might be concerned about his neighbor.

RATE OF FIRE

It is our understanding that the Seventh Circuit Court of Appeals indicated in its opinion for this case that the "rate of fire" of the semiautomatic rifles, handguns, and shotguns that Illinois has deemed "assault weapons" could be relevant to the legal analysis of whether they are different in kind from the M16 fully automatic rifle. First, we note that there is no official standard for measuring "rate of fire." In fact, there really is no such thing as a measurable "rate of fire" because there are so many variables that affect the pace at which a firearm can discharge projectiles (assuming that is what "rate of fire" refers to here).

One could conceivably measure the "cyclic rate" of fire for a particular firearm, which is the maximum rate of fire based solely on mechanical function. Essentially, it's the theoretical maximum rate of fire achievable by the weapon without any external factors affecting its operation, such as fatigue of the shooter, degradation of the barrel due to heat, wear, or ammunition/magazine limitations. This term "cyclic rate" was first used to measure belt-fed machineguns' potential volume of fire for suppressing enemy forces. It is generally understood that a fully automatic rifle, such as the USMC's M27 Infantry Automatic Rifle, can mechanically fire between 700-900 rounds[9] per minute depending on the age and condition of the rifle, as well as other physical factors.

Determining the cyclic rate for a semiautomatic rifle of any type, on the other hand, is essentially an unachievable myth that is more focused on marketing than reality. That is because, unlike a fully automatic rifle where the trigger can just be depressed once and rounds will discharge at a set, uniform pace (mechanically-speaking), semiautomatic fire is influenced by the particular user of the weapon: i.e., how fast the person can function the trigger; resistance to fatigue; management of recoil; etc. Various factors with the rifle itself can also affect how fast rounds are discharged, including barrel length, whether direct impingement or a gas piston, buffer weight, spring tension, powder load of ammunition, weight of bolt carrier.

There are also practical limitations that cyclic rate does not contemplate, such as damage to the firearm from heat buildup and ammunition availability or time for magazines changes. Discharging rounds at a rate of 700-900 rounds per minute would likely destroy the barrel before the minute is up. Setting that aside, military personnel are trained to reload a magazine in 1.5 seconds; so to achieve that rate of fire would require 24-30 magazine changes in under one second each, as well as having 24-30 magazines loaded and readily available for quick reloads. Our experience as NRA trained marksmanship instructors with civilian students gives us an expectation of the average civilian managing a 4-5 second reload time, and this while under no life threatening event that would initiate the Body Alarm Response. *The body's physiological responses to life and death situations often cause auditory exclusion* (temporary loss of hearing), *tunnel vision, loss of near, monocular, and night vision, loss of motor control* (such as pulling a

[9] See **Exhibit 4**, HK M27 IAR Product Sheet Sept 2012 page 3

trigger, reloading a magazine) *and vasoconstriction* [10](leading to rapid heart rate). So the practical rate would be much less for them.

What's more, there is the separate question of a practical rate of fire to maintain accuracy. Just because a firearm will fire at a certain rate does not make that rate particularly useful, as range increases accuracy diminishes along with the rate of sufficiently accurate fire. As explained above, automatic fire is not aimed fire for the purpose of hitting a specific target but rather is for suppressive fire to pin down the enemy where hits and near misses (within 2 meters) have an affect[11]. As range increases, the shooting position of the military moves from standing to more stable positions such as kneeling, squatting and prone. Along with the increased stability, rates of fire slow down from automatic fire to semi-automatic fire to keep the shots in a smaller area for purposes of suppression. So the practical rate of fire for an M16 is also much greater than the practical rate of fire for a semiautomatic firearm in a self-defense situation where there is a particular target or targets causing the threat.

In sum, there really is no way of reliably determining a "rate of fire" for semiautomatic firearms, in light of these variables. One thing is for certain, however, the rate of semiautomatic fire is significantly less than that of automatic fire. With semiautomatic fire, there is a significant delay in pulling the trigger through the breaking point, hitting the overtravel point, releasing and resetting the trigger and setting up for the next firing capability, compared to just pulling and holding the trigger of a fully automatic rifle. That is in addition to the variables with the specific user described above, e.g., potential for fatigue of the finger in repeatedly pulling the trigger, skill at staging additional magazines and getting the rifle reloaded, and recoil management.
At the end of the day, the rate of automatic fire is obviously different in kind than semiautomatic fire; otherwise, the military would not insist on having automatic fire.

Sustained rate of fire - Using our experience as trainers, were we to estimate a starting expectation for untrained shooters to achieve a rate of fire with relative accuracy (50% hits on human size target), under no stress of life threatening events, shooting primarily firing from the standing position, firing semiautomatic fire with some reasonable degree of accuracy, we would start with these distances, rates and time frames, keeping careful notes for future refinement.

Distance	Rate of fire	time
7-10 yards	35-50 rpm	60 sec
15-25 yards	20-30 rpm	60 sec
50-80 yards	10-15 rpm	60 sec
100 - 150 yards	5-10 rpm	60 sec

[10] Tactical Training & Physiological Response (firstresponderswellnesscenter.com)
[11] Small Arms Weapons Systems (SAWS) conducted by the US Army Combat Developments Command Experimentation Command at Fort Ord, CA, published in May 1966. Page 2-42, para (2) through Page 2-49. See **Exhibit 2**.

Other factors that must be applied to this are size of cartridge (the bigger the more recoil and impact on accurate rate of fire), a moving or stationary target, sighting system, (field of view), positioning, and availability of replacement magazines.

SELF-DEFENSE

Based on our training and experience, it is our opinion that:

A. The AR-platform rifle has been the most significant design in weaponry for common use among the public over the last 60 years. The lightweight, buffered design, with the proper bullet selection, is lethal enough to penetrate the 12" required to enter lethal areas, expand to create the most trauma necessary to stop the aggression of an attacker, has sufficient ammunition capacity to overcome the Body Alarm Response of inaccurate fire, poor shot placement, poor bullet behavior, multiple assailants trying to win the fight, etc., to better one's chances of successfully ending the attack. We cannot emphasize the importance of the low recoiling 5.56 x 45mm cartridge, fired from the Armalite designed rifle with its internal buffering system for both combat and self defense purposes. The shortened barrel we recommend allows the rifle to maintain a lower weight when suppressed, yet still be portable enough to move within constricted spaces necessary in all military mobility platforms (rotary wing aircraft, ground vehicles, and urban structures).

B. The best designed home defense weapon would be an 11.5" AR-platform short-barreled rifle with a suppressor, loaded with a 30-round magazine, a 1000 lumens flashlight on a side rail and an adjustable buttstock to allow the weapon to fit the clothing worn at the time it is needed. This highly portable, lightweight, low recoiling system, easy to point to the aggressor, would increase survivability of the victim immediately.

C. The features on rifles that Illinois restricts (e.g., pistol grips, barrel shrouds, adjustable/removable stocks, and flash suppressors) do not serve any unique military purpose. As civilians now, we continue to train with firearms to be prepared for self-defense purposes and for recreation. The same rules of physics and shooting fundamentals apply whether the person using the firearm is in the military or not. Those features are to facilitate the comfortable and thus safe and effective use of the rifle, in *any* context. To say that semiautomatic-only rifles using ammunition designed for self-defense scenarios is the same as a select-fire M-16 using ammunition designed for combat, merely because they share external features designed to facilitate their safe, ergonomic, and effective use, would be like saying a street-legal, civilian Hummer is the same as a military High Mobility Multi-purpose Wheeled Vehicle ("HMMWV"), merely because they look similar and both have adjustable seats, headlights, and power-steering.

COMPENSATION

Jeffrey Eby is being compensated at the rate of $180.00 per hour.

Michael Musselman is being compensated at the rate of $180.00 per hour.

Dated: May 10, 2024

s/Jeffrey Eby
Jeffrey Eby

Dated: May 10, 2024

s/ Michael Musselman
Michael Musselman

EXHIBIT 1

Peer threats contest the joint force in all domains through several methods:
Information warfare *Preclusion* *Isolation* *Sanctuary* *Systems warfare*

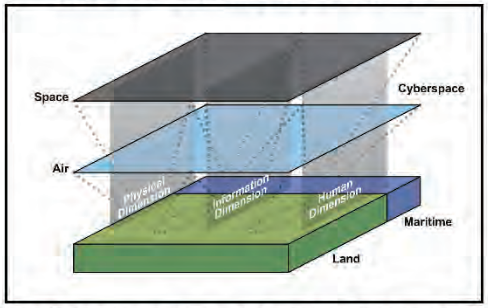
The U.S. joint force addresses these threats through

Unified action:
The synchronization, coordination, and/or integration of the activities of governmental and nongovernmental entities with military operations to achieve unity of effort (JP 1, Volume 1).

The Army's contribution to unified action is

Multidomain operations:
The combined arms employment of joint and Army capabilities to create and exploit relative advantages that achieve objectives, defeat enemy forces, and consolidate gains on behalf of joint force commanders.

Army forces conduct multidomain operations throughout an operational environment that consists of 5 domains and 3 dimensions



and executed by Army echelons during competition, crisis, and conflict across the range of military operations

XXXX XXX XX X
Joint ← → Army

respecting the

Principles of war
Maneuver Objective Offensive Surprise Economy of force
Mass Unity of command Security Simplicity

reflecting the

Tenets of operations
Agility Convergence Endurance Depth

adhering to

Imperatives of operations:
- See yourself, see the enemy, and understand the operational environment
- Account for being under constant observation and all forms of enemy contact
- Create and exploit relative physical, information, and human advantages in pursuit of decision dominance
- Make initial contact with smallest element possible
- Impose multiple dilemmas on the enemy
- Anticipate, plan, and execute transitions
- Designate, weight, and sustain the main effort
- Consolidate gains continuously
- Understand and manage the effects of operations on units and Soldiers

executed through

Offensive operations *Defensive operations* *Stability operations* *Defense support of civil authorities*

to accomplish missions, defeat enemy forces, and consolidate gains that meet joint and national objectives.

Introductory figure. FM 3-0 logic chart

FM 3-0 contains eight chapters and three appendixes:

EXHIBIT 2

UNCLASSIFIED

AD NUMBER

AD-488 336

NEW LIMITATION CHANGE

TO

DISTRIBUTION STATEMENT - A

Approved for Public Release; Distribution Unlimited.

Limitation Code: 1

FROM

DISTRIBUTION STATEMENT - NONE

No Prior DoD Distribution Security Control Statement Assigned.

Limitation Code: NONE

AUTHORITY

U.S. Army Operational Test and Evaluation Command, CSTE-IMZ, Alexandria, VA, via memo., dtd June 3, 1996 signed by Mr. Gary C. Miller, DCS/Info. Management.

THIS PAGE IS UNCLASSIFIED

FOR OFFICIAL USE ONLY

SMALL ARMS WEAPON SYSTEMS — (SAWS).

PART ONE: MAIN TEXT.

SOURCE DATA
SMALL ARMS
WEAPONS SYSTEM
STUDY

MAY 1966

(11) 10 May 66
(12) 272p.

U. S. ARMY COMBAT DEVELOPMENTS COMMAND
EXPERIMENTATION COMMAND FORT ORD, CALIFORNIA

PROTECTIVE MARKING OF THIS DOCUMENT WILL BE TERMINATED 3 YEARS AFTER ORIGINATION.

FOR OFFICIAL USE ONLY

COPY NO.____

THIS REPORT IS FOR INFORMATION ONLY. ACTION COPIES ARE SUBMITTED DIRECTLY TO COMMANDING GENERAL, US ARMY COMBAT DEVELOPMENTS COMMAND. THE VIEWS EXPRESSED IN THIS REPORT ARE THOSE OF THE COMMANDING GENERAL, US ARMY COMBAT DEVELOPMENTS COMMAND EXPERIMENTATION COMMAND AND ARE NOT NECESSARILY THOSE OF THE US ARMY COMBAT DEVELOPMENTS COMMAND OR THE DEPARTMENT OF THE ARMY.

SMALL ARMS WEAPON SYSTEM (SAWS) FIELD EXPERIMENT

In Two Parts

PART ONE: MAIN TEXT

FOR OFFICIAL USE ONLY

HEADQUARTERS
UNITED STATES ARMY COMBAT DEVELOPMENTS COMMAND
EXPERIMENTATION COMMAND
Fort Ord, California

SMALL ARMS WEAPON SYSTEMS (SAWS) FIELD EXPERIMENT

~~(CDCEC 65-4)~~

10 May 1966

APPROVED:

L. G. Cagwin
L. G. CAGWIN
Major General, United States Army
Commanding

FOR OFFICIAL USE ONLY

BLANK PAGE

AUTHORITY

1. Letter, CDCRE-E, HQ, USACDC, 23 February 1965, subject: US Army Combat Developments Command Experimentation Center Experiment - Small Arms Weapon Systems (SAWS)

2. Directive, US Army Combat Developments Command, 5 March 1965, subject: Army Small Arms Weapon Systems Program (SAWS)

3. Outline Plan USACDCEC Experiment 65-4, Small Arms Weapon Systems (SAWS) (U), July 1965

4. Letter, CDCRE-E, HQ, USACDC, 7 September 1965, subject: Outline Plan, Small Arms Weapon Systems (SAWS) Experiment

CORRELATION

The Small Arms Weapon Systems (SAWS) Experiment is identified as USACDC Action Control No. M3523 and supports the following:

a.	Army Concept Program	Army 75
b.	Army Tasks	1: High Intensity Conflict 2: Mid Intensity Conflict 3: Low Intensity Conflict Type I 4: Low Intensity Conflict Type II 7: Complementing Allied Landpower
c.	Phase	Evaluation
d.	Functions	Firepower

CONTRACTUAL AGREEMENT

Scientific Support

Research Office, USACDCEC, Stanford Research Institute, Contract No. DA 04-200-AMC-1104(X).

ACKNOWLEDGMENT

The United States Army Combat Developments Command Experimentation Command wishes to express appreciation to the United States Army Training Center, Infantry, Fort Ord, California, for its outstanding cooperation and support during the conduct of the SAWS experiment.

CONTENTS

Part One: Main Text

ABSTRACT xvi

SECTION I INTRODUCTION

A. Purpose 1-1
B. Scope 1-1
C. Objectives 1-2
D. Phasing and Location 1-3
E. Concept 1-3
F. Conduct of the Experiment 1-4

SECTION II EXPERIMENTAL DESIGN

A. General Characteristics of the Design 2-1
B. Experimentation Materiel 2-1

1. Weapons and Ammunition 2-2
2. Organization of Materiel for Experimentation . 2-8

C. Instrumentation 2-8
D. Experiment Personnel 2-15

1. Source of Support Personnel 2-15
2. Source of Experimentation Subjects 2-15
3. Organization of Experimentation Subjects . . 2-15
4. Training Program for Experimentation Subjects . 2-16

E. Experimentation Procedures 2-22

1. Uniform Operational Policies - General . . 2-22
2. Control and Balance of Weapon Mix Structure and Equipment 2-22
3. Modes of Fire 2-23
4. Control for Differences in Firer Location and Opportunity 2-23
5. Control of Squad Leader Variability 2-23
6. Control for Effects of Learning 2-23
7. Data Collection Procedures - Primary Measures 2-24
8. Administrative Procedures 2-24

CONTENTS (Continued)

F. Experimentation Tactical Situations 2-25

1. Situation 1: Rifle Squad in Line Assault . . . 2-27
2. Situation 2: Rifle Squad as a Base of Fire Supporting the Assault 2-27
3. Situation 3: Machinegun Squad in Fire Support of the Assault 2-30
4. Situation 4: Rifle Squad in Approach to Contact . 2-30
5. Situation 5: Rifle Squad as a Base of Fire Supporting the Advance 2-30
6. Situation 6: Machinegun Squad in Fire Support of Advance 2-35
7. Situation 7: Rifle Squad in Defense Against Attack 2-35
8. Situation 8: Rifle Squad in Night Defense Against Attack 2-38
9. Situation 9: Machinegun Squad in Defense Against Attack 2-38
10. Summary of Tactical Situations 2-38

G. Effectiveness Measures (Evaluation Criteria) . . . 2-41

1. Effectiveness Concept 2-41
2. Measures of Effectiveness 2-42
3. Effectiveness Qualities - Combat Effectiveness Components 2-48

SECTION III METHODOLOGY FOR THE PRESENTATION OF RESULTS

A. Organization of Results 3-1
B. Data Presentation Format 3-1
C. Explanation and Description of Data 3-3

1. Performance and Statistical Probability Measures 3-3
2. Combined Use of Descriptive Performance Measures and Statistical Probability Data . . 3-6
3. Standard Scores 3-7
4. SAWS Target Effects and Overall Effectiveness Scores 3-10
5. Expected Scores 3-11
6. Graphical Presentation of Measures as a Function of Time and Range 3-12
7. Histogram (Bar Graph) Presentation of Near Misses as a Function of Target Location 3-18

D. Analysis and Derivation of Conclusions . . . 3-20

CONTENTS (Continued)

SECTION IV TRAINING RESULTS

A. Rifle 4-1

1. Disassembly and Assembly 4-1
2. Trainfire Record Range 4-3
3. 25-meter Rifle in Automatic Mode . . . 4-7
4. 200-meter Rifle in the Automatic Mode . . 4-7

B. Automatic Rifle 4-9

1. Disassembly and Assembly 4-9
2. Interim Transition Record 4-9
3. 25-meter Automatic Rifle 4-9

C. Machinegun 4-9

1. Assembly and Disassembly 4-9
2. Record Firing, Tables II, III, and IV . . . 4-9

D. Contamination of Training Scores by Weather . . 4-17

SECTION V MATERIEL RELIABILITY RESULTS

A. Purpose of Reliability Data 5-1
B. Data Collected and Observations 5-2
C. Reliability Results and Findings 5-2

1. Major Causes of Malfunctions in US 7.62mm Weapons 5-7
2. Major Causes of Malfunctions in 5.56mm Weapons 5-7

D. Effect of Malfunctions on Experimentation . . . 5-12

SECTION VI SQUAD WEAPON MIX FIRE EFFECTIVENESS RESULTS

A. Rifle Squad Experiment 6-1

1. Situation 1: Rifle Squad in Line Assault . . 6-1
2. Situation 2: Rifle Squad as Base of Fire Supporting the Assault 6-20
3. Situation 4: Rifle Squad in Approach to Contact . 6-37
4. Situation 5: Rifle Squad as a Base of Fire Supporting the Advance 6-48
5. Situation 7: Rifle Squad in Defense Against Attack 6-69

CONTENTS (Continued)

6. Situation 8: Rifle Squad in Night Defense Against Attack 6-78
7. Combined Results - Rifle Squad Experiment . 6-89

B. Supplementary Rifle Squad Experiment . . . 6-93

1. MC Versus MB 6-93
2. CX Versus CY 6-93
3. MC Versus CY 6-96

C. Machinegun Squad Experiment 6-99

1. Situation 3: Machinegun Squad in Fire Support of the Assault 6-99
2. Situation 5A: Machinegun Squad as a Base of Fire Supporting the Advance (375 to 560 meters) . . 6-99
3. Situation 6: Machinegun Squad in Fire Support of the Advance (446 to 753 meters) 6-100
4. Situation 9: Machinegun Squad in Defense Against Attack 6-101
5. Discussion 6-101

SECTION VII DUPLEX AMMUNITION EXPERIMENT

A. Rifle Duplex Ammunition Experiment 7-1
B. Automatic Rifle Duplex Ammunition Experiment . 7-18
C. M60 Machinegun Duplex Ammunition Experiment . 7-18

SECTION VIII LETHALITY DATA IMPLICATIONS . . . 8-1

SECTION IX CONCLUSIONS 9-1

Part Two: Annexes

ANNEXES

A Squad Organization and Operational Policies
B Ranges, Instrumentation, and Data Collection
C Materiel
D Correlation Analysis
E Small Arms Lethality

CONTENTS (Continued)

F	Bibliography	
G	Distribution	

Figures

2-1	US 7.62mm Weapons	2-3
2-2	Colt 5.56mm Weapons	2-4
2-3	Stoner 63 5.56mm Weapons	2-5
2-4	Soviet-type 7.62mm Weapons	2-6
2-5	Types of Ammunition	2-7
2-6	Standing, Kneeling, and Head and Shoulder Targets	2-13
2-7	Acoustic Near Miss Sensor	2-14
2-8	Panel Near Miss Sensor	2-14
2-9	Situation 1, Range A	2-28
2-10	Situation 2, Range A	2-29
2-11	Situation 3, Range A	2-31
2-12	Situation 4, Approach to Contact, Range B	2-32
2-13	Situation 4, Range B	2-33
2-14	Situation 5, Range B	2-34
2-15	Situation 6, Range B	2-36
2-16	Situation 7, Range C	2-37
2-17	Situation 8, Range C	2-39
2-18	Situation 9, Range C	2-40
2-19	Example of Sustainability	2-46
3-1	Distribution of Data, Hypothetical Weapon-Squad Mix A and Mix B in Situation 1	3-14
3-2	Distribution of Data, Hypothetical Weapon-Squad Mix C in Situation 2	3-15
3-3	Example of CET as a Function of Range	3-17
3-4	Histogram (Bar Graph) Presentation, Near Misses as a Function of Target Location	3-19

CONTENTS (Continued)

4-1	Disassembly Time of Rifles	4-4
4-2	Assembly Time of Rifles	4-5
4-3	Disassembly Time of Automatic Rifles	4-11
4-4	Assembly Time of Automatic Rifles	4-12
4-5	Disassembly Time of Machineguns	4-15
4-6	Assembly Time of Machineguns	4-16
4-7	Range 19 Record Scores as a Function of Time of Day	4-19
4-8	Range 18 Record Scores as a Function of Haze Conditions	4-19
4-9	Rifle Squad Technique of Fire Range (Linear Targets)	4-20
4-10	Rifle Squad Technique of Fire Range (Oblique Targets)	4-21
4-11	Rifle Squad in Approach to Contact Range	4-22
4-12	Rifle Squad in Assault Range	4-23
4-13	Squad in Defense Range (Rifle or Machinegun)	4-24
4-14	Machinegun Support of Attack Range	4-25
4-15	Machinegun Support of Assault Range	4-26
6-1	Summary of Results--Situation 1	6-5
6-2	Vertical Profile--Situation 1	6-7
6-3	Cumulative Number of Near Misses and Targets Hit--Situation 1	6-8
6-4	Number and Distribution of Near Misses --Situation 1	6-14
6-5	Summary of Results--Situation 2	6-23
6-6	Vertical Profiles--Situation 2	6-25
6-7	Cumulative Number of Rounds Fired, Targets Hit, Near Misses, and Percent of Ammunition Remaining--Situation 2	6-26
6-8	Number and Distribution of Near Misses --Situation 2	6-32

CONTENTS (Continued)

6-9	Summary of Results--Situation 4	6-41
6-10	Cumulative Number of Targets Hit and Percent of Ammunition Remaining--Situation 4	6-43
6-11	Summary of Results--Situation 5	6-51
6-12	Summary of Results--Situation 5 (Array X)	6-53
6-13	Summary of Results--Situation 5 (Array Y)	6-55
6-14	Cumulative Number of Rounds Fired, Targets Hit, Near Misses, and Percent of Ammunition Remaining --Situation 5	6-57
6-15	Number and Distribution of Near Misses --Situation 5	6-63
6-16	Summary of Results--Situation 7	6-71
6-17	Cumulative Exposure Time, Targets Hit, Rounds Fired, Total Hits, and Percent of Ammunition Remaining	6-73
6-18	Summary of Results--Situation 8	6-81
6-19	Cumulative Exposure Time--Situation 8	6-83
7-1	Cumulative Number of Targets Hit--Situation 1	7-7
7-2	Number and Distribution of Near Misses--Situation 1	7-8
7-3	Cumulative Number of Targets Hit--Situation 2	7-9
7-4	Number and Distribution of Near Misses--Situation 2	7-10
7-5	Cumulative Number of Targets Hit--Situation 4	7-11
7-6	Cumulative Number of Targets Hit--Situation 5	7-12
7-7	Number and Distribution of Near Misses--Situation 5	7-13
7-8	Cumulative Exposure Time--Situation 7	7-14
7-9	Cumulative Exposure Time--Situation 8	7-14
7-10	Cumulative Number of Targets Hit	7-25
7-11	Cumulative Exposure Time	7-27
7-12	Number and Distribution of Near Misses--Situation 1	7-28

CONTENTS (Continued)

7-13	Cumulative Number of Targets Hit--Situation 3	7-34
7-13	Cumulative Number of Targets Hit--Situation 4	7-35
7-14	Number and Distribution of Near Misses --Situation 3	7-36
7-14	Number and Distribution of Near Misses --Situation 6	7-37
7-15	Cumulative Exposure Time--Situation 9	7-38

Tables

2-1	Comparative Weight and Ammunition Basic Loads by Weapons	2-9
2-2	Squad Weapon Mixes and Squad Ammunition Basic Loads	2-12
2-3	Basic Marksmanship Rifle Instruction	2-17
2-4	Basic Marksmanship Automatic Rifle Instruction	2-19
2-5	Basic Marksmanship Machinegun Instruction	2-19
2-6	Transition Training	2-20
2-7	Personnel Trained and Cross-trained	2-21
2-8	Hypothetical Example of Cumulative Exposure Time (CET)	2-45
Subtable A	Cumulative Exposure Times	3-5
Subtable H	Cumulative Exposure Time p Factors	3-5
4-1	Rifle and Assembly Test	4-2
4-2	Rifle Record Fire Qualification Scores	4-6
4-3	Average Number of Hits by Rifle in Automatic Mode (25-meter Range)	4-8
4-4	Average Number of Hits by Rifle in Automatic Mode (200-meter Range)	4-8
4-5	Automatic Rifle Disassembly and Assembly Tests	4-10
4-6	Automatic Rifle Interim Transition Record	4-13
4-7	Automatic Rifle Average Hits Underarm (Unsupported) and Hipsling Positions (25-meter Range)	4-13

CONTENTS (Concluded)

4-8	Machinegun Disassembly and Assembly Tests .	4-14
4-9	Machinegun Tables II, III, IV Average Number of Hits	4-17
5-1	Malfunctions and Stoppages of Weapons . . .	5-3
5-2	Malfunctions Rates	5-5
Table a	Sum of Raw Scores Across All Targets (Events Weighted Unequally)	6-38
Table b	Average of 12 Event Standard Scores (Events Weighted Equally)	6-38
Table c	Ambush Event (10 Targets - 21 to 34 Meters) .	6-39
6-1	Effects of Special Weapon Mixes	6-94
6-2	Comparative Scores of Special Weapon Mixes .	6-97
7-1	Raw Score Results (Rifle Duplex Experiment) .	7-2
7-2	Expected Duplex Score (Rifle Duplex Experiment) .	7-5
7-3	Expected Duplex Scores Compared With Top Ranked Rifle Mixes (Rifle Duplex Experiment) .	7-16
7-4	Raw Score Results (Automatic Rifle Duplex Experiment)	7-19
7-5	Expected Duplex Scores (Automatic Rifle Duplex Experiment)	7-21
7-6	Raw Score Results (Machinegun Duplex Experiment)	7-23
7-7	Expected Duplex Scores (Machinegun Duplex Experiment)	7-32

ABSTRACT

Field experimentation was conducted to determine the relative effectiveness of rifle and machinegun squads armed with US 7.62mm, Soviet 7.62mm, Colt 5.56mm and Stoner 5.56mm weapons. This report describes the experiment, the effectiveness measures used, the results, and the conclusions. Results are concerned with training, materiel reliability, and the fire effectiveness of squads armed with the different weapons and firing both simplex and duplex ball ammunition. Measures of effectiveness were the level of target effects and the ability of the weapons to sustain the effects. Data includes the number of targets hit, total number of hits on targets, number of near misses as an indication of suppressive effects, and the amount of ammunition expended--all as a function of time. Squad size, organization, and weapon system weight were held constant.

Squads armed with low impulse 5.56mm weapons were superior to squads armed with 7.62mm weapons in target effects, sustainability of effects, and overall effectiveness. Duplex ball ammunition was generally superior to simplex ball ammunition at close ranges. Data are related to lethality indices in a separate classified annex. Considerations of lethality support experimentation results indicating the superiority of 5.56mm weapons.

SECTION I

INTRODUCTION

This report describes USACDCEC SAWS (small arms weapon systems) field experimentation completed 21 February 1966. A previous USACDCEC SAWS report, dated 31 January 1966, included only the experimentation completed by 24 December 1965.

This report supersedes the 31 January report, updating it with the field experimentation and associated analyses conducted after 24 December. All conclusions of the previous report remain valid, but they have been supplemented. Additional input data refinements and a more precise treatment of computer produced data have resulted in some changes in the numerical data presented for some of the experimental situations. These data refinements accentuate and clarify differences in weapon mixes presented in the 31 January report but result in no significant changes in either the performance measures or the rank order of weapons.

The report consists of nine sections. This first section identifies the purpose, scope, objectives, phasing and location, concept and general conduct of the experiment. Section II details the experimentation design, including a description of the experimentation ranges and the effectiveness criteria used. Section III explains the method of data presentation and analysis. Sections IV, V, and VI present the results of the experiment as related to training, materiel reliability, and fire effectiveness, and Section VII presents the results of an experiment comparing simplex ball and duplex ball ammunition. Section VIII consists of a brief note on the implications of existing lethality data to the SAWS findings, referring the reader to a separate classified annex for the primary lethality analysis. Major USACDCEC conclusions of the SAWS experiment and analysis are presented in Section IX. Reference data are contained in Annexes A through C. A separate volume is planned to provide detailed engineering design information and specifications of the instrumentation used in the SAWS experiment.

A. PURPOSE

The purpose of the SAWS field experiment was to assist in the evaluation of designated candidate small arms weapon systems as part of the Army-wide SAWS program.

B. SCOPE

The following specific experimentation tasks were assigned by USACDC directives:

1. Determination of the relative fire effectiveness of dismounted squads armed with various mixes of rifles, automatic rifles, and machineguns, including Soviet-type weapons.

2. Determination of the relative fire effectiveness of squads armed with standard US 7.62mm weapons firing duplex ball ammunition, compared with squads firing ball ammunition.

3. Provision of certain data, such as firing scores, that might provide some insight into the relative ease or quality of training afforded by the different weapon systems, as a byproduct of the preparatory training phase of the experiment.

C. OBJECTIVES

The outline plan approved by USACDC assigned eight main objectives:

1. As a byproduct of experimental design, development of a quantitative effectiveness criterion by which rifle and machinegun squads armed with candidate weapon systems, can be compared under tactical conditions.

2. Provision of hard data for determining the combat effectiveness of candidate weapons within an organizational and tactical context.

3. Provision of data to assist in determining the increases or decreases, if any, in manpower implied by the candidate weapon systems for use in cost effectiveness analysis.

4. Provision of comparative data on the tactical ammunition consumption rates of candidate weapons, relative to target effects achieved, as one input into cost effectiveness studies of increases or decreases in ammunition requirements implied by the various weapons.

5. As a byproduct of the preparatory training phase of the experiment, provision of data on the relative training effectiveness of the candidate weapons.

6. Identification of weapon characteristics that produced superior fire effectiveness within an experimental organizational and tactical context.

7. Provision of data resulting from the field experimentation for use in computer simulation.

8. Contribution to such Infantry Rifle Unit Study (IRUS) answers as the SAWS project can practically afford without prejudice to the constraints of time, resources, and SAWS objectives.

D. PHASING AND LOCATION

The experiment was accomplished at Fort Ord in four phases.

Phase I -- Preparation (23 February 1965-30 September 1965)

Phase II -- Training (24 August 1965-21 October 1965)

Phase III -- Field Experimentation (22 October 1965-21 February 1966)

First Increment (22 October 1965-24 December 1965)

Second Increment (3 January 1966-21 February 1966)

Phase IV -- Analysis and Reporting (18 December 1965-10 May 1966)

E. CONCEPT

The experiment was conducted to determine the relative fire effectiveness of rifle squads and machinegun squads armed with candidate weapons in the context of rifle platoons and companies in various tactical situations. Squad weapon system weight and the size and control structure of the squad were held constant. Squads were armed with the candidate weapon systems and Soviet-type weapons. The squads were then employed in the same representative tactical situations on instrumented ranges using selected firing techniques.

The experiment was unique because it integrated the following related aspects of the experimental design:

1) Evolution and application of a meaningful measure of combat fire effectiveness of infantry squads

2) Procurement and installation of instrumentation to sense and record events that supported the measure of fire effectiveness as a function of time and target arrays that realistically simulate an enemy in tactical situations

3) Assignment of enough soldiers (975) as experimentation subjects to allow the assignment of six independent squads to each weapon mix, permitting a balancing of runs to reduce the effects of differences in individuals and extraneous variables in the environment.

F. CONDUCT OF EXPERIMENT

The experiment was designed to provide immediate answers for the SAWS evaluation while concurrently making a long term contribution to knowledge of the effectiveness of infantry small arms in a tactical and organizational context in support of IRUS.

USACDCEC used 975 experimentation subjects in the experiment, with the subjects organized into infantry squads armed with candidate weapon mixes. The squad weapon mixes were evaluated in nine meaningful tactical situations on three instrumented ranges. A total of 1007 record runs were conducted.

The field experiment was conducted in a platoon framework employing nine-man rifle squads and seven-man machinegun squads. The instrumented ranges provided target arrays consisting of targets that simulated the important aiming cues associated with personnel targets. The design of the instrumentation permitted collection of target hits, near misses, and rounds fired as a function of time, all of which can be related to various combat firing distances. The sensing and recording of data was largely automated. The large number of record runs and the depth of data established a data base that has been only partially analyzed for this report.

Formal weapon training was conducted to ensure that all personnel were equally qualified, to the extent possible, to participate as experimentation subjects.

Exploratory firing was conducted to obtain data for assessing best firing techniques, to identify operational policies, to validate safety and control procedures, and to evolve the most meaningful tactical situations.

The first increment of field experimentation, conducted from 22 October 1965 to 24 December 1965, addressed the objectives assigned and provided the data base for the initial findings and main conclusions of the 31 January 1966 report. The first increment also identified the need for additional high priority experimentation. This follow-on experimentation, from 3 January to 21 February 1966, completed the initially planned and follow-on experiments. Completion of this additional field experimentation has allowed the initial findings to be refined and expanded.

SECTION II

EXPERIMENTAL DESIGN

Part A describes the general characteristics of the experiment. Part B describes the weapons used in the experiment and the manner in which they were organized into mixes of weapon types in a squad context. Part C provides a broad general description of the instrumentation and equipment used in the experiment. (A detailed description of instrumentation appears in Annex B.) Part D discusses the organization, control, and training of personnel. (The training programs and implications of training for the various weapons are more fully discussed in Section IV.) Part E details experimentation procedures, including operational policies and administrative procedures. The control and balance of experimental variables is discussed in this section. Part F details each of the experimental tactical situations used to evaluate the performance of the various weapon mixes. The SAWS combat effectiveness criteria are outlined in Part G, and their value in the SAWS analysis is discussed here.

A. GENERAL CHARACTERISTICS OF THE DESIGN

The USACDCEC field experiment was designed to measure the fire effectiveness of three US and one foreign weapon families in a small unit organizational context and in representative tactical situations. To achieve this objective, three tactical ranges were constructed, each representing separate but related squad tactical situations. Each range provided two rifle squad situations and one machinegun squad situation; the experiment encompassed six rifle squad and three machinegun squad scenarios.

Instrumented target arrays were laid out for each tactical situation and targets were programmed to appear to the experimentation subjects, in conjunction with the firing of weapons simulators, in a way that would provide subjects visual and audible target cues normally encountered in combat. Instrumentation designed to measure near misses in relation to targets was used on two of the ranges. All target elements were designed to detect hits (and some to detect near misses) as a function of time. Important qualities of the experiment are the recording of events as a function of time and the inclusion of near misses as an indication of suppressive effects. Included in the experiment are three primary design elements: 1) the competing weapons and their associated mixes within a constant size organization, 2) the targets and their associated instrumentation, and 3) the tactical situations embodied in the three ranges.

B. EXPERIMENTATION MATERIEL

1. Weapons and Ammunition

The experimentation weapons consisted of 13 weapons of four families. The weapons, listed below, are illustrated in Figures 2-1 through 2-4.

US 7.62mm	Colt 5.56mm	Stoner 5.56mm	Soviet 7.62mm
M14 rifle	M16E1 rifle	Stoner rifle	AK47 rifle
M14E2 AR*	Colt AR	Stoner AR	- - -
M60 bipod MG**	- - -	Stoner bipod MG	RPD (squad level) bipod MG
M60 tripod MG	- - -	Stoner tripod MG	DPM (company level) bipod MG

Weapons of the US 7.62mm family and the M16E1 rifle of the Colt family are currently standard US weapons. The other 5.56mm weapons (Colt automatic rifle and Stoner family) are US developmental weapons. Weapons of the Soviet family are Soviet-type weapons found in several armies. Those used in the experiment were manufactured in East Germany, the Soviet Union, and Communist China; parts and ammunition were interchangeable. The Stoner family was designed for maximum interchangeability of parts and components between weapon types, although the other weapon families also posses varying degrees of interchangeability of parts between weapon types.

A basic purpose of this experiment, implied in the candidate weapons selected, was to evaluate fire effectiveness of low muzzle impulse and high muzzle impulse weapons.*** The Stoner and Colt 5.56mm systems are of the low muzzle impulse type. The standard US 7.62mm weapons are high muzzle impulse weapons firing the standard US 7.62mm (NATO) cartridge. The Soviet rifle and RPD squad-level machinegun cartridges are considered intermediate impulse cartridges, while the Soviet company-level machinegun (DPM) fires a cartridge with energy similar to the US 7.62mm (NATO) cartridge. Figure 2-5 illustrates the ammunition types used in the SAWS Field Experiment.

The nominally standard US 7.62mm duplex cartridge has two tandem loaded 7.62mm projectiles that together weigh slightly more than

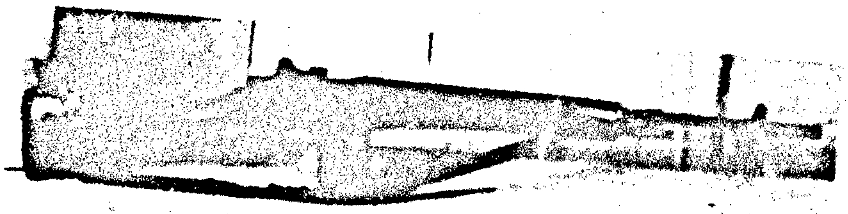
---

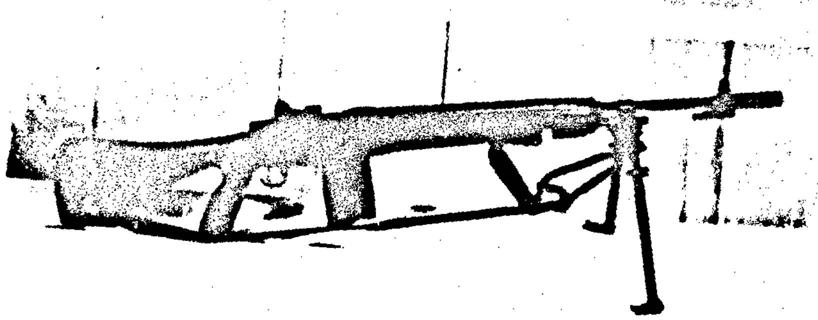
* AR - Automatic Rifle

** MG - Machinegun

*** Table C-6 (Annex C) presents the comparative ammunition characteristics of low impulse 5.56mm ammunition and high impulse US 7.62mm ammunition.

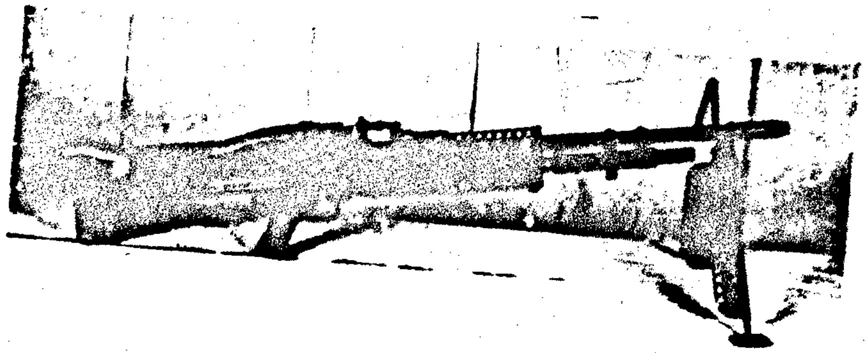
M14 Rifle

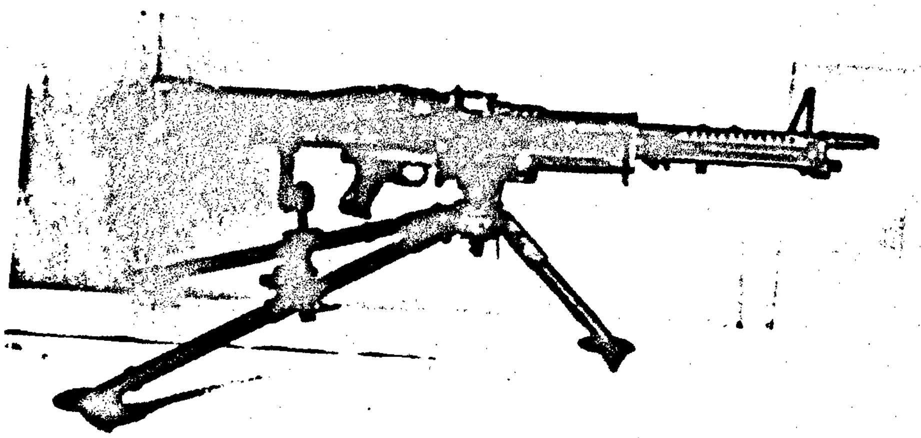




M14E2 Automatic Rifle

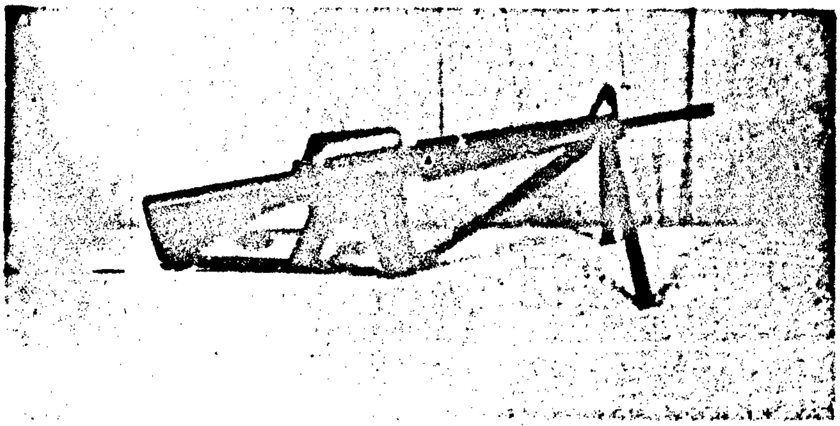
M60 Machinegun, Bipod Mounted



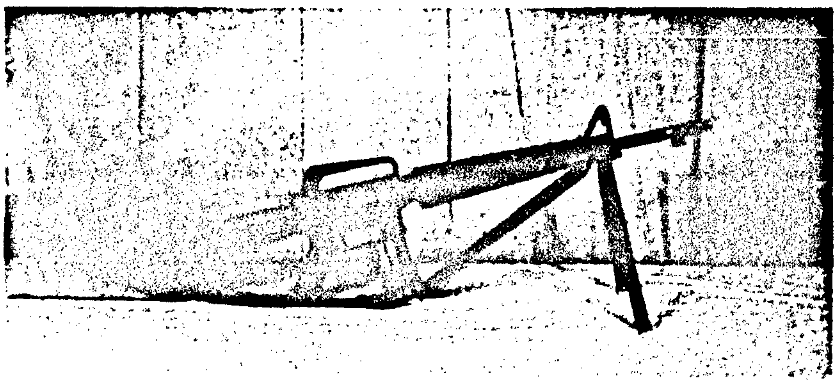


M60 Machinegun, Tripod Mounted

Figure 2-1 US 7.62mm WEAPONS

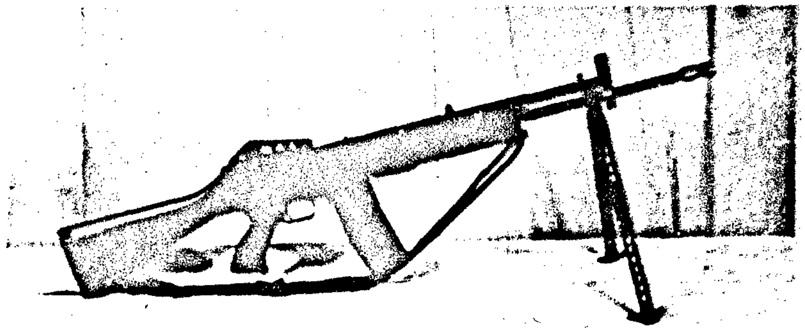


M16E1 Rifle

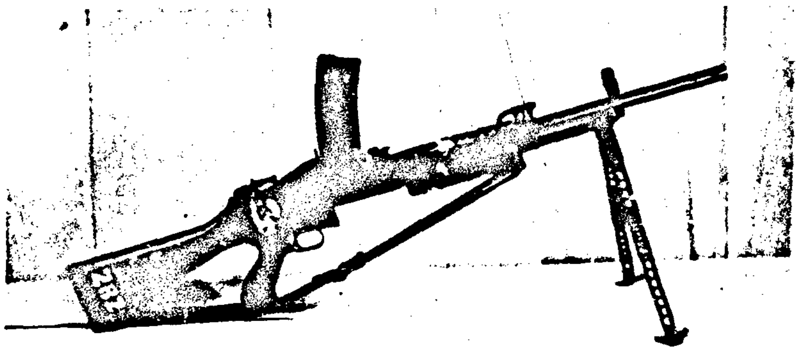


Colt Automatic Rifle

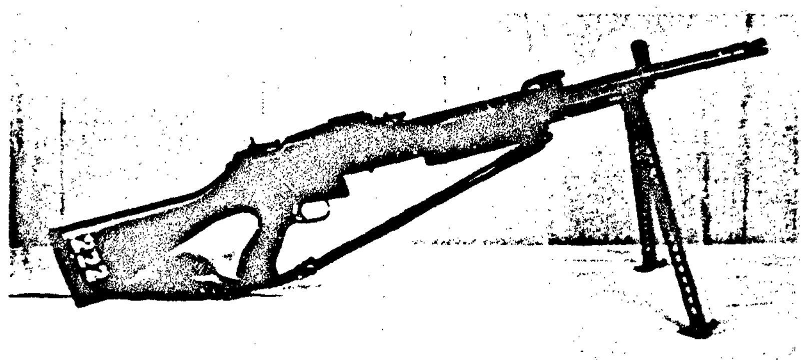
Figure 2-2 COLT 5.56mm WEAPONS



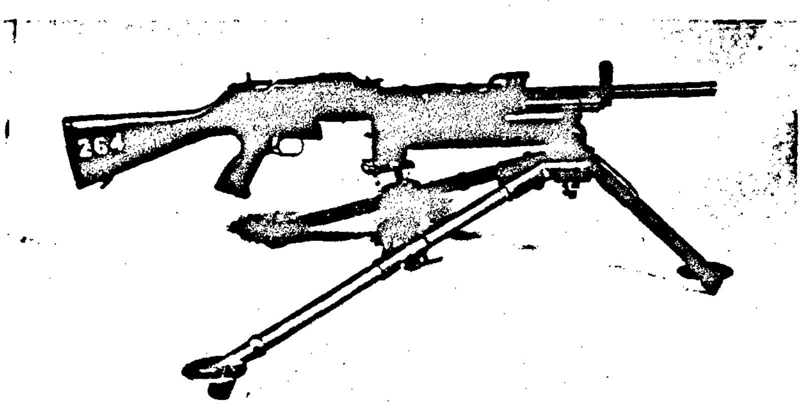
Rifle



Automatic Rifle



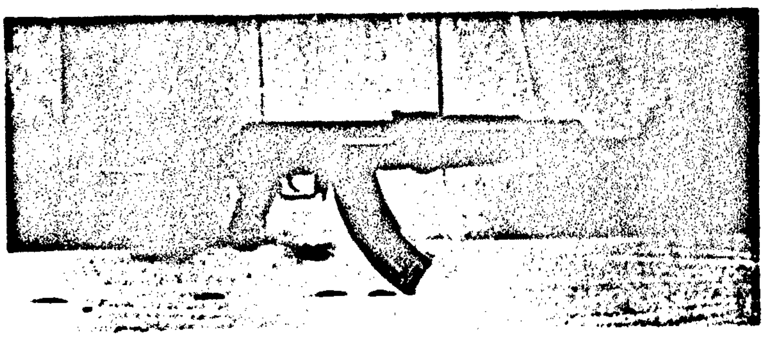
Machinegun, Bipod Mounted

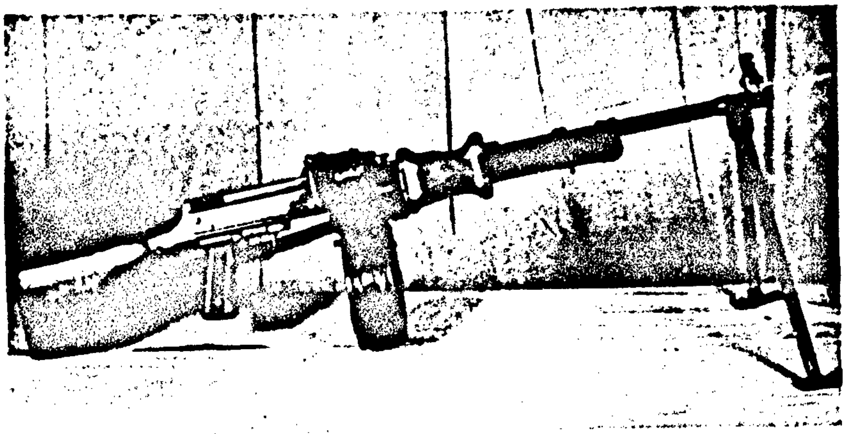


Machinegun, Tripod Mounted

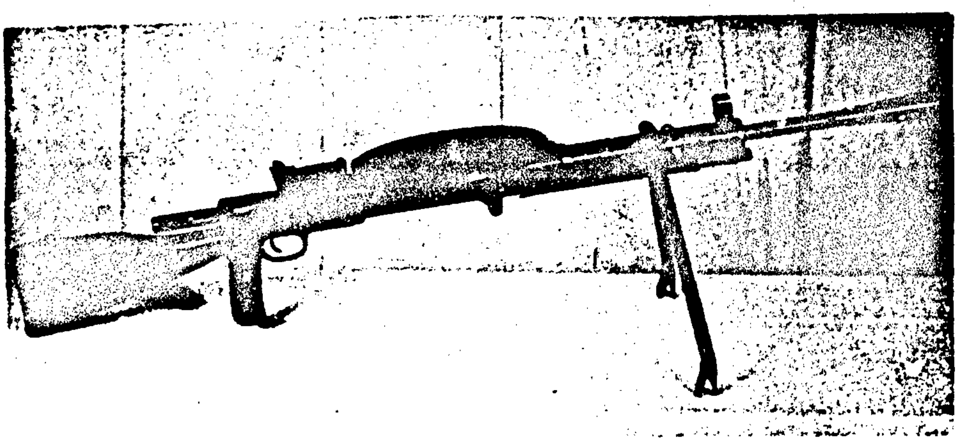
Figure 2-3 STONER 63 5.56mm WEAPONS

AK47 Rifle





RPD Machinegun, Bipod Mounted



DPM Machinegun, Bipod Mounted

Figure 2-4 SOVIET-TYPE 7.62mm WEAPONS

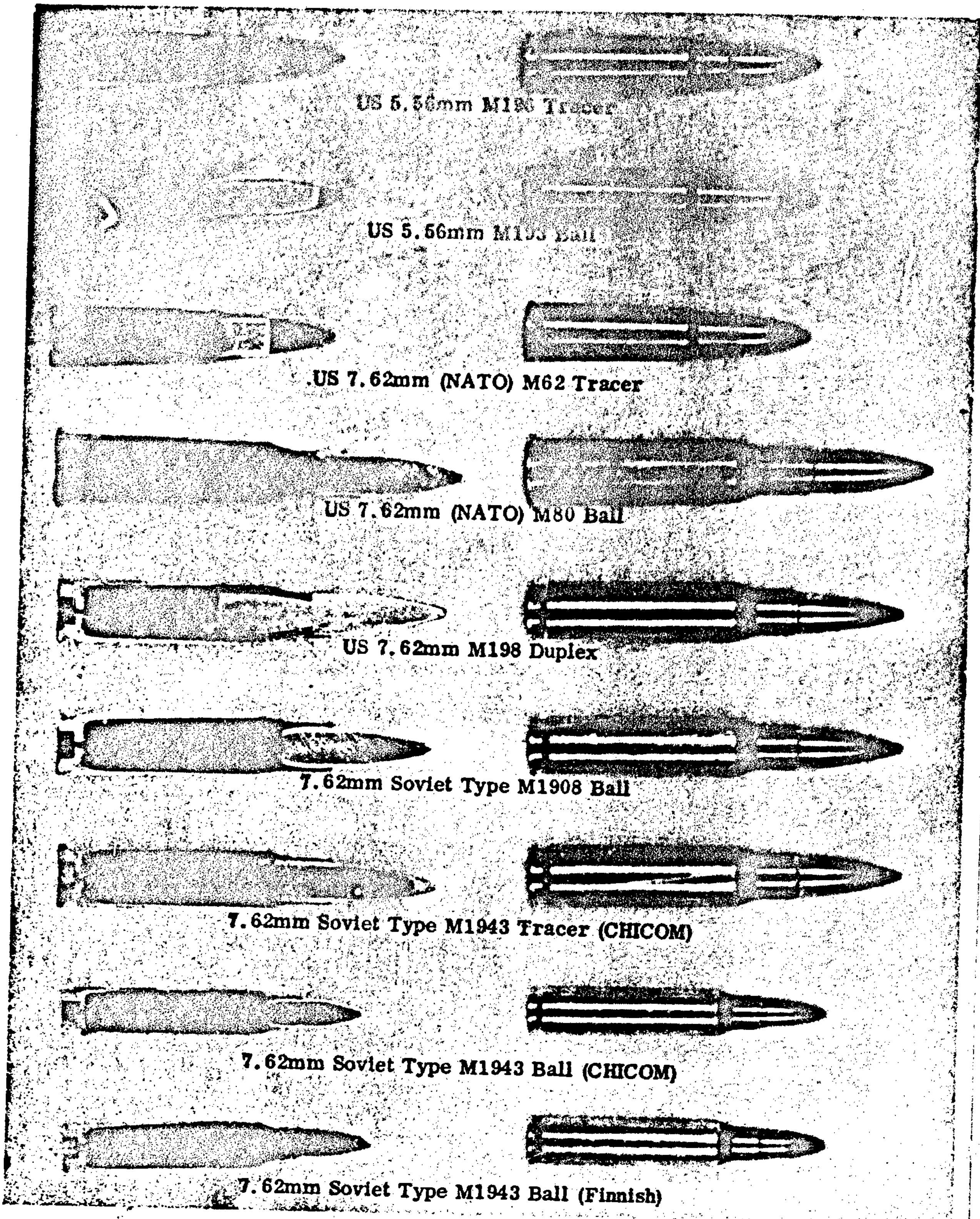


Figure 2-5 TYPES OF AMMUNITION

the standard simplex projectile and have a lower velocity than the simplex round. The duplex round was designed to increase hit probability at ranges to about 300 meters.

Details of weapons and ammunition characteristics are listed in Annex C.

The candidate weapons, ammunition, and spare parts for the experiment were selected and provided by the Army Materiel Command (AMC). Except for the Soviet-type weapons, the weapons were in new condition when USACDCEC received them.

Weight characteristics of the candidate and Soviet weapons are summarized in Table 2-1. This table also shows the weapon ammunition basic loads used in this experiment. System weights used in determining the relative fire effectiveness of the experimentation weapons were those of the current standard 7.62mm weapons with currently prescribed basic loads. These weights were adopted to hold squad systems weight constant and the weights represent current Army weight doctrine; these current ammunition loads have been determined to approach the maximum permissible weight and to be heavier than desirable.* For detailed comparative data on weapons and ammunition, see Annex C.

2. Organization of Materiel for Experimentation

For comparisons, system weights and the size and structure of the squad were held constant, but the weapon mixes were varied. These mixes are shown in Table 2-2.** Squad ammunition basic loads for these weapon mixes, based on the individual weapon loads given in Table 2-1, are also shown in Table 2-2.

C. INSTRUMENTATION

On each range were instrumented target arrays connected by buried cables to a control and recording van behind the firers. Each target element of an array consisted of some or all of the following components:

1) A target body with a hit sensor, representing a kneeling or standing soldier or the head and

* A Study to Conserve the Energy of the Combat Infantryman, USACDC, 5 February 1964.

** The squad weapons mixes were selected to permit comparison of the weapons for the SAWS experiment; they were also designed to provide building blocks of data that could be used, with an IRUS scaling experiment, to compute the small arms fire effectiveness of alternative squad, platoon, and company organization.

Table 2-1

COMPARATIVE WEIGHT AND AMMUNITION BASIC LOAD

Item	Rifles in Rifle Squad					ARs and MGs in Rifle Squads				
	M14	M14E2	M16E1	Stoner	AK47	M14E2	Colt AR	Stoner AR	M60 Bipod MG	Stoner Bi[illegible] MG
eapon (unloaded)	9.69 lb	12.56 lb	6.87 lb	8.25 lb	8.75 lb	12.56 lb	8.00 lb	10.62 lb	24.37 lb	11.44 l
eapon (loaded)	11.27 lb	14.14 lb	7.87 lb [A]	9.52 lb [B]	10.87 lb [B]	14.14 lb	9.00 lb [A]	11.89 lb [B]	31.77 lb [E]	16.43 l
pod and case		C	0.75 lb	1.32 lb		C	0.75 lb	1.32 lb	C	1.32 l
·ipod										
are barrel kit										
›unds available at stem weight current Army 7.62mm apon[N]	100 rd 17.59 lb	60 rd [D] (17.30 lb)	300 rd (17.62 lb)	180 rd (17.19 lb)	120 rd (17.23 lb)	260 rd 33.10 lb	724 rd (33.10 lb)	492 rd (33.08 lb)	120 rd [H] (33.08 lb)	600 rd (32.72 ll
eapon system weight equal numbers of unds	17.59 lb 100 rd	20.46 lb (100 rd)	11.12 lb (100 rd)	14.15 lb (100 rd)	16.44 lb (100 rd)	33.10 lb 260 rd	17.50 lb (260 rd)	23.12 lb (260 rd)	48.41 lb [I] (260 rd)	21.56 l (260 rd

NOTE: System weights and ammunition basic loads for all weapons in rifle squ on one-man loads. Those for machinegun squads are based on three-m (a three-man gun team).

[A] 30-round aluminum magazine

[B] 30-round steel magazine

[C] Bipod organic to the weapon

[D] 60 rounds at rifle system weight; however, 80 rounds were allowed

[E] 100-round bandoleer

[F] 150-round bandoleer

[G] 100-round drum

[H] A rifleman was used as a caliber .45 pistol. Com' (17.59 lb) and the gunner ammunition in bandoleer

[I] Includes weight of the pis

[J] 47-round drum

[K] 200-round metal box

[L] 900-round metal box

[M] System weight is based o rounds of ammunition in for assistant gunner and

[N] Computed on the basis of cartridge is 5.55 percent

[O] Three 900-round metal b

Table 2-1

AMMUNITION BASIC LOADS BY WEAPON

ARs and MGs in Rifle Squads				MGs in Machinegun Squads					
Stoner AR	M60 Bipod MG	Stoner Bipod MG	RPD MG	M60 Tripod MG	Stoner Tripod MG	DPM MG	M60 Bipod MG	Stoner Bipod MG	RPD MG
10.62 lb	24.37 lb	11.44 lb	14.93 lb	24.06 lb	10.81 lb	22.00 lb	24.37 lb	11.44 lb	14.93 lb
11.89 lb[B]	31.77 lb[E]	16.43 lb[F]	20.66 lb[G]	31.46 lb[E]	15.80 lb[F]	27.70 lb[J]	31.77 lb[E]	16.43 lb[F]	20.66 lb[G]
1.32 lb	c	1.32 lb	c			c	c	1.32 lb	c
				17.37 lb	19.37 lb				
				12.56 lb	5.87 lb	4.88 lb	12.56 lb	5.87 lb	
492 rd (33.08 lb)	120 rd[H] (33.08 lb)	600 rd (32.72 lb)	300 rd[G] (32.12 lb)	800 rd 129.65 lb[M] 900 rd 129.49 lb	2298 rd[L] (120.63 lb) 2545 rd[F] (129.63 lb)	752 rd[J] (126.98 lb)	1000 rd[K] (129.28 lb) 1123 rd[E] (129.60 lb)	2850 rd[O] (129.06 lb) 3059 rd[F] (129.63 lb)	1833 rd[G] (129.62 lb)
23.12 lb (260 rd)	48.41 lb[I] (260 rd)	21.56 lb (260 rd)	30.28 lb (260 rd)	129.65 lb 800 rd[K] 129.49 lb 900 rd[E]	74.18 lb (800 rd)[L] 74.89 lb (900 rd)[F]	132.73 lb (800 rd)[J]	112.59 lb (800 rd)[K] 112.43 lb (900 rd)[E]	56.76 lb (800 rd)[L] 57.47 lb (900 rd)[F]	69.67 lb (800 rd)[G]

basic loads for all weapons in rifle squads are based
ıchinegun squads are based on three-man loads

[H] A rifleman was used as an ammunition bearer and armed with a caliber .45 pistol. Combined system weight for the rifleman (17.59 lb) and the gunner (33.10 lb) provided 294 rounds of ammunition in bandoleers for a total weight of 50.63 lb

e allowed

[I] Includes weight of the pistol carried by the ammunition bearer

[J] 47-round drum

[K] 200-round metal box

[L] 900-round metal box

[M] System weight is based on weight of M60 tripod MG, 800 rounds of ammunition in metal boxes, and caliber .45 pistols for assistant gunner and ammunition bearer

[N] Computed on the basis of the ball cartridge, 7.62mm duplex cartridge is 5.55 percent heavier

[O] Three 900-round metal boxes plus a 150-round bandoleer shoulders of a soldier in a foxhole, colored field green with a dirt-smeared decal face. (Figure 2-6)

2) A mechanism to raise and lower the target on computer command and to lower it when it was hit.

3) A target weapon signature simulator (weapon simulator) that provided realistic auditory and visual weapon cues of noise, blast and flash of a rifle, automatic rifle, or machinegun, according to computer programmed commands, and shut off when the target was hit (not all target elements had, or needed, simulators).

4) A near miss sensor to sense misses within 2 meters of the target body. These sensors were used for the target elements in five of the nine tactical situations. Two types of near miss sensors were used on different ranges: an acoustic sensor (Figure 2-7) at the shorter firing distances and a camouflaged panel sensor at the longer distances (Figure 2-8).

The individual target elements, grouped tactically in arrays, were programmed to give weapon signature cues and to raise and lower targets according to programmed exposure times. Exposure times were selected to portray movements representative of the combat situation being portrayed. The programmed total target exposure times for each situation are given in Appendix 4 to Annex B.

In addition to the target array instrumentation, microphones were placed at each static firing position to allow the rounds fired to be counted and recorded as a function of time. (Manual counts of remaining ammunition were made for the two tactical situations where experimentation subjects were moving.)

The control and recording van housed a control console and an on-line computer with a magnetic tape recorder. Reproducibility of target system behavior for each squad in a situation was provided by computer command program.

The following basic data were recorded as a function of time to the nearest 0.01 minute: hits (both first hits and any subsequent hits before the targets fell completely), near misses, target up and target

Table 2-2

SQUAD WEAPON MIXES AND SQUAD AMMUNITION BASIC LOADS[A]

US 7.62mm Mix Weapons (No. and Type)	US 7.62mm Mix Load (rounds)	Colt 5.56mm Mix Weapons (No. and Type)	Colt 5.56mm Mix Load (rounds)	Stoner 5.56mm Mix Weapons (No. and Type)	Stoner 5.56mm Mix Load (rounds)	Soviet 7.62mm Mix Weapons (No. and Type)	Soviet 7.62mm Mix Load (rounds)	Hybrid Mix Weapons (No. and Type)	Hybrid Mix Load (rounds)
Nine-man rifle squad: squad leader and two four-man fire teams									
9 M14 rifles	1290	9 M16E1 rifles	3618	9 Stoner rifles	2352	9 AK47 rifles	1504	--	--
9 M14E2 rifles	1080	9 Colt ARs	3323	--	--	--	--	--	---
7 M14 rifles 2 M14E2 ARs	1220	7 M16E1 rifles 2 Colt ARs	3548	7 Stoner rifles 2 Stoner ARs	2244	-- --	-- --	-- --	-- --
5 M14 rifles 2 M60 bipod MGs	1088	-- --	-- --	7 Stoner rifles 2 Stoner bipod MGs	2460	7 AK47 rifles 2 RPD bipod MGs	1440	7 M16E1 rifles 2 Stoner bipod MGs	3322[B]
Seven-man machinegun squad: squad leader and two three-man machinegun teams									
2 M60 bipod MGs	2246[C]			2 Stoner bipod MGs	6118[C]	2 RPD bipod MGs	3678		
2 M30 tripod MGs	1600[D]			2 Stoner tripod MGs	4596[D]	2 DPM bipod MGs	1504		

[A]Basic loads at equal squad weapon systems weight: 189.33 pounds for rifle squad and 259.30 pounds for machinegun squad (See Table 2-1)

[B]1200 rounds (in bandoleers) for MGs, 2122 rounds for rifles

[C]In bandoleers

[D]In boxes

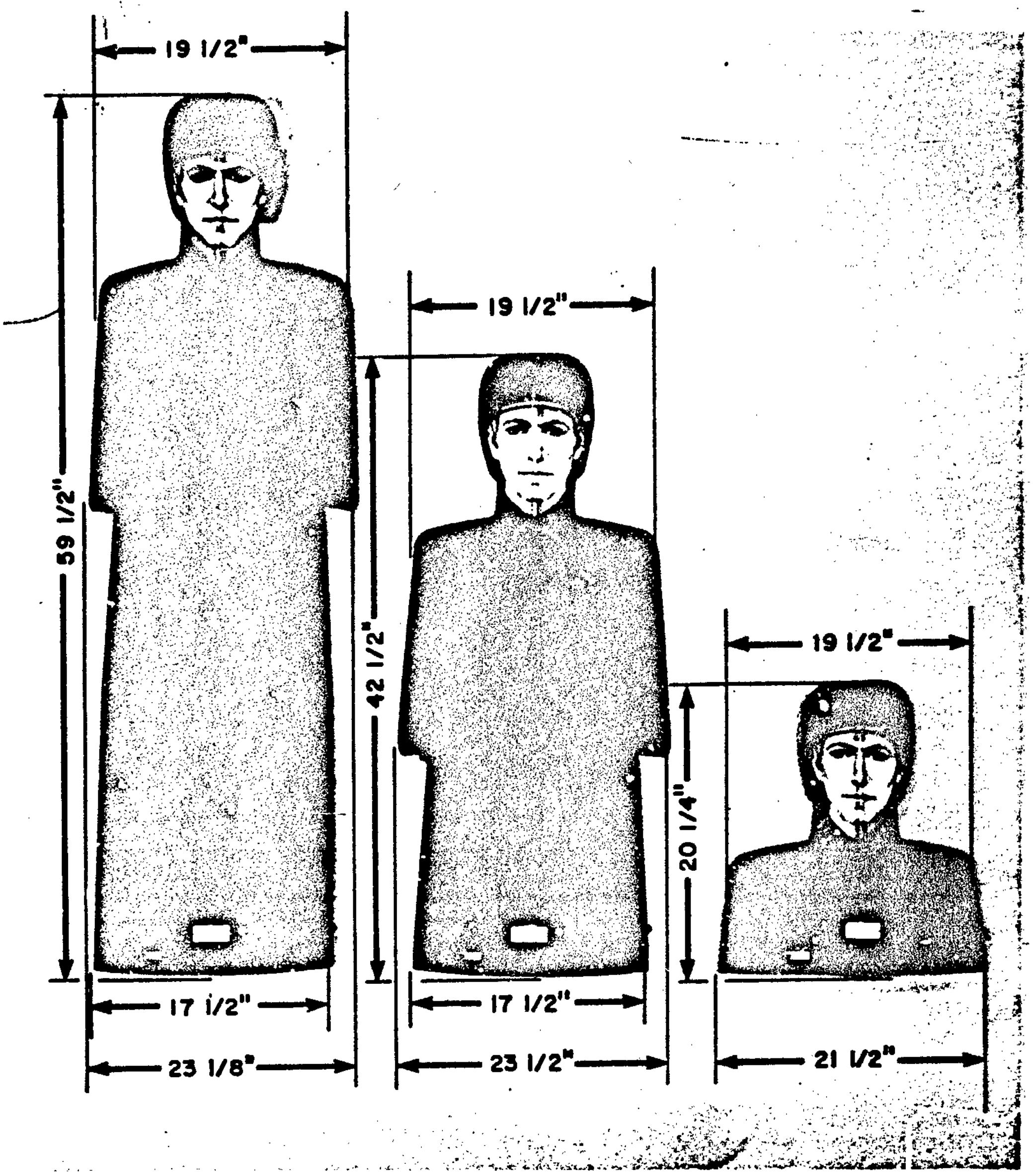


Figure 2-6

STANDING, KNEELING, AND HEAD AND SHOULDER TARGETS
(903, 623, 237 sq in. areas, respectively)

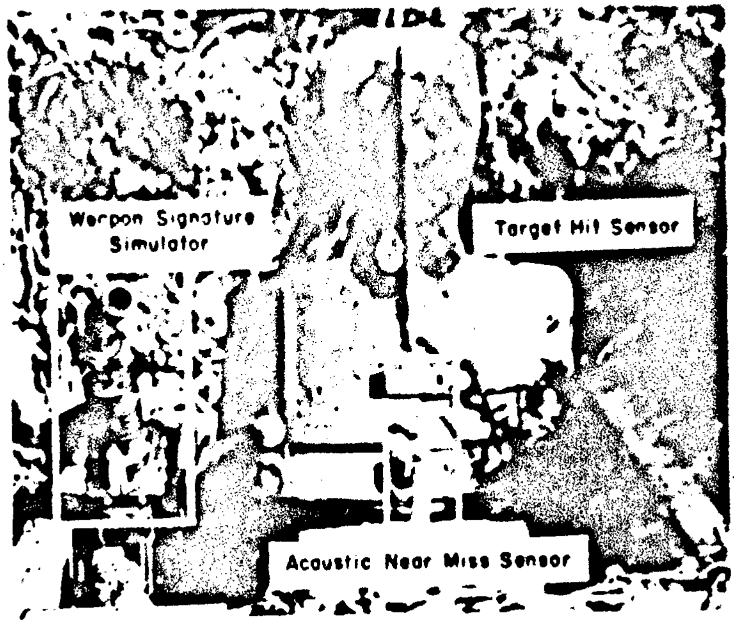


Figure 2-7 ACOUSTIC NEAR MISS SENSOR
(Head and Shoulder Target)

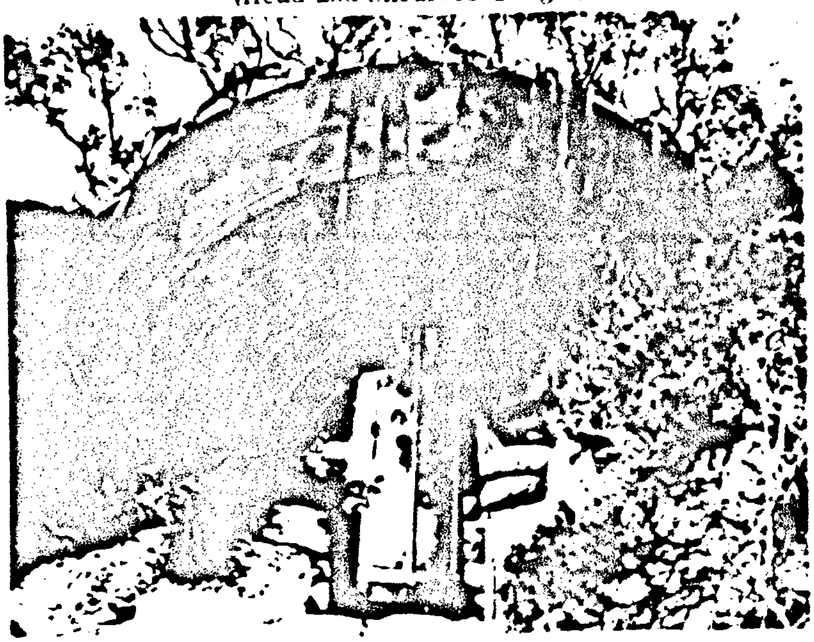


Figure 2-8 PANEL NEAR MISS SENSOR
(Kneeling Target)

down, weapon signature simulator on and off, and rounds fired per weapon. The instrumentation was capable of discriminating between individual rounds to 5 milliseconds.

The instrumentation is described in further detail in Annex B. A supplemental detailed technical report will be published at a later date.

D. EXPERIMENT PERSONNEL

1. Source of Support Personnel

Support personnel for purposes of administrating and supporting the general conduct of the experiment (other than experimentation subjects) were from Project Team II, Experimentation Support Group, and the 194th Armored Brigade of USACDCEC.

2. Source of Experimentation Subjects

Experimentation subjects were provided by the 194th Armored Brigade. Subjects assigned to the six primary mixes--UA, UB, CA, CB, SA, and SB (the mixes equipped with nine rifles and with seven rifles and two automatic rifles)--were from infantry companies of the 41st Infantry Battalion. Subjects assigned to the other weapon mixes--SC, UC, UD, RA, and RC--were from armored and artillery units as well as from the 41st Infantry; they had all been previously trained and had qualified with the M14 rifle.

3. Organization of Experimentation Subjects

a. Organization into Squad Weapon Mixes

Experimentation subjects were organized into: (1) nine-man rifle squads consisting of a squad leader and two four-man fire teams, and (2) seven-man machinegun squads consisting of a squad leader, two machinegunners, two assistant machinegunners, and two ammunition bearers.

b. Sample Size - Implications

As far as practical, to randomize and balance uncontrolled variables--such as differences in the abilities of experimentation subjects, effects of weather, the effects of time of day (especially light), changing conditions of vegetation, and the motivational effects of proximity to weekends and holidays--six squads were assigned to each weapon mix. The use of six squads allowed them to be scheduled to fire in balanced matrices in each tactical situation with respect to date and time of day. A total of 105 squads, consisting of 975 experimentation subjects (including supernumeraries) was required.

c. Matching of Personnel

The number of personnel available allowed them to be assigned initially at random, on the basis of 72 men to the rifle mix--six nine-man experimentation squads plus nine-man squads from which supernumeraries were drawn to replace personnel lost for illness or other reasons--and 42 men to the machinegun mix. On completing the training phase, subjects were reassigned within their weapon type. The same number of experts, sharpshooters, and marksmen were assigned to each experimentation squad within a mix.

To conduct the experiment, special measures had to be taken to select experimentation subjects that could be retained for each phase of the experiment and, where necessary, to obtain their deferment from overseas levy.

Personnel records of all personnel were reviewed and cataloged, both at the time of initial assignment and at the completion of training, to ensure that personnel of all mixes were as closely equivalent as possible on all variables that could be expected to correlate with performance.

4. Training Program for Experimentation Subjects

The training phase of the experiment was conducted from 24 August to 21 October 1965 on Fort Ord Infantry Training Center ranges. Results of training tests and an analysis of the SAWS training program appear in Section IV (Training Results).

a. Training Objectives

Training objectives were to make all personnel proficient with their respective SAWS weapons, and to obtain data on the relative effectiveness of training inherent to the various weapons.

b. Training Program

The training program consisted of basic marksmanship and transition training, and followed current Army marksmanship courses outlined in Army Subject Schedules 7-111 and 7-112 dated November 1964; FM 23-71 dated July 1964; FM 23-16 dated June 1965; and FM 23-67 dated October 1964.

(1) Basic Marksmanship Instruction

Basic marksmanship instruction included mechanical training, instructional and qualification firing, target detection, and night firing. Where weapon differences prevented combined training--for

Table 2-3

BASIC MARKSMANSHIP
RIFLE INSTRUCTION

Subject	Total Hours	Ammunition per Firer
Orientation and Mechanical Training	4	0
Target Detection	6	0
Preparatory Marksmanship (25 meter firing)	14	132
Field Firing	4	56
Record Firing (includes 3 hours of concurrent target detection)	16	192
Night Firing	5	44
Familiarization of Automatic Technique	12	258
Total	61	682

NOTE: Modifications to Combat Readiness Marksmanship Proficiency Standard Course A1: Orientation and Mechanical Training was increased from 2 to 4 hours; Record Firing was increased from 8 to 16 hours to provide learning factors; Night Firing was increased from 2 to 5 hours to provide 3 hours of refresher on techniques; and familiarization of Automatic Fire Technique was included to prepare experimentation subjects for automatic firing with rifles.

example, mechanical training, sight adjustment and establishing battle-sight zero--qualified instructors using equivalent training aids and instructional material taught the experimentation subjects each weapon system separately. The hours of basic instruction presented are shown, with the ammunition used, in Tables 2-3, 2-4, 2-5, and summarized here:

Rifle Marksmanship (Combat Readiness Marksmanship Proficiency Standard Course	61 hours

A-1, modified to include 12 hours of automatic fire)	
Automatic Rifle Marksmanship	29 hours
Machinegun Marksmanship (Tables I through VI)	34 hours

(2) Transition Training

After completing basic marksmanship, rifle and machinegun squads were given separate transition training designed to train them to perform effectively as members of rifle and machinegun squads and to acquaint them with the safety and range procedures employed on the SAWS field experimentation ranges (Table 2-6).

Rifle squad transition training consisted of 24 hours of instruction as outlined in Army Subject Schedule 7-111 dated November 1964 and TC 23-9 dated January 1965. It included controlled tactical firing exercises in the approach to contact, assault, and defense.

Machinegun squad transition training consisted of eight hours of instruction in crew drill and controlled tactical firing exercises in support of the attack, support of the assault, and defensive firing.

c. Supplementary Training

Supplementary training was provided later to meet requirements caused by normal attrition and the need for new squads. This training was given at various times in November 1965, December 1965, and January 1966. The 228 personnel trained or cross trained as riflemen, automatic riflemen, or machinegunners are reflected in the totals shown in Table 2-7. Personnel who had received no previous training were given the full complement of training. Personnel being cross trained received instruction on disassembly, assembly, functioning, zero firing, automatic fire techniques, trigger manipulation, loading, and range safety as necessary. All personnel received equivalent amounts of training.

d. Training Facilities

Facilities used during training included classrooms and target detection and firing ranges. Infantry Training Center classrooms and ranges at Fort Ord were used during basic marksmanship training without modification. Sketches of ranges used for transition training appear in Section IV.

Table 2-4

BASIC MARKSMANSHIP
AUTOMATIC RIFLE INSTRUCTION

Subject	Total Hours	Ammunition per Firer
Orientation and Mechanical Training	2	0
Target Detection	2	0
Preparatory Marksmanship (25 meter firing)	12	236
Record Practice (Instructional Firing)	4	79
Record Practice (Qualification Firing)	4	74
Night Firing	5	104
Total	29	493

NOTE: Modifications to Army Subject Schedule 7-111: Mechanical Training was given to familiarize firers with new weapon systems: refresher training in Target Detection and Night Firing was given because these areas are covered in Basic Rifle Marksmanship Training of which this training is normally a part.

Table 2-5

BASIC MARKSMANSHIP
MACHINEGUN INSTRUCTION

Subject	Total Hours	Ammunition per Firer
Orientation and Mechanical Training	3	0
Bipod Firing (Table 1)	4	42
Tripod Firing, Practice (Table II)	4	108
Tripod Firing, Record Practice (Table III)	4	78
Tripod Firing, Record (Table IV)	4	108
Transition Firing, Practice & Record (Table V)	8	396
Day Defensive Field Firing (Table VI)	7	200
Total	34	932

NOTE: Modifications to Army Subject Schedule 7-111: Mechanical Training was increased from 2 to 3 hours; Table VII (Assault Firing) and Table VIII (Day and Night Predetermined Firing) were deleted as not pertinent to the SAWS Experiment.

Table 2-6

TRANSITION TRAINING

Subject	Total Hours	Ammunition * per Firer	
		Rifles	ARs
Rifle Squad			
Orientation	4	0	0
Squad Technique of Fire	4	20	40
Squad in the Approach to Contact	8	60	120
Squad in the Assault	4	100	260
Squad in the Defense	4	60	100
Total	24	240	520

Subject	Total Hours	Ammunition* per Firer
Machinegun Squad		
Support of Attack and Assault Firing	5	700
Defense Firing	3	200
Total	8	900

* Indicates amount of ammunition allocated for the exercise, not necessarily amount expended which varied from firer to firer.

Table 2-7

PERSONNEL TRAINED AND CROSS-TRAINED

Type Training	Personnel Trained (Initial Weapon) Training Course	Personnel Not Completing Training	M14 Riflemen Retrained		Stoner Riflemen Retrained	RPD MG Personnel Retrained	M60 Ammunition Bearers	Stoner Riflemen	MG Refamiliarization	Stoner MG Retrained in AR Role
			Completed Training	Did Not Complete Training						
Riflemen										
M14	184	9[A]								
M14E2 (rifle role)	71	5[A]								
Colt	128	3[A]								
Stoner	128	12[A]								
AK47	100	1[A]				8				
Automatic Riflemen										
M14E2	16									
Colt AR	16									11
Stoner AR	16							4		
M60 MG (AR role)	16									
Stoner MG (AR role)	16									
RPD MG (AR role)	16									
Machinegunners										
M60 (bipod)	46[C,B]		24[B]				3[C]		12	
M60 (tripod)	40[C] (6)[C,B]	1[A]	24[B]	1[A]			(3)[C]		10	
Stoner (bipod)	40[C]				24				10	18
Stoner (tripod)	37[C]				23				14	
RPD (bipod)	15	15[B]							12	
DPM (bipod with tripod group)	34 [14][B]								8	
TOTALS	975	46	48	1	47	8	3	4	66	29

[A] Figures include personnel who were not sufficiently trained to be used in field experimentation because of PCS, death, hospitalization, AWOL, confinement, or emergency leave.

[B] Personnel did not complete original training because of ammunition shortages, but 14 completed training at a later date.

[C] Received both bipod and tripod training.

[B] To be used as ammunition bearers.

NOTE: ( )[C] indicates same personnel as shown in column above marked with [C].

[ ] indicates footnote applies to number within.

e. Training Data Collected

The following types of data were collected during training:

1) Timed disassembly and assembly of weapons
2) Hits on targets
3) Size and type of shot groups
4) Number of targets engaged and number hit
5) Round dispersion
6) Ammunition expenditure
7) Number and type of malfunctions
8) Individual qualification

The primary measures of training performance were the firing scores taken on various ranges at fixed points during training. Each time firing scores were taken, each weapon system group had had the same amount of training of the same kind under comparable conditions. Results of the training program and firing scores are given in Section IV (Training Results).

E. EXPERIMENTATION PROCEDURES

1. Uniform Operational Policies - General

Uniform operational policies established for each tactical situation included policies for the situation and for each type of weapon in each mix of each family. These policies governed the ammunition basic load, the burst length (for example, semiautomatic or two round), the ammunition mix (such as the ratio of ball to tracer), the firing position (shoulder pointed, for example), the type of support (with or without sling or bipod), and the type of weapon zero and sight setting. In addition, a standard policy was used for assigning sectors of fire and for assigning weapons to foxholes and to positions in moving formations. These policies and firing techniques were derived from standard doctrine and, where doctrine was not specific, from exploratory firing. They are tabulated by situation in Annex A.

2. Control and Balance of Weapon Mix Structure and Equipment

As discussed in paragraph D-3, firers assigned to each mix of weapons were matched, as far as possible. They were also matched in assignments to the weapon types in a mix. When tracers were used by only a portion of a mix (for example, automatic rifles) they were also used by the firers in corresponding positions in all other mixes. This ensured that differences in the mixes would be a function of weapon differences, rather than tracer rounds employed.

The schedule of runs was equally balanced in a matrix, providing for randomizing and balancing out the effects of extraneous variables (paragraph E-3 of Section I).

When not in use, experimentation weapons were held in guarded vans, and periods of care and cleaning were supervised.

3. Modes of Fire

Doctrine and exploratory firing indicated that the best mode of fire for the M14 rifle was semiautomatic fire in all situations. Since the limited time available for the experiment did not permit use of more than one technique of fire for each weapon in each tactical situation, the M14 rifle was fired semiautomatically and the other candidate rifles were, with several exceptions, fired in two round bursts.* Exceptions were the defense situations (Situations 7 and 8), where time permitted comparison of all rifles in both automatic and semiautomatic fire. Another exception was the base of fire situation in the attack against delaying action (Situation 5), where all rifles fired only semiautomatically. Automatic rifles and machineguns were fired, respectively, in identical burst lengths in each tactical situation.

4. Control for Differences in Firer Location and Opportunity

The effects of such differences in firer opportunity as intervisibility were controlled, as far as possibile. The squad leader and the same special weapons (such as automatic rifles) were always assigned to the same foxholes or positions. The other firers were assigned from right to left in the descending order of their training phase marksmanship scores.

5. Control of Squad Leader Variability

Squad leaders exercised administrative control over experimentation squad except during actual experimentation runs. The effects of the variability of squad leaders was controlled by using standardized, firing policies and eliminating the free play of squad leaders' opportunities.

6. Control for Effects of Learning

To minimize transference effects between weapons and other undesirable learning effects, each squad was trained only in the weapons of its specific weapon mix, and each squad fired each situation only once.

* As a rifle, the M14E2 was fired in two-round bursts because the directive required that it be fired automatically. The AK47 was fired semiautomatically in Situations 1, 2, 4, 5, and in the second series for Situations 7 and 8.

Measures were taken to ensure that the experimentation subjects would not see the tactical situations before firing them. Steps were also taken to ensure that experimentation personnel had equal access to their assigned experimentation weapons during the experiment. When not in use, the experimentation weapons were held in guarded vans. During the experiment, experimentation subjects were also denied access to their TO&E weapons. However, the experimentation subjects, all soldiers of the 194th Armored Brigade had previously been trained in the M14 rifle. Some had also been trained in the M14E2 automatic rifle and M60 machinegun. This bias in favor of the US 7.62mm system was not desirable, but could not be avoided because only previously trained soldiers were available for use as experimentation subjects.

7. Data Collection Procedures - Primary Measures

a. Primary Measures Data

Most of the SAWS data were provided as output from the SDS 910 computer located on each range in the form of magnetic tapes. These data included hits, near misses, and rounds fired as a function of time.

To ensure the proper collection of valid data, a range officer, an operations analyst, (range scientist), an instrumentations maintenance officer, and a field engineer were always present at each range. In addition , test firing was also done on a regular basis for the purpose of exercising, adjusting, and calibrating the instrumentation before and during the experiment.

b. Supplementary Data

In addition to the data collected by instrumentation, meteorological data were taken continuously at each range. Reliability data were gathered during each squad trial. Target instrumentation calibration was checked between each squad trial and the results recorded. This included a manual count of hits on targets and near miss sensor panels, and a count of remaining ammunition.

8. Administrative Procedures

a. Briefings and Debriefings

Squads were given identical administrative and semitactical briefings on each range immediately before firing, and were debriefed for information about weapon malfunctions immediately after firing.

b. Safety Procedures

Because of the scale and nature of the experiment, special safety measures were necessary to reduce the possiblities of accidents, without detracting from the essential realism or validity of the experiment. Among the safety measures used were briefings on scale models and actual terrain immediately before firing with respect to safety limits, the use of specially trained controller teams at each firing line and in each moving firing situation, provision of cook-off pits for safe disposition of jammed hot weapons, and procedures for clearing hot weapons after a trial by shooting off the last round. Moving pictures were taken of controllers and firers during each squad run. These were shown later for study and correction of safety procedures and weapons malfunctions.

F. EXPERIMENTATION TACTICAL SITUATIONS

Experimentation was based on nine tactical squad firing situations grouped three to a range. The three situations on each range were interrelated parts of a platoon and company framework situation but fired separately for reasons of data collection and safety. The three platoon-company framework situations selected were:

1) Assault against defense (Range A)
2) Attack against delaying action (Range B)
3) Defense against attack (Range C)

These three platoon-company framework situations were constructed to ensure that squad situations could be related for analysis and synthesis (especially later for IRUS purposes) and to provide for the measurement of representative mechanisms and modes of fire of small unit small arms combat.

Each tactical situation constituted a model consisting of selected terrain characteristics, target array layouts, friendly firer layouts, firing distances and range-target frequencies, and timing of events representative of the situation being portrayed. (See Annex B for range sketch maps and detailed range information, to include Target System Command Program Tables.) These tactical situations, together with the effectiveness criteria, provide the fundamental basis for the analysis. The component situations and their effectiveness values can be weighted, if desired, to modify the basic model, within limits.

The target layouts were determined by examining the dispositions and dimensions given in US, Soviet, and other doctrine and, where possible, adopting dimensions that were common to the several doctrines. Detailed intervisibility and survey data were collected during layout of the ranges. As far as possible, such target behaviors as type of individual target body, up and down movement, target exposure times, and weapon simulator cues were based on tactical realism.

The firing distances used in the tactical situations were chosen to represent the frequent and useful ranges of small arms combat with additional longer range increments added for purposes of securing a broader data base. The maximum range fired by rifle squads was 560 meters and the maximum for machineguns was 753 meters.* Safety considerations and available terrain did not have an important effect on the firing distances selected. The percentages of targets by range for the nine tactical situations are shown below:

Range (Meters)	Percentage of Targets[a]	
	Rifle Squad	MG Squad
0-50	15	2
51-150	35[b]	11
151-250	10	8
251-350	16	17
351-500	16	29
500-650	8	21
651-750	0	12

[a]Includes targets used in the night situation and targets presented more than once in a given situation

[b]Includes targets on assault course that ranged from 148 to 15 meters

The nine squad situations consisted of six rifle squad situations and three machinegun squad situations. Of the six rifle squad situations, two involved moving firing and one involved a night firing situation. The nine situations are tabulated below and described in the following paragraphs.

* Preliminary experimentation on Range B (Situations 5 and 6) showed that firers could distinguish neither targets nor target array locations at these longer ranges, even when provided with more substantive auditory cues and visual cues than they would have in combat. This was true, even though individual targets had camouflaged semicircular near miss panels 4 meters in diameter behind them. The squads were therefore provided additional specific intelligence of the target array locations so that firing data could be collected at these ranges.

Assault Against Defense (Range A)	Attack Against Delaying Action (Range B)	Defense Against Attack (Range C)
1. Rifle squad in line assault	4. Rifle squad in approach to contact	7. Rifle squad in defense against attack
2. Rifle squad as base of fire supporting the assault	5. Rifle squad as a base of fire supporting the advance	8. Rifle squad in night defense against attack
3. Machinegun squad in fire support of the assault	6. Machinegun squad in fire support of advance*	9. Machinegun squad in defense against attack

1. Situation 1: Rifle Squad in Line Assault

Situation 1, focusing on the left target array on Range A (Figure 2-9), represented a 100-meter assault by a squad in line formation. The action lasted 2 minutes. The assaulting troops employed marching fire as they moved up the slope. Firing commenced 115 meters from the nearest target and ceased 15 meters from it. The target array being assaulted occupied a position 50 meters wide and 30 meters deep with the elevation rising 4 meters from the front to rear on the same slope as the assaulting troops. The array consisted of 17 head and shoulders targets representing concealed and partially concealed dug-in enemy soldiers, as a squad with other company elements as part of a reinforced rifle company in defense. Although irregular, the lateral interval between targets averaged 6 meters. Each target in the array had an acoustic near miss sensor, and all but three had weapons simulators.

Situation 1 evaluated rifle squad weapons mixes in marching fire against targets in foxholes at ranges of 148 to 15 meters.

2. Situation 2: Rifle Squad as a Base of Fire Supporting the Assault

This situation was also located on Range A (Figure 2-10). In addition to the target array used in the assault situation, this situation included an additional array to the right. The right array contained 13 head and shoulders targets (a squad with other company elements) occupying a position 50 meters wide and 35 meters deep with elevation rising 4 meters.

* Machinegun squads fired this situation from two different positions. In follow-on experimentation in January, the machinegun squads fired from the same positions used by the rifle squad in Situation 5.

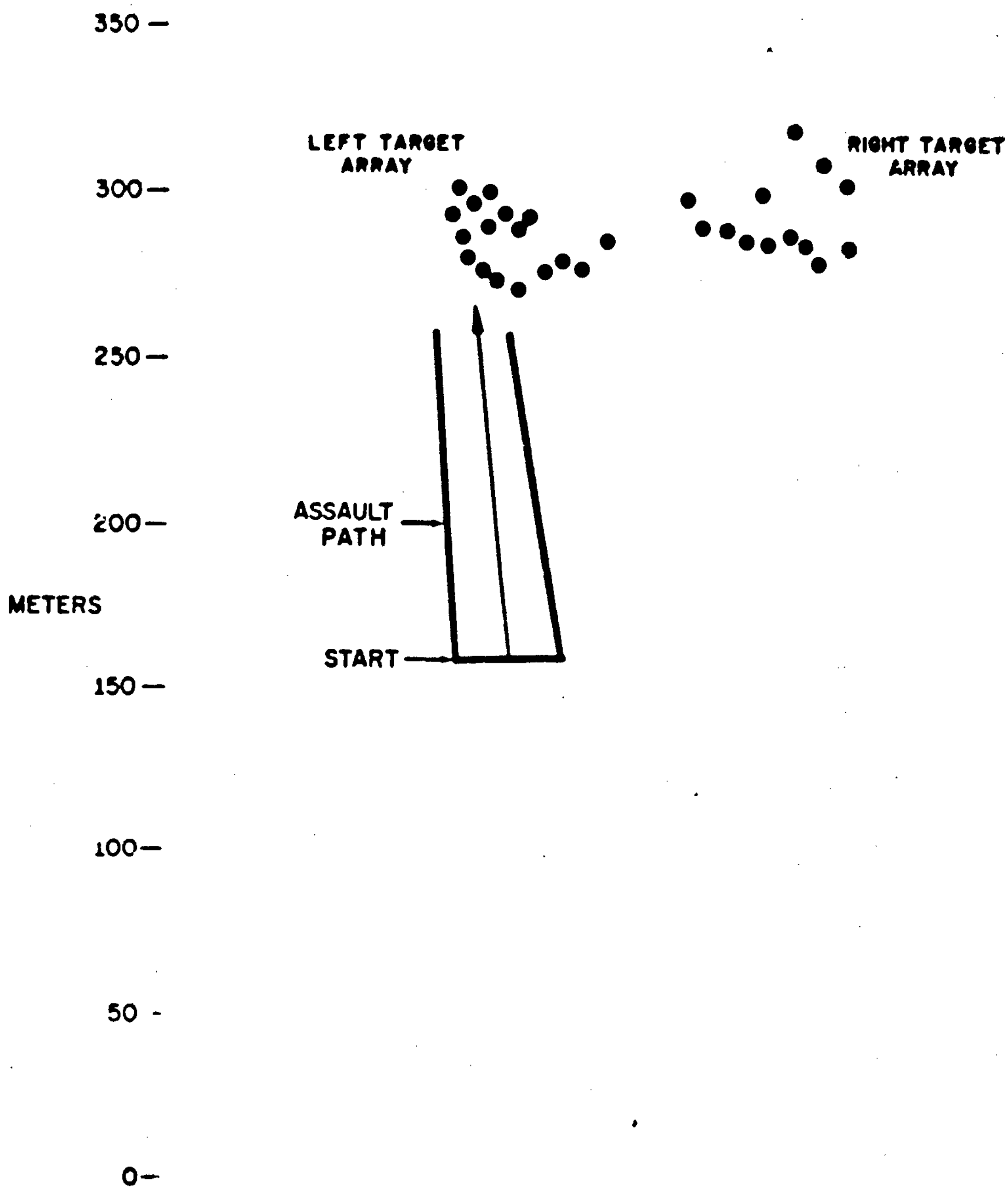


Figure 2-9
SITUATION 1, RANGE A

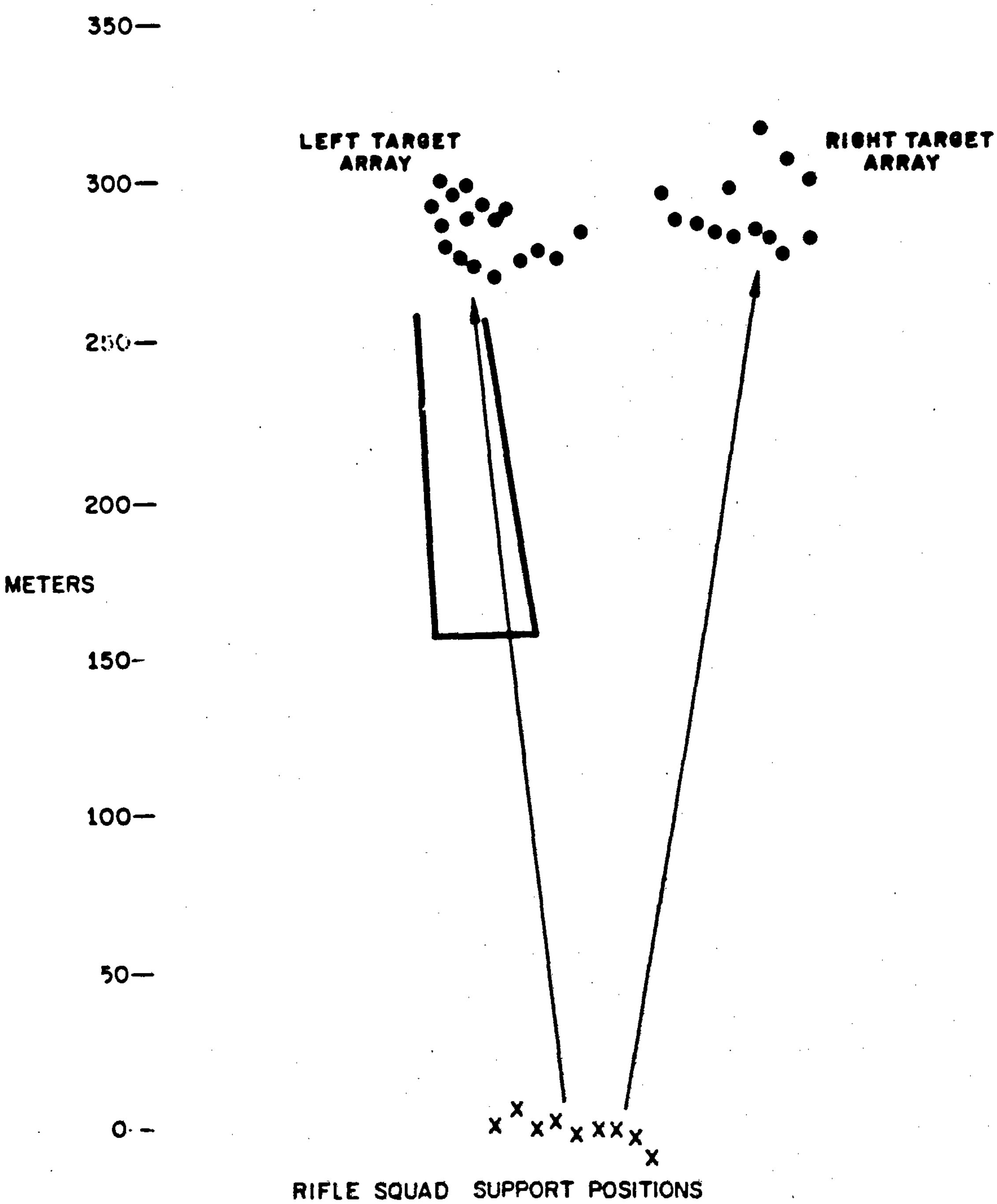


Figure 2-10

SITUATION 2, RANGE A

from the front to the rear. All but two of the targets were equipped with weapons simulators, and all had acoustic near miss sensors.

The firers were located in nine shallow foxholes, laterally about 6 meters apart and staggered in depth along the forward edge of a ridge. The foxholes represented typical hastily prepared individual battlefield positions. The squad fired first on the left target array (the array used in Situation 1) and then shifted its fire to the right target array to simulate the shifting of fire as the assault troops closed on the enemy. The distances from the firers to the two target arrays was from 263 to 326 meters.

Situation 2 evaluated rifle squad weapon mixes firing supporting fire from hastily prepared foxholes at concealed and unconcealed targets in foxholes at a range of 263 to 326 meters.

3. Situation 3: Machinegun Squad in Fire Support of the Assault

This situation utilized the same terrain, targets and firing positions as that used by the rifle squad in Situation 2. However, this situation depicted a machinegun squad in support of a rifle squad in the assault. The two machineguns of the squad were positioned 25 meters apart (Figure 2-11).

4. Situation 4: Rifle Squad in Approach to Contact

This situation, located on Range B (Figure 2-12), included 12 events and employed 40 targets (four head and shoulders, 32 kneeling and four standing). The 12 events were laid out along a course over which the rifle squad advanced in a sweep formation as a line of skirmishers. The events represented action by snipers, scattered enemy security elements, and an ambush. The overall course was 430 meters long (Figure 2-13).

As the squad approached an event at a location identical for each squad, the targets--30 equipped with weapons simulators--were actuated and the men stopped and fired. The firing distances for the events varied from 19 to 180 meters. Target exposure times varied from 2 to 10 seconds. The targets were not equipped with near miss sensors.

The approach to contact situation evaluated the rifle squad mixes in standing quickfire at briefly exposed visible targets. This situation, in which firers were time stressed, was designed especially to evaluate the pointing characteristics of small arms.

5. Situation 5: Rifle Squad as a Base of Fire Supporting the Advance

The rifle squad occupied unprepared prone firing positions averaging 6 meters lateral distance apart and staggered 48 meters along the forward edge of a ridge (Figure 2-14). Squads representing fire support of an advancing rifle squad (Situation 4) delivered fire on two target arrays. The

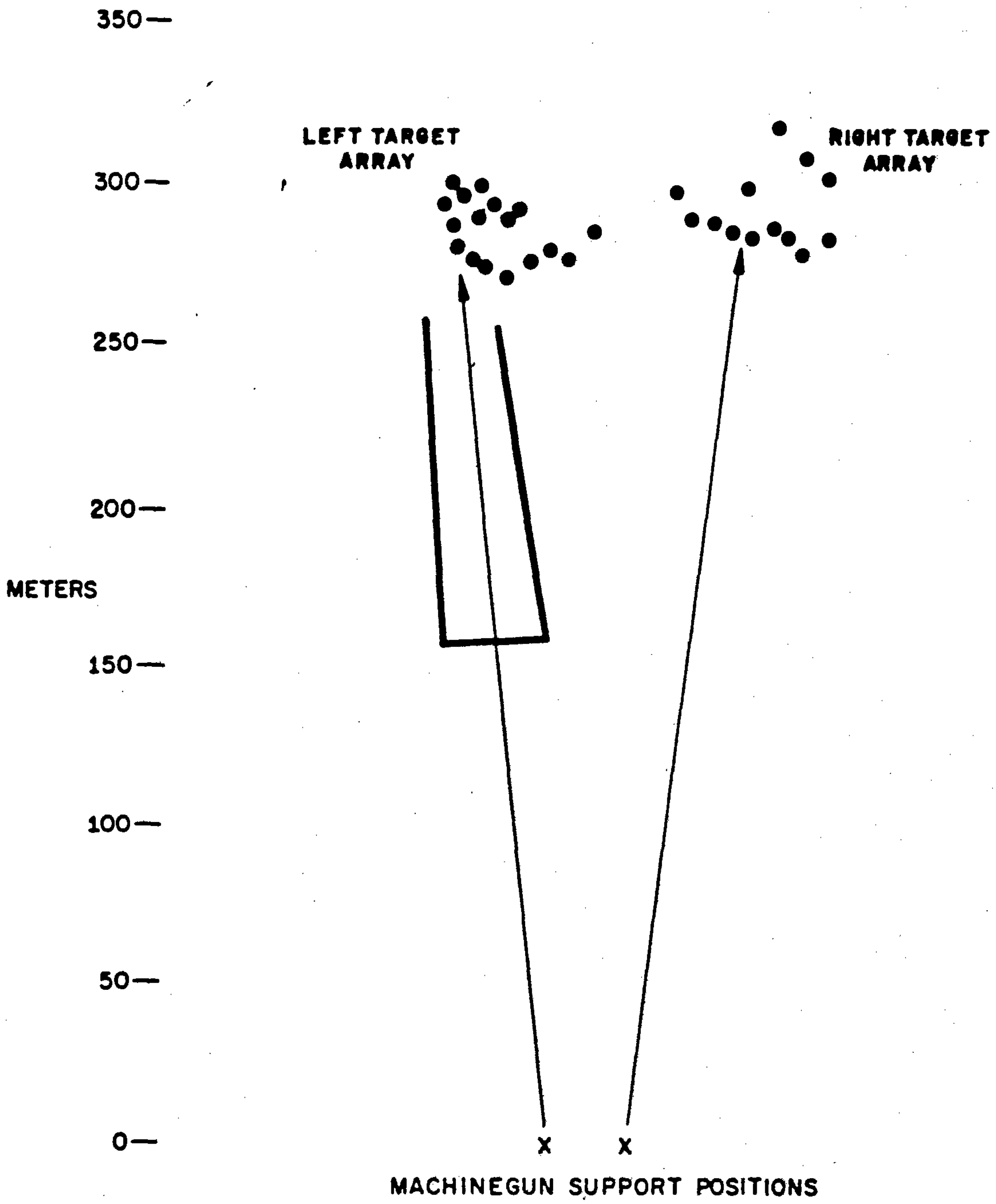


Figure 2-11
SITUATION 3, RANGE A

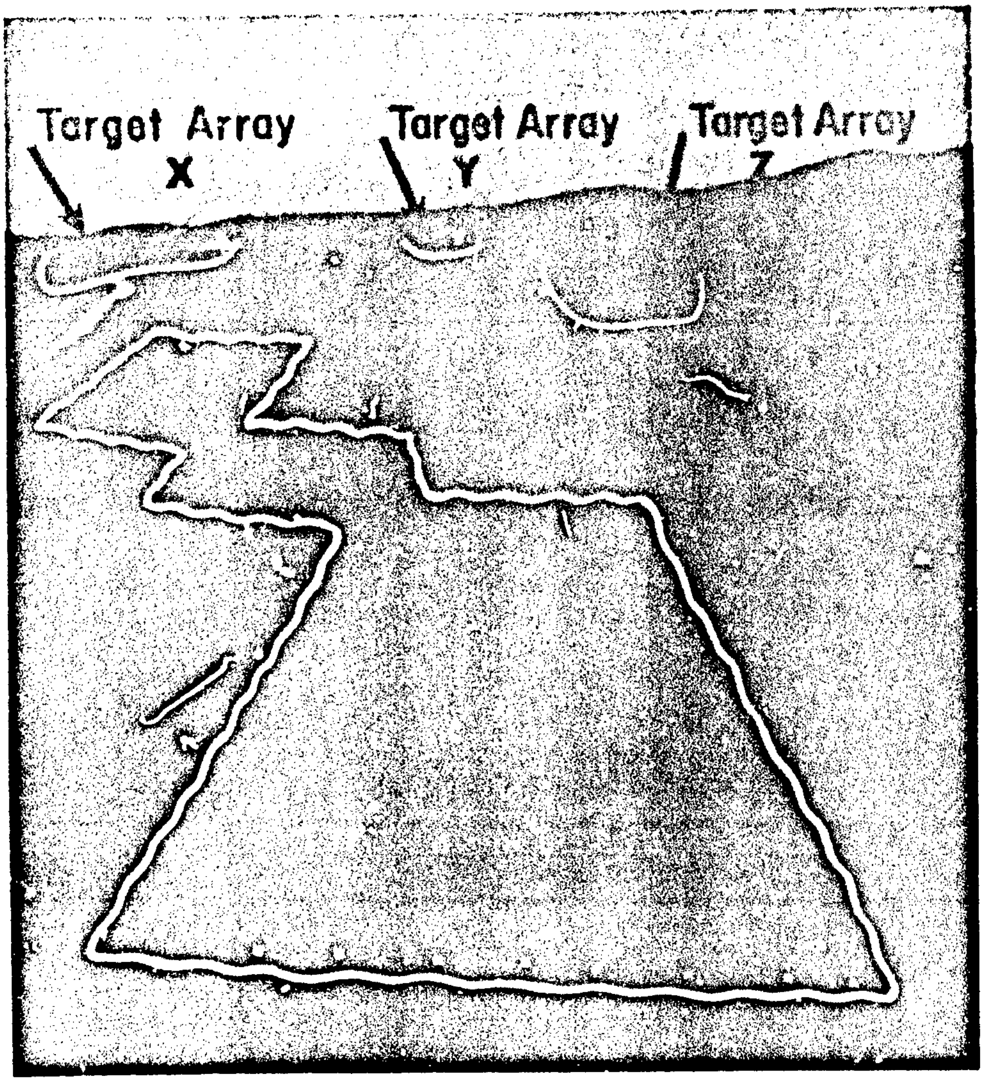


Figure 2-12

SITUATION 4, APPROACH TO CONTACT, RANGE B

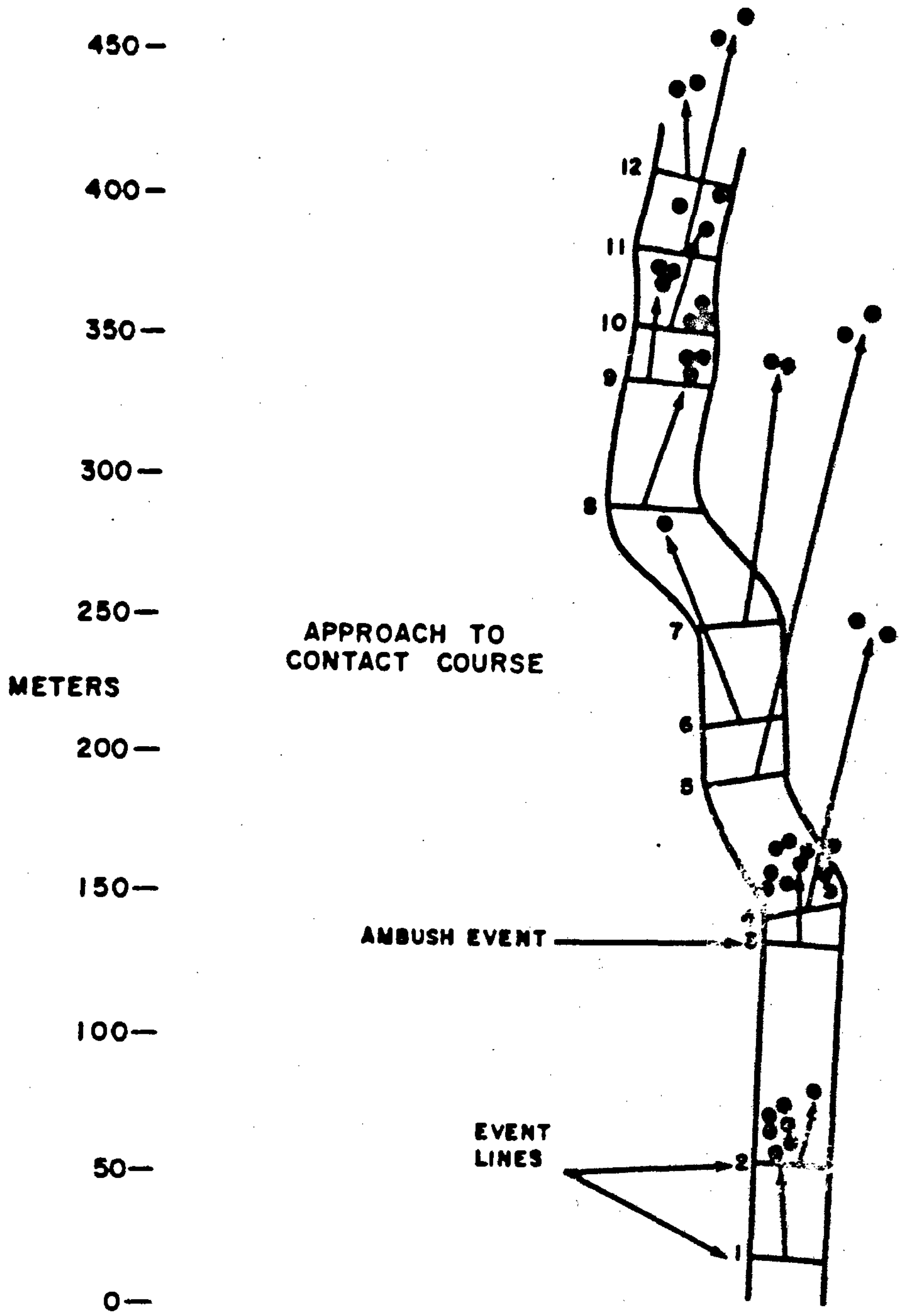


Figure 2-13

SITUATION 4, RANGE B

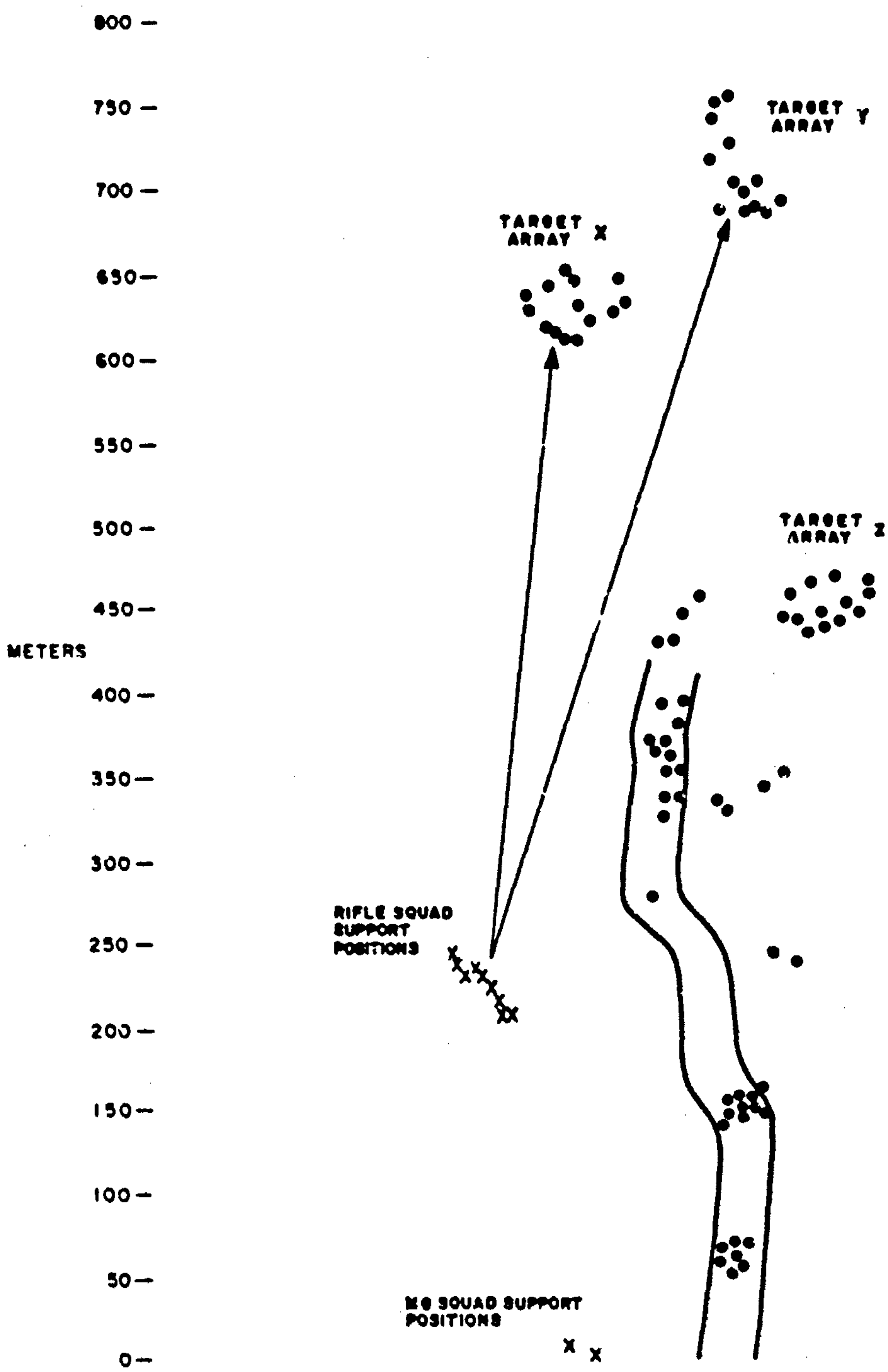


Figure 2-14

SITUATION 5, RANGE B

arrays represented partially dug-in enemy in a delaying position. Target Array X contained 14 targets (five head and shoulders and nine kneeling) occupying an area 60 meters wide and 42 meters deep, with an elevation from front to rear targets of about 7 meters. Its range from the firers was 379 to 445 meters. Six of the 14 target elements in this array had weapon simulators. The more distant Target Array Y with three head and shoulders, three kneeling and seven standing targets, was 477 to 560 meters from the firers, occupying an area 45 meters wide and 62 meters deep with elevations rising about 7 meters. Six of the 13 targets had weapon simulators. The targets of both arrays were equipped with near miss sensors. The rifle squad initially fired on Target Array X and then shifted its fire to Array Y, firing 2 minutes on each array.

Situation 5 evaluated rifle squad weapons mixes delivering long range supporting fire from prone positions against concealed partially dug-in targets at ranges of 379 to 560 meters.

6. <u>Situation 6: Machinegun Squad in Fire Support of Advance</u>

This situation was also on Range B (Figure 2-15). Machineguns of the machinegun squad weapon mixes occupied positions about 12 meters apart along the forward edge of a knoll 240 meters to the rear of the rifle squad position of Situation 5. In addition to firing upon Target Arrays X and Y discussed in Situation 5, Target Array Z was also fired upon and contained 13 targets occupying an area 52 meters wide and 32 meters deep, with an elevation from front to rear targets of about 7 meters. Like Arrays X and Y, all targets of this array had near miss sensors and six were equipped with weapons simulators. Target Array Z was located to the right of Target Arrays X and Y at a shorter range and contained five head and shoulders and eight kneeling targets. Ranges to the three target arrays from the machinegun squad position were 603 to 646 meters for Array X, 690 to 753 meters for Array Y, and 446 to 488 meters for Array Z. Firing time was 2 minutes on each array.

Situation 6 evaluated the machinegun squad weapon mixes in firing long range supporting fire from prone positions at concealed and partially concealed, partially dug-in targets at ranges from 446 to 753 meters. It was designed to evaluate long-range fire effectiveness of the weapons under tactical conditions.

7. <u>Situation 7: Rifle Squad in Defense Against Attack</u>

This situation took place on Range C (Figure 2-16). There were 50 targets, four head and shoulders, 17 kneeling and 29 standing, located and programmed to raise and lower to represent an attack becoming an assault. Some of the targets appeared more than once. The attack began at a range of 344 meters and culminated with targets appearing in an

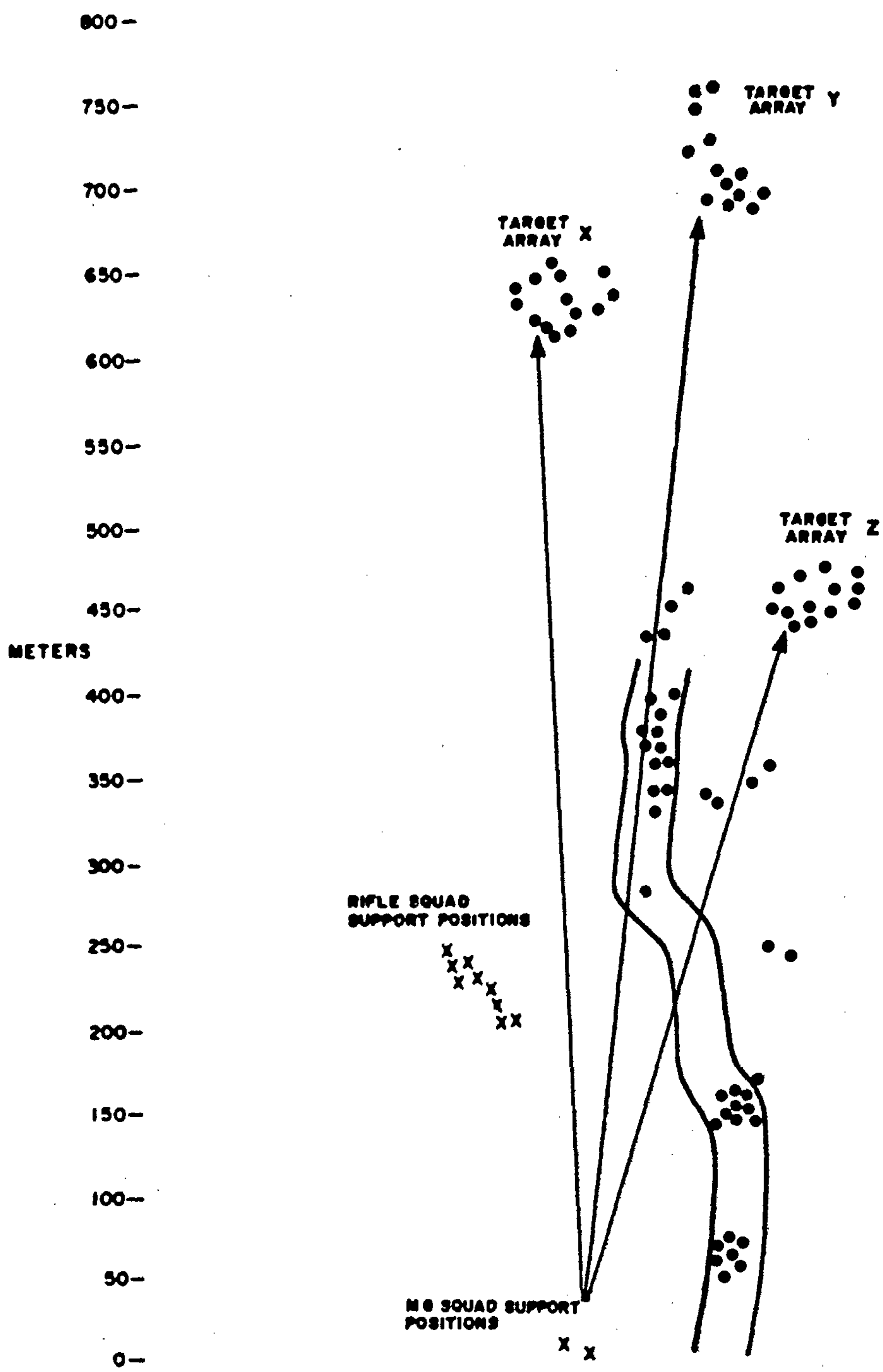


Figure 2-15

SITUATION 6, RANGE B

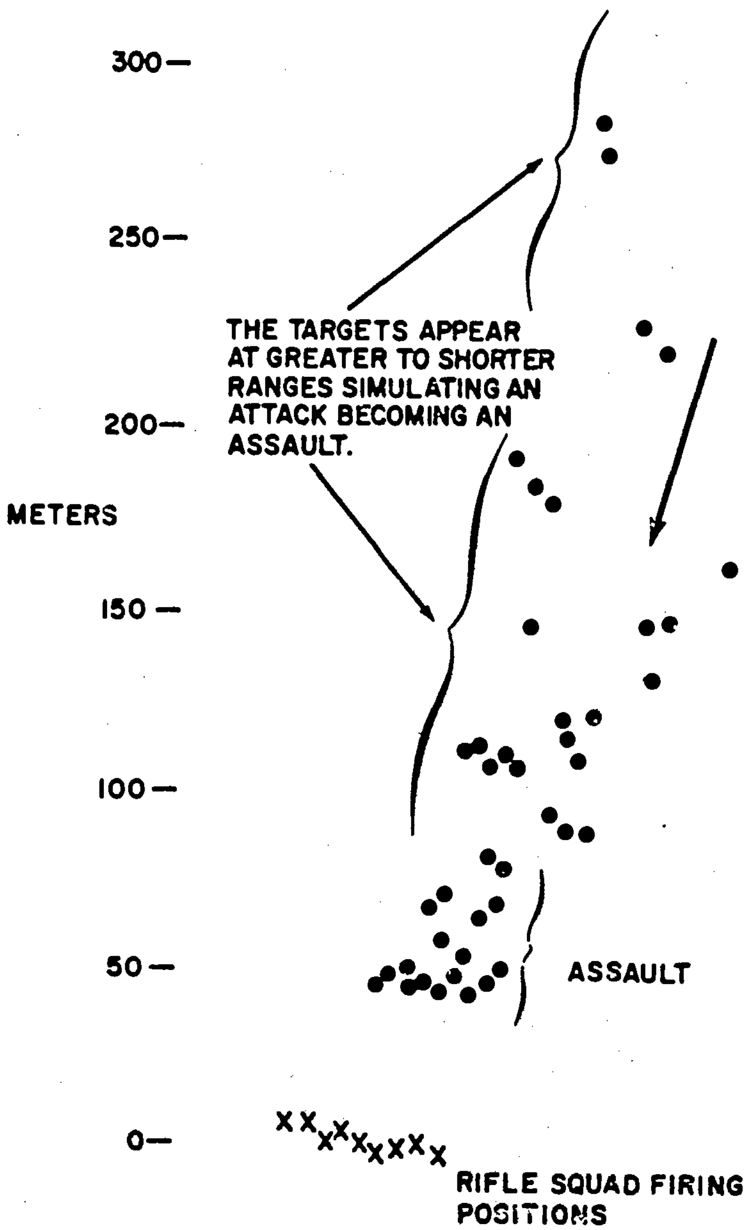


Figure 2-16

SITUATION 7, RANGE C

assault formation 43 meters from the firing positions. Thirty of the 50 targets had weapon simulators; none had near miss sensors. The defending squad occupied hastily prepared foxholes averaging 6 meters lateral distance apart.

Situation 7 (daylight defense) evaluated rifle squad weapons mixes in firing from hastily prepared foxholes at visible targets advancing from 344 to 43 meters.

8. Situation 8: Rifle Squad in Night Defense Against Attack

The night situation was also located on Range C and was similar to Situation 7. However, the scenario was slightly shorter. Thirty-two of the 50 targets used in Situation 7 were utilized; 22 targets were equipped with weapons simulators. Some of the targets appeared more than once. There were three head and shoulders, nine kneeling and 20 standing targets; they were located and programmed to raise and lower to represent an attack becoming an assault. The attack began at a range of 234 meters and culminated with targets appearing in an assault formation 43 meters from the firing position (Figure 2-17). Simulator flash and sound were the main cues for firers in this night situation.

Situation 8 evaluated rifle squad weapons mixes firing night defense from hastily prepared foxholes at target flash and sound cues of targets "advancing" from 234 to 43 meters.

9. Situation 9: Machinegun Squad in Defense Against Attack

This situation utilized the same terrain, targets and firing positions as that used by the rifle squad in day defense (Situation 7). However, in this situation the machineguns occupied selected foxholes of the position that had been occupied by the rifle squad (Figure 2-18).

This situation evaluated the machinegun squad weapon mixes firing from hastily prepared foxholes at visible targets advancing from 344 to 43 meters.

10. Summary of Tactical Situations

The nine tactical situations, together with the effectiveness criteria discussed in paragraph G of this section, provide the model for the experiment and analysis of squad-level small arms fire effectiveness. The model can be adjusted (within limits) by weighting the situations and the effectiveness measures within a situation. The logic underlying the experimental design, terrain selection, tactical target arrays, instrumentation, and programming of events in these tactical situations was to present squads armed with different weapons and weapon mixes with situations

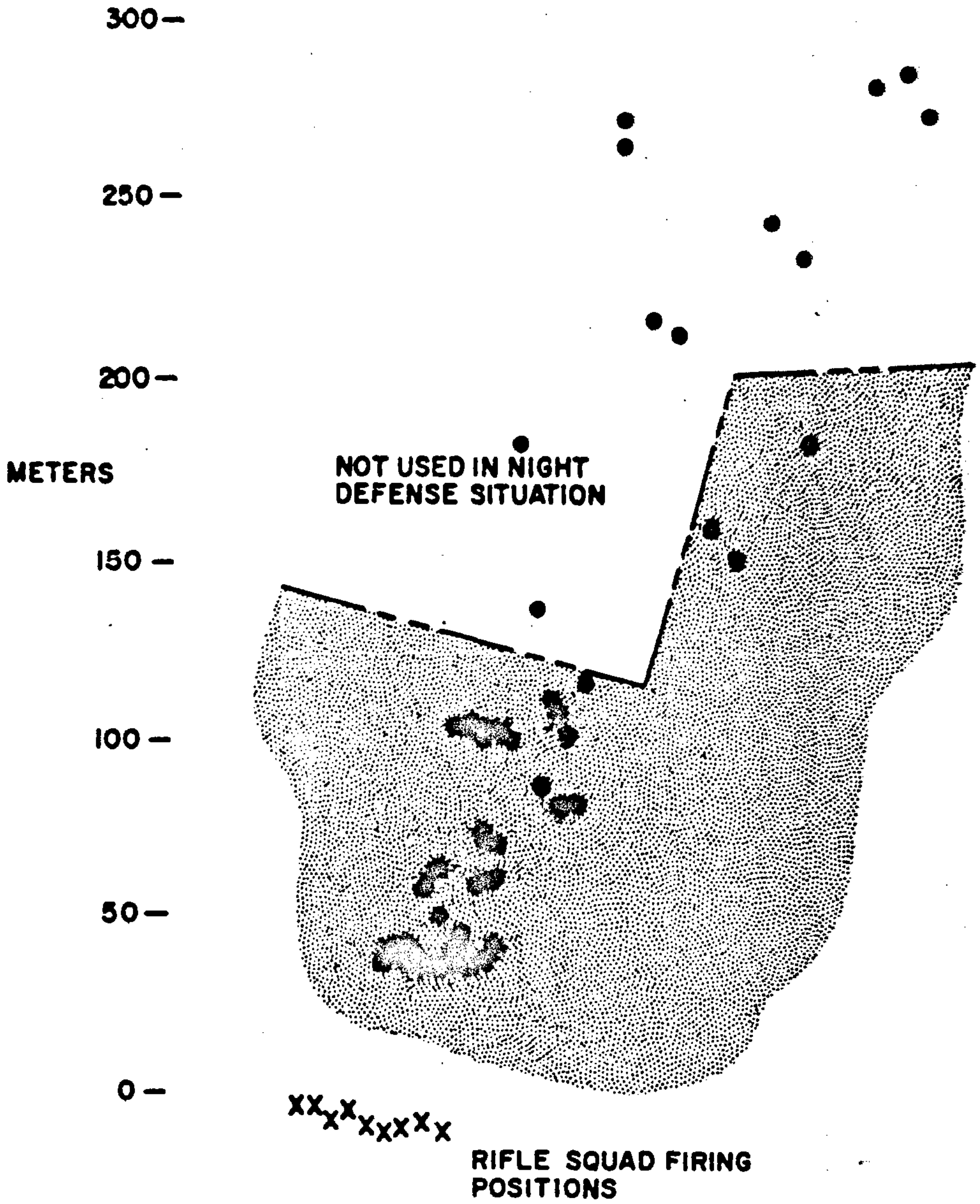


Figure 2-17

SITUATION 8, RANGE C

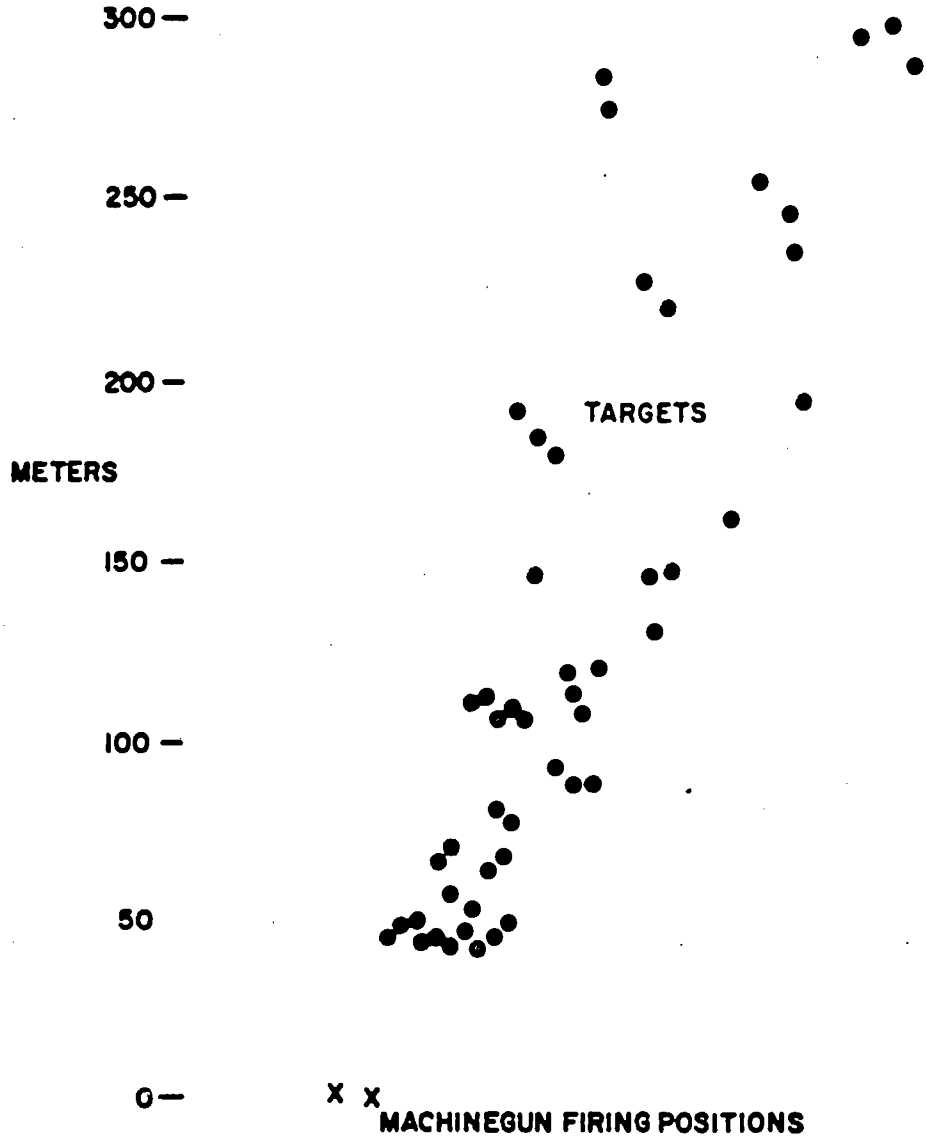


Figure 2-18
SITUATION 9, RANGE C

that would impose on the man-weapon systems, conditions, interactions, and modes of fire reasonably representative of combat. Target acquisition was included as an integrated part of the effectiveness evaluation of the man-weapon systems. Firers were subjected to the stress and uncertainties of intervisibility problems and the knowledge that, if and when revealed, targets would be fleeting or exposed for unpredictable periods. However, stress was not otherwise included.

The final elements of the tactical situations were the operational policies of friendly elements--the basic loads of ammunition, ammunition mixes, burst lengths, and firing policies used with each tactical situation. These are discussed in paragraph E of this section and presented in tabular form in Annex A.

G. EFFECTIVENESS MEASURES (EVALUATION CRITERIA)

This subsection describes the effectiveness measures used in evaluating and ranking the squad weapon mixes. It consists of three paragraphs: Paragraph 1, discussing the qualitative effectiveness concept from which the measures are derived; Paragraph 2, presenting the effectiveness measures themselves; and Paragraph 3, discussing other effectiveness qualities.

1. Effectiveness Concept

The effectiveness measures selected for use in the experiment were derived from the following qualitative effectiveness concept, which also served to guide their use. This concept is necessarily judgmental as a hypothesis, as must be the starting point and foundation of any effectiveness criteria. It also depends particularly on informed military judgment or military experience, since system evaluation implies that the things measured must be valuable qualities of the systems, in the context and environment of their use.

The purpose of the infantry fire fight is to gain fire superiority. Other factors being equal, small arms fire superiority prevents the enemy's fire or movement, permitting mission accomplishment.

Achievement of fire superiority requires two elements: 1) attaining a greater magnitude of target effects than the enemy, as a function of time, and 2) sustaining this level of target effects longer than the enemy can sustain his level of target effects, and long enough to accomplish the mission. These two elements are referred to here as target effects and sustainability.

Neither element is meaningful unless related to time. The two-sided nature of the fire fight places a premium on achieving results (target effects) more quickly than the opponent can achieve them. The concept of sustainability also implies time.

a. Target Effects

To understand target effects, the nature of the target and the friendly firers must be considered.

In combat, the infantry small arms target is normally a group target--an array of individual targets dispersed in width, depth, and usually height. The target arrays frequently present a pattern in shape, structure, and size. Normally most of the targets in the array are concealed or partially concealed, and firing on the array is often directed at a combination of cues--such as terrain form (for example, the military crest of a hill), and target weapon signatures--and movement, rather than at fully visible individual human targets. When targets are not concealed, they are usually very near or exposed only briefly.

Friendly firers are also a group (in this experiment, a squad) and behave in a group context. The individual man-weapon interacts with others in the group at the firing position (for example, muzzle blast and dust), in feedback of target intelligence (for example, incidental observation of another's tracer or of the ground strike of another's bullets), and in effects on the enemy target array.

Thus, the fire effects produced have characteristics that may differ significantly from those of single weapons fired at single visible targets. Within this context of group firers and group targets, the two principal target effects produced by small arms weapons are hits and near misses, and they combine in their effects on a target array.

(1) Target Hits

The effects of hits on individual targets of an array are highly sensitive to the timing of the hits and to the damage they inflict on the array. First hits on individual targets are more important than subsequent hits on the same target. In combat the target may drop and cease to be a target after the first hit and, in any event, there is little utility in killing a target more than once.

(2) Near Misses

If near enough and in sufficient volume, near misses cause the target soldier to seek cover and thereby take his weapon out of action or prevent his movement. Suppressive effects of small arms, particularly automatic or rapidly firing weapons, may have a greater effect on the outcome of infantry actions than the lethal effects of hits. Near misses, however, will not produce suppression if the weapons and firing doctrine cannot produce casualties. The nearness of a miss as a function of time is only one factor contributing to suppression, but it is a necessary condition if a weapon is to have any suppressive effect. For purposes of ranking weapons, near misses can be dealt with by recording them as a function of time, without having to define the quantitative level of near misses that constitutes suppression.

Near miss data also provides information on distribution of fire. Information on the distribution of fire greatly extends our knowledge of the behavior of weapon systems, and firing doctrine.

b. Sustainability

Sustainability—the other element needed to achieve fire superiority—is the length of time a weapon can fire at the ammunition consumption rate required to achieve a level of target effects with the amount of ammunition that the weapon system affords within specified weight limits. It is not used in the sense of reliability or durability.

The sustainability element of fire superiority then is the measure of how long the fire (level of target effects) can be kept up. With respect to a single small arms weapon, it is a function of three factors: 1) the weight rate of ammunition consumption in achieving a level of target effects, 2) the system weight of the weapon, and 3) the weight limitation on the weapon system portion of the soldier's combat load carrying capacity. Sustainability in a small arms system is highly sensitive to system weight, since the infantryman is severely weight-limited. System weight limits used for the experiment are discussed on page 2-8.

c. Interrelationships

Hits cannot be related to near misses in an absolute sense because of the impossibility of defining the level of near misses constituting suppression for a given situation. However, the relative value of hits or near misses as a measure can be obvious for a given situation. There are also the possibilities of examining near misses parametrically.

The relationship between sustainability and target effects is clearer. A gain in sustainability potential can be taken out at the unit commander's option as 1) within limits, a higher level of effects, 2) greater sustainability at an equal level of effects, 3) reduced soldier's load at the same level of effects (increase in mobility), or 4) some combination of these.

2. Measures of Effectiveness

Based on the qualitative effectiveness concept, three primary measures of effectiveness were selected: cumulative target exposure time, near misses, and percentage of ammunition remaining (sustainability). In addition, two collateral measures were selected: targets hit and total hits.

a. Primary Measures of Effectiveness

(1) Cumulative Exposure Time

Each target of an array was programmed to be exposed for a predetermined period that was identical for each squad in a given tactical situation. In the day defense situation, for example, the sum of the programmed exposure times for all the targets of the entire array of 50 targets was 15.976 minutes. However, individual targets fell when hit, reducing their exposure time and thus the total or cumulative exposure time of the array. For programmed total exposure times for each tactical situation, see Appendix 4 to Annex B. In the hypothetical example shown in Table 2-8 there are ten targets in an array with a programmed total exposure time of 12.400 minutes. The sequence of ten targets shows that some targets were raised earlier and stayed up longer than others. The total target exposure time for targets attacked by Squad A is therefore shortened from the programmed 12.400 minutes to 5.700 minutes. This 5.700 minutes total exposure time is the cumulative exposure time (CET) for Squad A. Similarly, Squad B achieves a CET of 8.800 minutes. To the extent that a squad rapidly acquires and hits targets the CET will be less. A lower CET indicates that friendly forces in a fire fight are subjected to fewer man-minutes of return fire from the target array and consequently suffer fewer casualties and other effects. Therefore, the concept takes considerable account of vulnerability.

CET of the target system is a primary measure of fire effectiveness. It reflects both the number of targets in a group that were hit and the timeliness in which they are hit.

(2) Near Misses

Near miss data were obtained in three of the six rifle squad situations and two of the three machinegun squad situations.* Near misses passing within a 2 meter hemisphere about the target were sensed by an acoustic sensor; where camouflaged panel sensors were used (Situations 5 and 6), near misses were sensed by a 2 meter semicircular panel centered behind the target body. In both cases near misses were recorded as a function of time.

* The rifle squad situations were the assault (Situation 1), base of fire in support of the assault (Situation 2), and base of fire in support of the attack against delaying action (Situation 5). The two machinegun squad situations were those in support of the rifle squad in the assault (Situation 3) and in fire support of the advance (Situation 6).

Table 2-8

HYPOTHETICAL EXAMPLE OF
CUMULATIVE EXPOSURE TIME (CET)

Target Number	Target Sequence (minutes)		Individual Target Exposure Time (minutes)		
	Programmed Up Time	Programmed Down Time	Programmed Exposure Time[A]	Squad A[B]	Squad B[B]
1	0	1.700	1.700	.500	.300
2	.500	2.000	1.500	.500	1.200
3	.600	2.200	1.600	.700	1.500
4	1.000	2.500	1.500	.600	1.500[C]
5	1.200	2.000	.800	.800[C]	.800[C]
6	1.800	3.000	1.200	.200	1.100
7	2.200	4.000	1.800	1.000	1.000
8	3.500	4.500	1.000	.600	.500
9	4.000	4.300	.300	.300[C]	.300[C]
10	4.500	5.500	1.000	.500	.600
Programmed Total Exposure Time (minutes)			12.400		
Cumulative Exposure Time (minutes)				5.700	8.800

[A]Programmed down time minus programmed up time

[B]Hit time minus programmed up time (targets went down when hit)

[C]Target not hit

The measure of near misses used in the present report is total near misses. Near misses are a primary measure because of the importance of suppressive fire effects. However, because of instrumentation procurement limitations near misses could not be measured in all tactical situations.

(3) Sustainability

The primary determinant of weapon sustainability (in the sense that it is used here) is the length of time that available ammunition can sustain an attained level of effects. The measure of sustainability used here is the percentage of ammunition remaining for a squad mix when the squad weapon system weight constraint (starting system weight), tactical situation, and record run time are held constant for all squad mixes. In Figure 2-19, for example, if Squad Weapon Mix B used 50 percent of its ammunition load to attain a given level of effects, it would have only half the sustainability (ability to maintain the same level of effects longer) of Squad Weapon Mix A that attained the same level of effects with an expenditure of only 25 percent of its ammunition.

b. Collateral Measures

Collateral measures, as defined here, are lesser included functions of primary measures and therefore are subordinate to primary measures. They are performance measures, rather than effectiveness measures. However, the collateral measures of the number of targets hit and total number of hits provide some limited insights into weapon system behavior and sometimes facilitate interpretation of the primary measures.

(1) Targets Hit

This measure indicates the number of targets hit in a given target system, but gives no indication of the amount of time required to secure the hits. When related to total targets, it provides a measure of fire distribution and some insight into the cumulative exposure time measure. If the same number of targets in an array are hit, but at different times, the cumulative exposure time will be different.

(2) Total Hits

This measure takes into account multiple hits on targets. Since targets in this experiment fell on receiving a first hit, multiple hits could occur, as in combat, only because of rapid fire from a single weapon or because two or more firers acquired and hit a target almost simultaneously. The total hit measure has collateral worth as an effectiveness measure, especially if two systems rank equally in other respects.

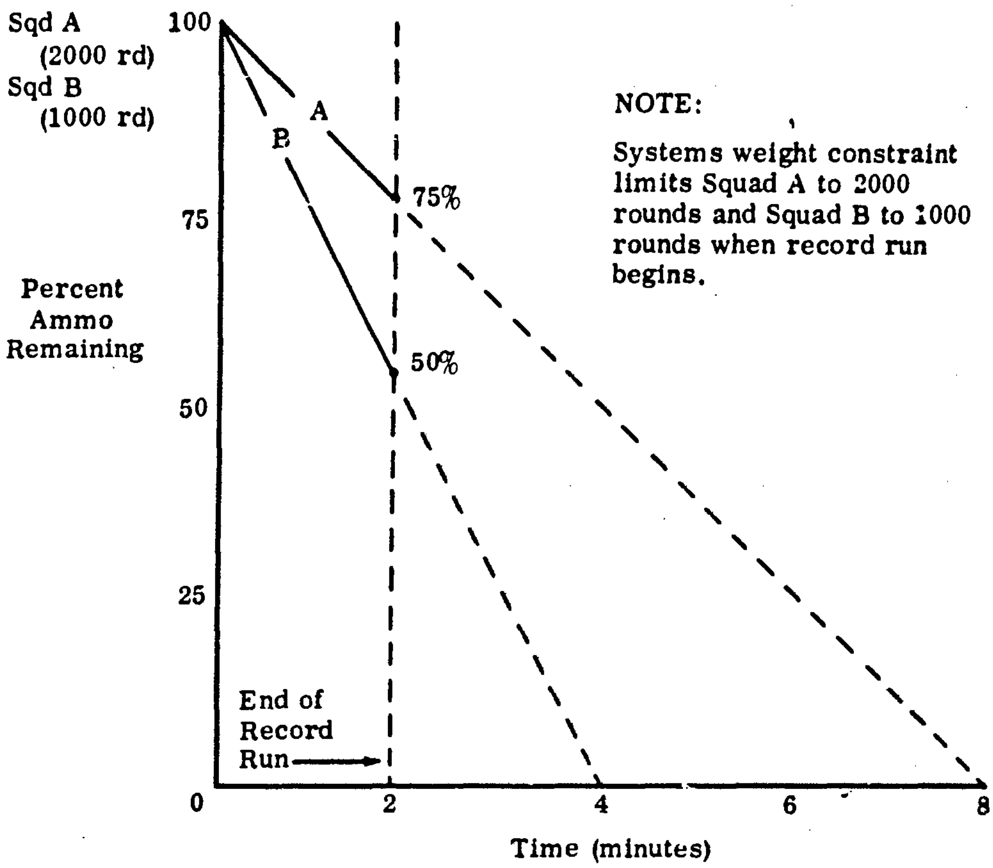


Figure 2-19

EXAMPLE OF SUSTAINABILITY

(3) Correlations

A correlation analysis was run on measures of effectiveness, both primary and collateral, to determine the extent of the relationships of the various measures to each other, and to gain further understanding of the nature of these relationships. Tables describing these relationships are presented in Annex D.

3. Effectiveness Qualities - Combat Effectiveness Components

Combat effectiveness components important to the evaluation of small arms weapon systems include the following:

a) Fire Effectiveness

b) Weight reduction

c) Tactical versatility

d) Reliability

e) Training

f) Collateral applications

They are discussed and related to the output of the SAWS field experiment, in turn.

a. Fire Effectiveness

USACDCEC's primary contribution is in this area. This report provides the fire effectiveness results, and relates lethality to the effectiveness results.

b. Weight Reduction (Mobility)

Weight reduction results--rankings of squad weapon mixes according to the amount of weight that can be eliminated from the soldier's or squad's combat load if a sustainability advantage is taken out (even partly) in weight reduction--can be computed from the weights of the weapon systems and the sustainability results presented in Section VI. The shorter, lighter weapons were naturally more easily carried and therefore increased the soldier's mobility.

c. Tactical Versatility

This quality includes: 1) the relative capability of candidate weapons to perform the functions of the rifle, carbine, submachinegun, automatic rifle, antitank grenade launcher, and M79 grenade launcher with the fewest number of weapon types; and 2) the relative suitability of the weapons for use by airborne, airmobile, mechanized and amphibious forces. The USACDCEC SAWS experiment implicitly covers some aspects of tactical versatility, particularly in the area of dismounted rifle and machinegun squads. For example, rifles, automatic rifles and machineguns were all fired in the automatic rifle role.

d. Reliability

This quality includes reliability, durability, ruggedness, and performance under extreme conditions. The experiment provided data on reliability-durability and operation in the field, including sandy conditions. Reliability results are presented in Section V.

e. Training

Training effectiveness for the experiment is discussed in paragraph D-4 of this section and in Section IV.

f. Collateral Applications

This includes such matters as suitability for use in the Military Assistance Program (MAP). The distinction between this quality and tactical versatility is one of degree. Insight into these areas can be derived from USACDCEC fire effectiveness, weight reduction, and reliability data. USACDCEC's answers to the essential elements of analysis (EEA) provided to USACDC by separate letter further relate USACDCEC SAWS data and results to some of these broader questions of collateral applications.*

* Letter, CDEC-TB, HQ USACDCEC, 1 April 1966, Subject: Essential Elements of Analysis (EEA), Small Arms Weapons System (SAWS) Program.

BLANK PAGE

SECTION III

METHODOLOGY FOR THE PRESENTATION OF RESULTS

A. ORGANIZATION OF RESULTS

The data and results from which the USACDCEC SAWS conclusions were evolved are presented in Sections IV through VIII. Each Section deals with a particular type of experiment or data base.

Section IV deals with training implications.

Section V presents the results of the USACDCEC analysis of the materiel reliability data collected during the experimentation.

Section VI details the results of fire effectiveness experimentation designed to discriminate among squads armed with different weapon mixes. That section is divided into three parts. Part A, dealing with the rifle squad mixes for which experimentation was originally planned and mixes provided for either in the USACDCEC outline plan or in a subsequent directive from USACDC Headquarters; Part B, covering follow-on rifle squad experimentation and presenting results of an investigation into the feasibility of adopting a rifle squad equipped only with Colt automatic rifles, or with a combination of Colt rifles and Stoner machineguns; Part C, discussing the comparative machinegun experiment.

Section VIII is a brief note discussing the relationship between current lethality data and the USACDCEC SAWS results and conclusions.

Section IX presents USACDCEC SAWS conclusions.

B. DATA PRESENTATION FORMAT

The numerical results for situations in most cases are presented within the framework of a single large consolidated table (comprised of subtables) and a set of graphs. Tables and graphs for each situation are accompanied by brief descriptions of the situations, summaries of the respective tables and graphs, a list of standard scores, and a summary analysis.

Three types of data are presented: descriptive statistical performance measures; probability measures, and graphic presentations of the data as a function of time and range, where applicable.

Performance measures, (the effectiveness and collateral measures discussed in Section II, are used to rank the squad mixes. Probability measures provide the means of determining the extent to which experimentally observed differences are chance results caused by variations in the experiment.

If observed differences have a low probability of occurring because of experimental variations, it may be considered with a high degree of confidence that the differences in performance measures are caused by system differences. Performance measures and their ranking should not be used without reference to statistical probability measures.

Sections IV, V, and VII do not deal directly with fire effectivness results. These data are presented primarily in a descriptive narrative format.

For purposes of brevity and clarity, it was necessary to assign a two-letter code designation to each weapon mix. The weapon mixes are referred to by this code in most of the tables and graphs of the report. The key is presented below.

UA - 9 M14 Rifles
UB - 7 M14 Rifles and 2 M14E2 ARs
UC - 5 M14 Rifles and 2 M60 MGs
UD - 9 M14E2 Rifles

CA - 9 M16E1 Rifles
CB - 7 M16E1 Rifles and 2 Colt ARs

SA - 9 Stoner Rifles
SB - 7 Stoner Rifles and 2 Stoner ARs
SC - 7 Stoner Rifles and 2 Stoner MGs

RA - 9 AK47 Rifles
RC - 7 AK47 Rifles and 2 RPD MGs

CX - 9 M16E1 Rifles (Same mix as CA, but used in follow-on experimentation as a control mix)
CY - 9 Colt ARs

MB - 7 M16E1 Rifles and 2 Colt ARs (Same mix as CB, but used in follow-on experimentation as a control mix)
MC - 7 M16E1 Rifles and 2 Stoner MGs

C. EXPLANATION AND DESCRIPTION OF DATA

1. Performance and Statistical Probability Measures

A difference will usually emerge if the characteristics of two mixes are measured. For example, one mix may measure 22 and another 20. A question then arises: does the observed difference represent a real difference in mixes, or is it due either to chance elements that affected the experiment or due to sampling variations?

There is no absolute yes or no answer, but statistical techniques can provide the probability that an observed difference is due to chance variation. This is the likelihood that a wrong decision would be made by rejecting (on the basis of the experimental observations) the hypothesis that there is no real difference in the systems.

In the example where one mix performance measured 20 and another 22, the probability can be estimated that if the experiment were repeated many times, a difference of two or more would occur from chance. Such a probability might turn out to be, for example, .03. If the mix that measured 22 were selected on this basis, there is a probability of .03 that the selection was wrong--wrong in the sense that there may be no differences in the system.

If a probability level of .20 is selected for rejecting the hypothesis of no real differences, there is a high risk in concluding that the observed performance difference reflects a real difference in mixes.

It is also possible to make another kind of erroneous decision, that of accepting the hypothesis that differences in a performance measure are due to chance when in fact there is a real difference in the performance of the mixes. The ability of a statistical test to indicate real difference in performance measures depends on the magnitude of the real difference and on the size of samples. These two factors influence the probability of observed differences in the performance measure and the magnitude of observed differences that will lead to rejection of the null hypothesis that there are no system differences. In this experiment, the sample sizes were as large as possible within the practical limit of the experiment, so that real differences in performance measures would have the greatest likelihood of being detected. Some real differences undoubtedly will remain undetected, but the rejection probability should be valid for any differences that are labeled significant.

The appropriate probability level for rejection is a matter of judgment involving a certain amount of risk. A low level for rejecting the hypothesis that the observed difference is real reduces the risk of erroneously concluding that there is a real difference when there is not, but it increases the risk of rejecting a mix that might in fact be superior in the quality measures.

To facilitate this judgment process, the report, for the majority of the results, presents a subtable for each measure presented in a situation, showing the probabilities that can be attached to experimentally observed differences in each possible pair of squad mixes. The probabilities are presented in numbers up to .40. These tables might indicate, for example, that the chance that the observed difference between mixes A and B could be equal to or greater than the measured amount is .08. As these probability figures more closely approach the value of .50, the risk that the experimentally measured differences were caused by chance factors becomes greater.*

Presented on the following pages are Subtables A and H from the table for Situation 2, which treats cumulative exposure time (CET).

Subtable A shows the mean (average) raw CET score in minutes of total target exposure time of each squad mix, and the standard deviation (SD) of each mix's score. Finally, it shows the mean standard score (z'). (The standard score concept will be discussed further below.) At the bottom of Subtable A is shown the mean (average) of the squad mix mean scores ($\bar{X}$), and its standard deviation (SD).

Each measure for the rifle squad experiment is also illustrated in a series of bar graphs located on the same foldout page as the numerical data and probability table presentations. The bar graphs portray the mean (average) scores of all mixes, the range of all squad scores, and the ranges of the six squad scores comprising the highest and lowest scoring mix for each measure for each situation. In addition to these bar graphs, histograms (a type of bar-graph representation) and graphical representations of distributions of measures as a function of time and range are presented for some experimentation situations. These two methods of data presentations are explained in paragraphs C-6 and C-7 of this section.

The bar graph for Situation 2 (Rifle Squad As A Base of Fire Supporting the Assault) should be referred to for comparison with Subtable A being discussed here. The first block of the graph shows CETs that were also treated in the first table of statistical figures, Subtable A. The first bar on the left shows the mean scores corresponding to mean CETs in Subtable A; the second bar shows the range of all squad scores regardless of

* It should be noted that these probabilities are not offered as precise confidence levels for formal tests of null hypotheses. Such a test would require either an a priori statement of the particular pair of mean values to be compared, or a composite analysis of variance with the pairwise test being used to identify significant analysis of variance contributions. In the absence of a significant F test these probabilities should only be considered to provide a rough indication of the relative importance of the magnitude of the differences tested.

Subtable A—CUMULATIVE EXPOSURE TIMES

Mix	$\bar{X}$ CET	SD	Standard Scores z'
UA	77.5	2.3	77.1
CA	78.2	10.0	71.2
UD	78.6	8.3	68.3
UB	80.0	6.6	59.0
SC	80.4	9.4	53.8
SB	81.0	10.1	48.9
SA	82.0	9.1	41.4
CB	82.1	4.6	40.4
UC	84.2	7.2	23.6
RA	85.1	10.9	16.6
$\bar{X}$	80.9		
SD	2.52		

Subtable H—CUMULATIVE EXPOSURE TIME p FACTORS

	UA	CA	UD	UB	SC	SB	SA	CB	UC	RA
UA		>.40	.38	.22	.24	.21	.14	.03	.03	.07
CA			>.40	.38	.35	.32	.26	.20	.13	.15
UD				>.40	.37	.33	.26	.19	.12	.15
UB					>.40	>.40	.32	.24	.15	.17
SC						>.40	.39	.35	.23	.23
SB							>.40	>.40	.27	.27
SA								>.40	.32	.31
CB									.28	.28
UC										>.40

the squad mix; the third bar shows the range of scores of the leading rifle squad mix (the UA mix composed of nine M14 rifles); and the fourth bar shows the CET score range for the lowest ranking rifle mix (the RA mix composed of nine AK47 rifles) (page 6-23).

The performance measure tables and the graphs complement each other, both showing the mean average scores for each mix in rank order. The tables also provide standard deviations, while the graphs provide the range of scores contributing to these deviations.

2. Combined Use of Descriptive Performance Measures and Statistical Probability Data

Subtables A and H (CET for Situation 2) shown above can be used to illustrate how the two types of data should be used. Subtable A indicates that mix UA (nine M14 rifles) ranks first with a CET of 77.5 minutes and mix CA (nine Colt rifles) is second with mean CET of 78.2 minutes. Subtable A does not state whether this difference as measured in the experiment is a statistically significant difference. In other words, if further experiments were conducted, what are the odds the results would go the other way? If the odds are high, it should be concluded that the measured difference is not statistically significant and that, for practical purposes, one system appears as good as the other as far as the particular measure is concerned.

In the case of the UA and CA comparison, a measure of such odds can be obtained by referring to the Subtable H adjacent to Subtable A, which shows probability (p) factors (for the two sample t-statistics). In the cell of row UA and of Column CA is the factor $p > .40$. This p-value indicates that a low level of statistical confidence attaches to the experimentally observed difference in Situation 2 CET as between UA and CA. As far as the experimental results are concerned, UA and CA in this situation appear about equally effective in CET.

In a comparison of UA with UC (five M14s and two M60s), however, one can read across the p-value table and see the number .03. In this comparison, confidence in the conclusion that UA is superior to UC is relatively high.

The combined use of statistical probability measures and the performance measures can serve as an aid for analysts and decision makers. In the case of the UA and CA comparison ($p > .40$) discussed above, there is little evidence for concluding that there is a real difference between mixes on the measure of CET. However, the systems may very well be different regarding the other effectiveness measures. Subtable B for Situation 2 (page 6-23) shows that in near misses CA scored 323 and UA scored 259. The statistical probability is .05. Similarly, in sustainability (Subtable C) (page 6-23) CA scored 50.5 and UA 22.0, with $p = .001$. Thus it might be concluded in this situation that the CET qualities of CA and UA are a toss up but that the experimental evidence strongly supports the conclusion that CA is superior to UA in near misses and sustainability. On this basis it might then be concluded that the experimental results in Situation 2 indicate that CA is the superior mix.

Successive pairs of systems can be analyzed by situation and event in the same fashion as above. Such a process, however, is time consuming and requires judgment at numerous points. One important type of judgment centers on what is the appropriate probability that should be used. Other judgments must center on possible tradeoffs suggested by the data. For example, System A produces 10 percent more near misses than System B but, relative to B, has 30 percent less sustainability in terms of the percent of ammunition remaining. Is such a tradeoff, or price in sustainability, worth the extra near misses? In part, the answer would depend on the absolute sustainability scores attained. It is one thing if A has a sustainability score of 80, and B, 50; perhaps another if A had 40 and B had 10. In the latter case a hypothetical squad might be in poor condition to resist an immediate counterattack after a successful attack.

However, it may be neither practical nor possible to go through a detailed analysis of the kind suggested here as a means of evaluating weapon mixes. It is therefore, desirable to provide an evaluation and appraisal of weapon mixes, preferably by a less involved method. To facilitate such an analysis, the concept of standard scores is useful. Hence, a short discussion of standard scores is presented in each subtable for each experimentation measure and in summary subtables.

3. <u>Standard Scores</u>

Scores obtained for weapon mixes for each of the measures in the SAWS experiment are not directly comparable between situations or between measures. For example, CET is measured in minutes, near misses in actual number, and sustainability in percent of ammunition remaining. Moreover, CET may average 3 minutes in one situation and 20 in another. In dealing with such observations, it is desirable to have scores that can be easily compared. This is what standard scores do.

Consider the following hypothetical example for a situation.

Measure of Effectiveness	Mean Score $\bar{X}$	SD	Raw Scores Mix A	Raw Scores Mix B	Deviations Mix A	Deviations Mix B	Standard Score (Z) Mix A	Standard Score (Z) Mix B	Adjusted Std Score (Z) Mix A	Adjusted Std Score (Z) Mix B
Near Misses	155.7	26.4	196	162	40.3	6.3	1.53	.24	79.8	80.6
CET	33.7	8.2	20	44	-13.7	10.3	-1.67	1.25	16.6	75.0

In this example, the mean score ($\bar{X}$) represents the average of the raw scores of the ten mixes in a given situation. The example also shows the standard deviation (SD) of these raw score averages.

Consider next the raw score measures for Mixes A and B. Note, for example, Mix A's near miss performance deviates from the mean score of all mixes by 40.3. When this raw deviation for the mix is divided by the standard deviation of the group score (26.4), the standard score ($\underline{Z}$) of 1.53 is obtained.

Such measures have a mean of zero and a standard deviation 1. To eliminate negative scores and put them on a scale similar to conventional scoring methods, they can be adjusted by selected constant factors. For the purpose of this experiment, they were adjusted as follows:

$$z' = 50 + 20\ \frac{X_1 - X}{SD}$$

where the expression in the brackets represents the standard score z, as shown in the table above, and z' represents the adjusted standard scores.*

The standard score, therefore, is used in this report as a numerical representation, or index, to facilitate understanding the relative effectiveness of each weapon system mix in each situation. A standard score that is below 50 automatically indicates that the actual performance of that weapon mix was above the average for that measure.

The standard scores not only provide an immediate index of whether weapons systems performance is above or below the average but they also provide an immediate visual index of how far that squad weapon mix's performance deviates from the average in relation to how far the other mixes deviate from the same average.

* X_1 is the raw score of the mix, $\bar{X}$ is the average raw score of all mixes, and SD is the standard deviation of the raw scores for all mixes.

The standard scores thus provide a ready means of combining the various performance measures. All performance measures (CET, near misses, sustainability, number of targets hit, and total number of hits) now have an identical average score of 50 and identical standard deviation of 20. Thus, if a weapon mix is above average in both CET and near misses, the results of combining these standard scores, no matter what weights were assigned to each must show a resulting mean (average) standard score of above 50--since its above average performance on both measures required it to have a standard score of above 50 on both measures. Therefore, although raw scores of different variables cannot be meaningfully combined, the standard scores can.

The combining of standard scores rather than the direct averaging of ranks, or some similar method, also takes into consideration the relative superiority or inferiority of the performances of different mixes on different measures. For example, it will be noted that mix UA did better than mix SB on the target effectiveness measure of CET in Situation 5--but that mix SB did better in the other target effectiveness measures of the number of near misses. If a decision were to be made to weight these two measures equally, the conclusion might be drawn that UA and SB were equal to each other in target effects, since UA was higher than SB on one of the measures while SB was higher on the other measure. A comparison of the standard scores presented below, however, might lead to a different conclusion.

Mix	CET		Near Misses			Target Effects
	Rank Order	Std Score	Rank Order	Std Score	Rank Order	Std Score*
						(Av of CET and NM)
UA	1	54.45	2	46.7	2	50.57
SB	2	53.67	1	71.3	1	62.49

* If CET and near misses were weighted equally

Therefore, combining standard scores to assist in the interpretation of results automatically considers that although mix UA was better than mix SB in CET, the difference was very slight; but that in the case of near misses, when SB was better than UA, the difference was relatively much larger.

* If CET and near misses were weighted equally.

4. SAWS Target Effects and Overall Effectiveness Scores

Subtables F and G of the consolidated tables for each situation present the average standard scores for each mix in target effects and overall effectiveness. Subtable F provides, in rank order, the overall standard scores for target effects (CET and near misses) combined. Subtable G presents the overall standard scores, in rank order, of the weapon mixes for target effects (CET and near misses) combined with the third primary effectiveness measure of sustainability (percentage of basic load of ammunition remaining at the conclusion of each situation).

Subtable F, therefore, presents the overall standard scores of weapon mixes rank ordered according to their overall target effects. For illustrative purposes, CET (representing targets hit as a function of time) has been equated in Subtable G with near misses (representing the number of near misses per unit of time). There are, mathematically, an infinite number of weightings that can be given other than the arbitrary 1-to-1 weights presented. If it were desired, for example, to weight near misses in the assault twice as much as CET, then the near miss standard score provided in Subtable B would be multiplied by 2, added to the CET standard score for Subtable A, and the result divided by 3.

In Situation 4 (Rifle Squad Approach to Contact), Situation 7 (Rifle Squad in Day Defense), Situation 8 (Rifle Squad in Night Defense), and Situation 9 (Machinegun Squad in Day Defense) near misses were not measured. Therefore, the overall target effects standard scores presented in Subtable F are based solely on CET. Thus, for these situations, the standard scores in Subtable F are identical to those in Subtable A (CET).

Subtable G presents the combined overall standard scores for each situation for all of the primary effectiveness measures (CET, near misses, and sustainability). In other words, Subtable G combines each of the primary effectiveness measures used in the experiment into an overall effectiveness criterion and rank orders the weapons mixes accordingly. It must be emphasized that these rank orders, for illustrative purposes only, weight each of the primary effectiveness measures equally. Thus, CET, near misses, and sustainability each contribute to one-third of each weapon mix's overall rank order, which in effect weights target effects (CET and near misses) two-thirds and sustainability one-third.

In Situations 4, 7, 8, and 9, where scores for target effects are based solely on first hits as a function of time (CET), target effects are still weighted two-thirds and sustainability one-third. Thus, regardless of the situation, the overall ranking of weapon mixes, as presented in Subtable G, is always the result of giving sustainability a weight of one-third.

For rifle squad Situation 2 (Base of Fire supporting the Assault), Situation 5, Rifle Squad as a Base of Fire Supporting the Advance), Situation 7 (Defense Against Attack), and Situation 8 (Night Defense Against Attack), there is a fifth column for each Subtable C (Sustainability). This column (titled "Sustainability Time") lists, in minutes, the amount of time that each of the given squad mixes would be able to sustain itself in that situation. Thus, if a squad weapon mix fired 75 percent of its ammunition over the 4 minute duration of Situation 2 (Base of Fire Supporting the Assault), the weapon mix was considered capable of sustaining itself in such a situation for 5.33 minutes.*

5. Expected Scores

The method of computing expected scores was the same for Series 1 and 2 of Situations 7, Series 1 and 2 of Situation 8, and the duplex experiment. The equations used to calculate expected scores for primary and collateral measures and the basic proportions used in these calculations were the same for each situation. This basic format was constructed as follows:

	Experimentation Squads	Control Squads
Series 1 (first firing)	A_m	B_m
Series 2 (second firing)	C_d	D_m

M = The mode of fire (ball or duplex, automatic or semiautomatic) used by all squads of the mix during their first firing of the situation

* The figures presented in the subtables of the various tables for each event provide the USACDCEC SAWS data in terms of means (averages), standard deviations, standard scores, and probabilities (illustrating levels of significance). However, there are a number of technical rules for the precise interpretation of these statistics; and a number of mathematical assumptions that must be satisfied if these are to be used precisely and in the most meaningful manner. In the final analysis, each score and statistic presented can be looked at and considered only in conjunction with all other statistics of the table. Thus, rank orders of weapons systems and standard scores have full meaning only in conjunction with the values in the probability subtables (H, I, J, K, and L). Furthermore, for a precise interpretation, it is necessary to be thoroughly familiar with the many assumptions inherent to the various statistical procedures and measures used and to understand thoroughly the mathematical relationships between these measures. An attempt has therefore been made to provide sufficient data to allow the reader to reconstruct the various situations, perform his own analyses, and draw his own conclusions. In this respect the chi square values for Bartlett's Test for Homogeneity of Variance as well as F values and corresponding probabilities for these F ratios are also presented.

D = The mode of fire used by three of the six rifle squads during the second firing, and the mode against which a comparison with the first firing's M mode was desired

A_m=Average scores for the three experimental squads (usually the odd numbered squads of the mix) after their first firing in M mode

B_m=Average score for the three control squads (usually the even numbered squads of the mix) after their first firing in M mode

D_m=Average score for the three control squads after their second firing of the situation using M mode

C_d=Average score for the three experimental squads after their second firing of the situation, but using D mode rather than M, which was used during their first firing, and which control squads continued using

The equation used to calculate the expected mix score (the score that would have been expected of the entire six squad mixes from the first firing of the situation if mode D, rather than M, had been used) reads:

$$\text{Mix Expected} = \frac{(A+B)\left(1 + \frac{BC - AD}{AD}\right)}{2}$$

6. Graphical Presentation of Measures as a Function of Time and Range

Results for rifle squad situations are also presented in the form of graphs. Hits, near misses, total hits, percent of ammunition expended, and number of rounds fired are illustrated all as a function of time and range. Except for Situations 7, and 8, time is represented on one axis and the measure of effectiveness on the other. All the measures indicated above may not be represented on all graphs.

Because the targets were programmed to rise and fall in sequence at different times in Situations 7 and 8, either individually or in groups, distributions of the effectiveness measures as a function of scenario time were not applicable. For Situation 7 and 8, therefore, the measures have been cumulatively plotted, starting with the targets at the greatest range (which came up first) and cumulating the measures through the assault targets that were closest to the firers and came up last.

These graphs present the relative effectiveness of the various weapon mixes at different ranges, and at different times in each situation. They also permit a ready analysis by weapon mix of the relationship of the various measures to each other at varying ranges and times.

For example, Figure 3-1 illustrates the distribution of targets hit and near misses for hypothetical Mixes A and B in Situation 1 (Rifle Squad in Line Assault).

The time scale is presented at the bottom of each graph. The range scale is presented on the center line between two graphs.

An examination of the graphs by comparing the maximum point of each curve (intersection of curves with right vertical axis) shows that Weapon Mixes A and B are equivalent in total number of near misses (400), but that Mix B is superior to Mix A in the number of targets hit during the Assault Situation (6.5 versus 4.5). Examination shows that the squads of Mix A averaged their first target hit (indicated by * on the curve) in the Assault at a range of 50 meters from the targets while Mix B averaged its first hit in the Assault at a range of 100 meters from the targets. A comparison of the curves further shows that Mix A squads hit, on the average, only one target during the movement from 130 meters in to 50 meters, while Mix B during the same time of movement across the same amount of ground had hit an average of three targets. However, the slopes and increase in curve ordinates between 50 meters and the end of the assault (30 meters from the targets in the experiment due to danger of damaging ground level target instrumentation) shows that both mixes averaged an identical 3.5 targets hit during this period. Examination of these graphs indicates that both mixes were equivalent in the Assault in their suppressive fire effects as a function of near misses and in their ability to hit targets at a range of 50 meters and closer, but that Mix B is superior in its ability to hit targets at ranges of more than 50 meters. Mix B's overall superiority at the completion of the Assault is therefore due solely to its superiority in attaining hits at ranges of more than 50 meters.

Figure 3-2 presents data for hypothetical Mix C from Situation 2 (Rifle Squad as a Base of Fire in Support of the Assault, ranges of 269 to 326 meters). The center vertical dashed line represents the division between the two target arrays. (See Section II for a description of Situation 2.) The first 2 minutes of fire were directed at the left array of 17 targets. At the end of 2 minutes (indicated by the time scale on the horizontal axis) firers shifted fire to the right array to reproduce the effects of the shift of fire that is necessary when the assault element closes with the enemy position.

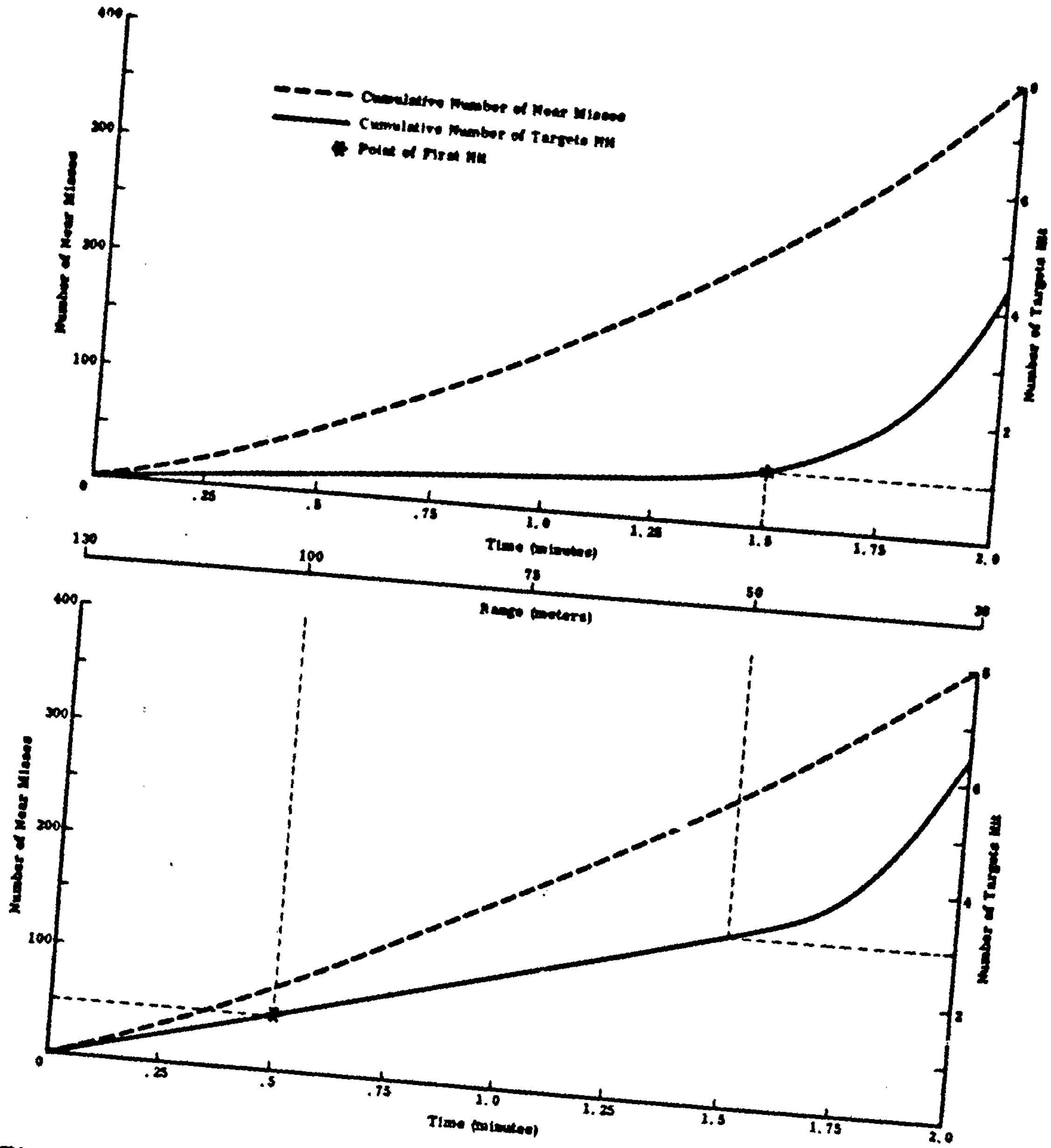


Figure 3-1 DISTRIBUTION OF DATA, HYPOTHETICAL WEAPON-SQUAD MIX A (top) AND MIX B (bottom) IN SITUATION 1 (RIFLE SQUAD IN THE LINE ASSAULT)

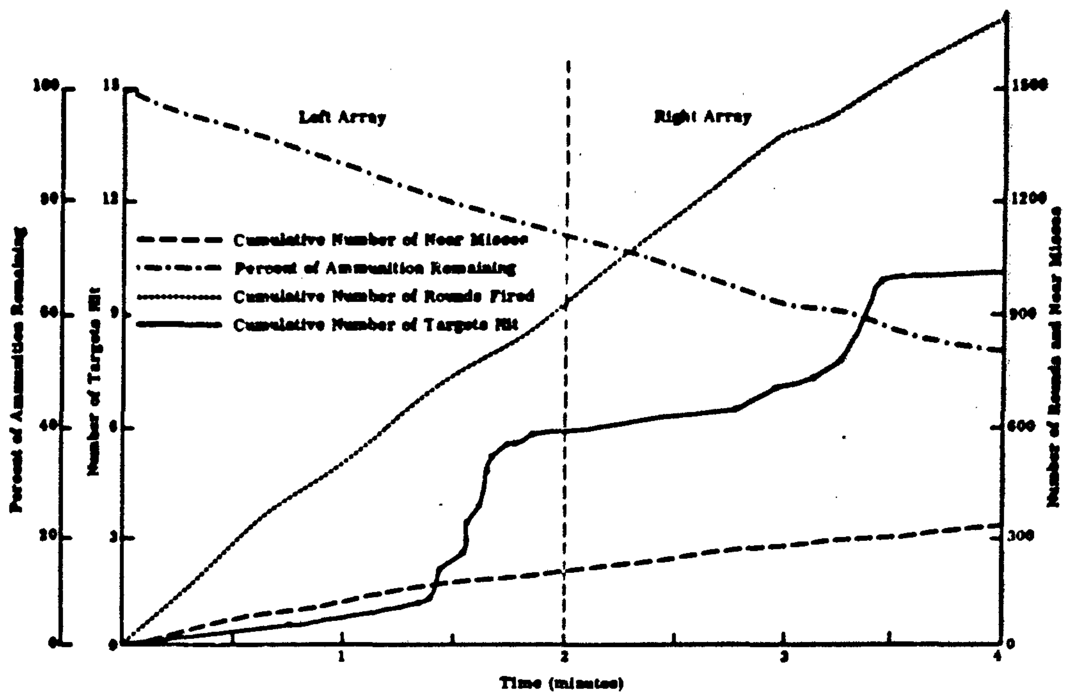


Figure 3-2 DISTRIBUTION OF DATA, HYPOTHETICAL WEAPON-SQUAD MIX C IN SITUATION 2 (RIFLE SQUAD AS A BASE OF FIRE IN SUPPORT OF THE ASSAULT)

In this example (Figure 3-2) it can be seen that the number of rounds fired and the number of near misses rose steadily and at a constant rate throughout the 4 minutes of fire. For every near miss registered within 2 meters of a target there were 5 rounds fired. By comparing the ends of the curves, it can also be seen that there were 1700 rounds fired and 10.5 targets hit, or one target hit for each 162 rounds fired. But, unlike near misses and ammunition expenditure, most of the targets hit for each array were hit during the latter portion of the 2 minute firing times. The graph shows that even though the rate of ammunition consumption and near misses for hypothetical Mix C is constant during the entire situation, the rate of hits is not. There were practically no hits during the first minute of fire on each array; however, during the latter part of the firing on each array the rate of hits increased at an extremely high rate. A gentle sloping curve, therefore, indicates that there were few hits while a steep slope of the curve indicates a high rate of hits.

Figure 3-3 presents an example of cumulative exposure time (CET) plotted as a function of range for a situation similar to Situation 7. In this situation targets rose individually or in small groups for brief exposures. The program provided for a sequence of target exposures starting at distant ranges and culminating in the exposure of ten close range (approximately 45 meter) targets. The exposure times of each target are cumulated from the most distant target through the closest target (from left to right on the horizontal axis of the graph). If every target were hit at precisely the same instant that it appeared, the target exposure time would be theoretically zero and the CET curve would be a horizontal line corresponding with the horizontal axis of the graph. On the other hand, if no target were ever hit, each target would remain up for its entire programmed exposure time, represented in Figure 3-3 by the curve labeled CPET (cumulative programmed exposure time). Therefore, all curves for all mixes must fall somewhere between the CPET curve and the horizontal axis. Thus, the mix with the CET curve closest to the horizontal axis hits the targets the quickest. The intersection of this curve with the right vertical axis of the graph represents the CET of that mix for the entire situation. A comparison of the slopes of the curves of any two mixes for any range increment will show which weapon mix was superior at that range. The mix with the curve that has the steepest slope at any given range is the poorest mix at that range.

Also illustrated are curves for the number of targets hit, the total number of hits and ammunition expenditure. From Figure 3-3, it can be seen that ammunition expenditure was greatest at the longer ranges while the number of targets hit was the least, and that it took longer to hit the targets that were hit. At the closest ranges (45 to 60 meters), however, there was very little ammunition expended (almost horizontal slope of the "rounds fired" and "percent of ammunition remaining" curves), yet the curves for both number of first hits (targets hit) and number of total hits on targets increases sharply in slope. Furthermore, not only are more

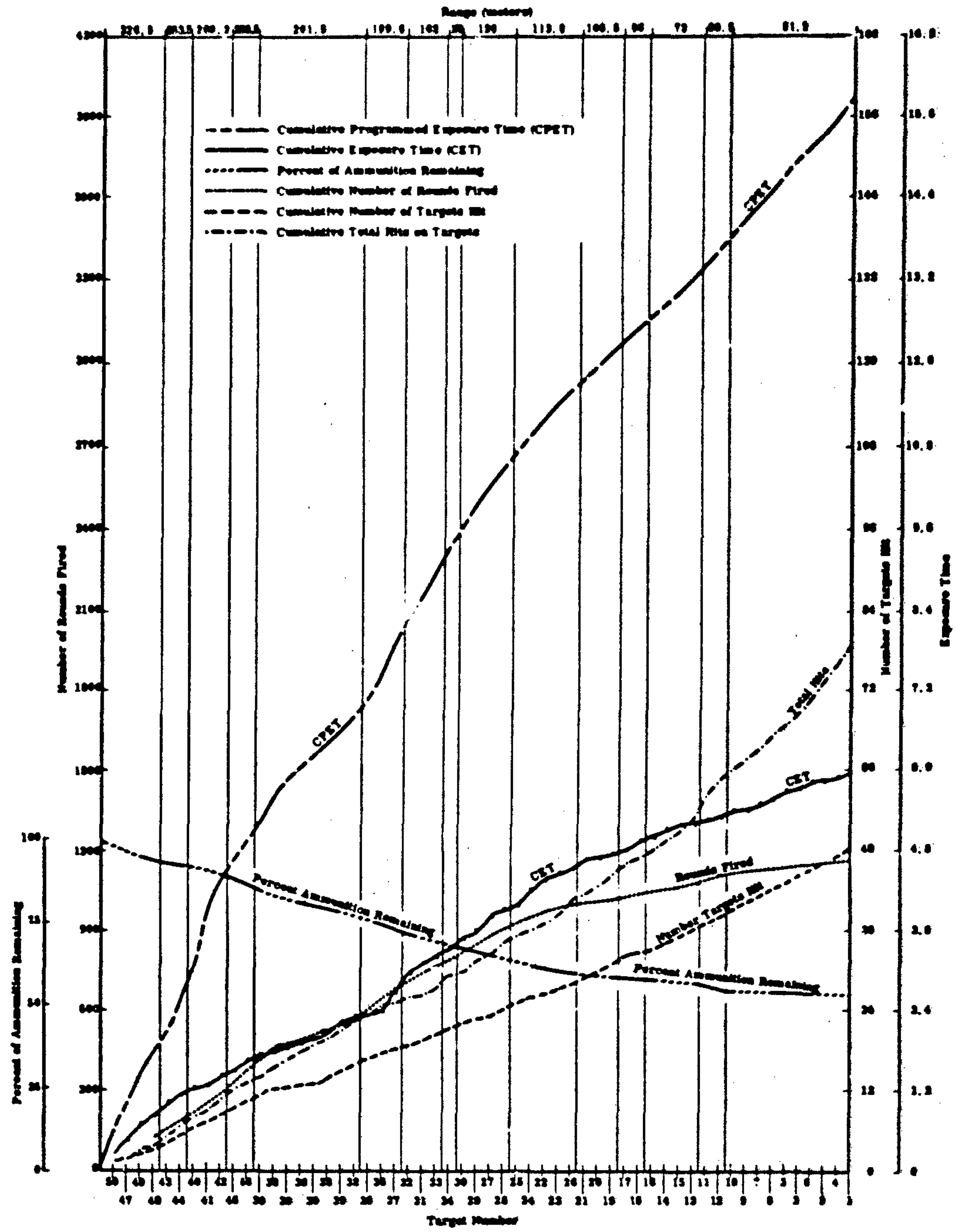


Figure 3-3 EXAMPLE OF CET AS A FUNCTION OF RANGE

targets hit but they are hit more quickly, as indicated by the relatively flat CET curve at the 45 and 60 meter ranges. The fact that the targets were hit so quickly can, of course, be related here to the fact that very little ammunition was expended. Had the targets not been hit so quickly, they would have been fired at for a longer time with a resulting increase in the amount of ammunition expended.

These graphical presentations of the distribution of effectiveness measures as a function of time and range permit a ready comparison of the behavior of the various effectiveness measures within a weapons mix, while at the same time permitting a comparison of the mixes with each other at varying ranges and under varying conditions.

7. <u>Histogram (Bar Graph) Presentation of Near Misses as a Function of Target Location</u>

For situations where near misses were recorded, the distribution of near misses across the target arrays are presented in the form of histograms, as in Figure 3-4. There is one histogram for each mix for each applicable situation. Each vertical bar represents one target. The height of the bar depicts the average total number of near misses by the six squads of the weapon mix for that target. Each set of histograms is accompanied by a schematic sketch (to scale) of the target array to which the histogram applies. The type of weapon simulator associated with each target and the target number is given at the bottom of each vertical bar. The targets (vertical bars) are shown from left to right in the same order that they appear in the actual array (and in the inset schematic).

A comparison of the relative effects of automatic firing and semiautomatic firing weapons regarding distribution of fire patterns is possible through a comparison of these histograms, as is a comparison of the relative suppressive effects of the different weapon systems and mixes. An analysis of the distribution of fire in the target area relative to the type of enemy fire from the position allows conclusions to be drawn regarding the extent to which fire is drawn to automatic weapons as opposed to relatively slow firing semiautomatic rifles (indicated by R on the histogram).

The example (Figure 3-4) shows no apparent relationship between types of enemy weapon and distribution of fire at first glance. In fact, Position 10, a rifle position firing a small volume of semiautomatic fire (simulator fired spaced single shots), received more near misses than any other target. However, examination of the inset schematic of the target array shows that this target was located directly in front of a machinegun and down the slope from it. It is also located between many of the firers and three other targets (two rifles and one automatic rifle). Therefore,

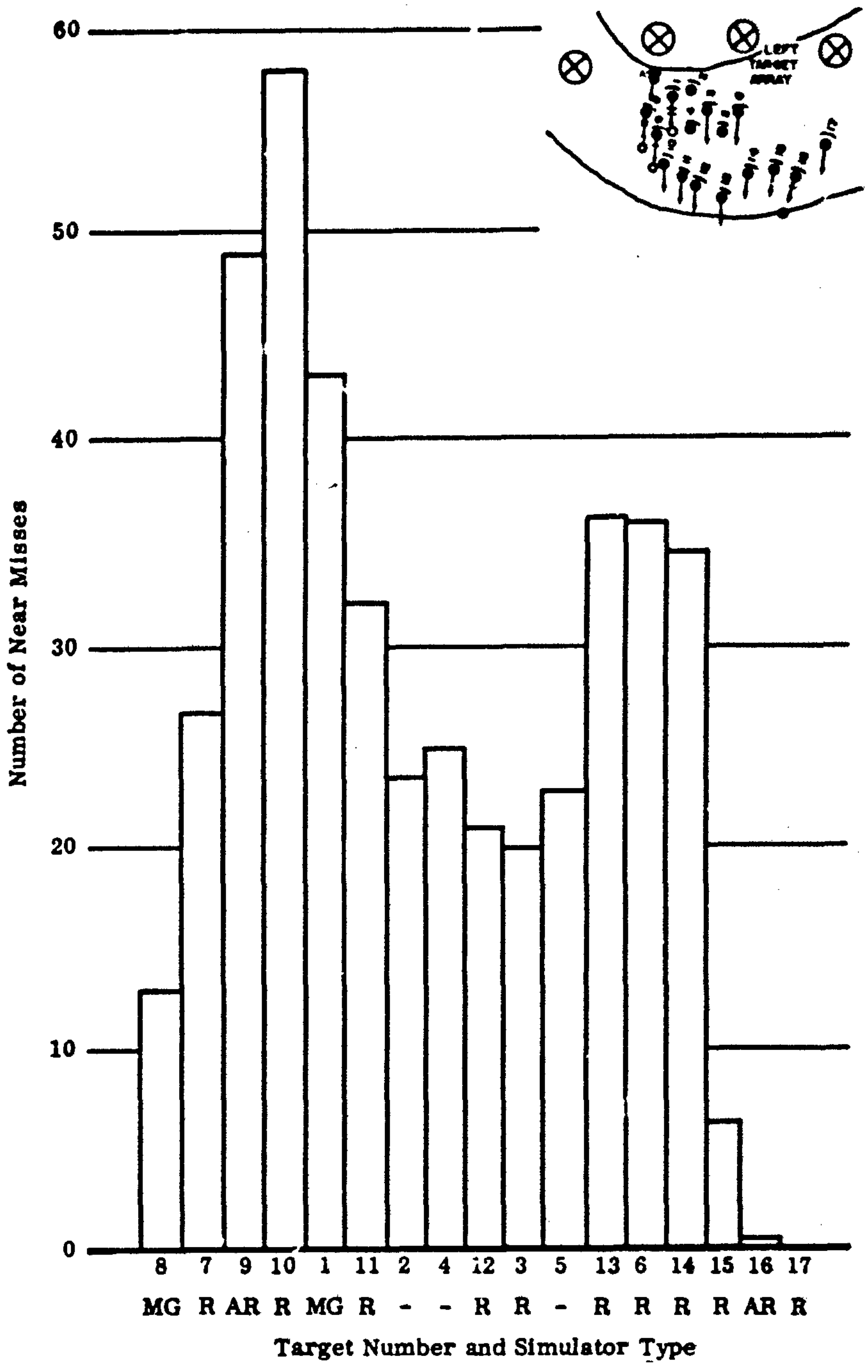


Figure 3-4 HISTOGRAM (BAR GRAPH) PRESENTATION, NEAR MISSES AS A FUNCTION OF TARGET LOCATION

it can be seen through a comparison of the histogram and the schematic sketch that rounds fired at a machinegun, an automatic rifle, and two other riflemen would all pass close to Target 10. Thus, one round of ammunition may register as a near miss on as many as four different targets, in the same manner that one round is capable of contributing to the suppressions of more than one soldier in combat. It also becomes obvious that a ratio of the total number of near misses (as registered in the SAWS experiment) to the number of rounds fired cannot be interpreted as the probability that any given round will be within a given distance of the target. For example, if 2000 rounds were fired by a weapon mix and 200 near misses were recorded, it does not mean that one out of every ten rounds($\frac{2000}{200}$ = 10) passed within the 2 meter near miss zone of a target, because one round may have been registered as a near miss by two or more targets.

This histogram may therefore be used as a primary tool for analysis of the mechanisms of distribution of fire, interactions of target-firer characteristics, and for comparison of the various weapon mixes regarding both suppressive fire and distribution of fire characteristics. Not included in this report, but available at USACDCEC for analysis, are detailed breakdowns of near misses for each individual target as a function of time and range. When related to data regarding the frequency that specific targets were hit, analysis permits a determination of the pattern of random and aimed hits as a function of distribution of fire.

D. ANALYSIS AND DERIVATION OF CONCLUSIONS

The following five sections (Section IV through VII, and IX) present results of the SAWS experiments and deal with the USACDCEC SAWS conclusions and the analyses from which the conclusions were evolved.

USACDCEC has, in effect, presented the results of the SAWS experiment in a format of tables and graphs allowing independent mathematical analysis of the data presented. At the same time decision makers are permitted to integrate military judgment into the mathematical results.

In formulating its conclusions, USACDCEC has exercised military judgment only to the limited extent that on some occasions a judgmental decision had to be made, regarding, for example, the implications of the ability of a weapon to sustain itself when all other things were equal. If target effects are approximately equal for two weapon mixes, but one mix is significantly better than the other in its ability to sustain these effects, then the weapon mix with the sustainability advantage would normally be chosen. In like manner, although the average score for one mix might be superior to the average score for another mix, it becomes necessary to consider just how valid and of how much practical importance the differences are.

In combining scores for the presentation of combined overall results in the various tables, cumulative exposure time, near misses, and sustainability were weighted equally (except where near misses were not measured), as were each of the rifle squad situations. However, before any conclusions could be drawn on the basis of rank orders, raw scores, or standard scores, it was necessary to consider each difference in connection with the probabilities that the numerical differences were really valid differences and not the result of operations of chance factors. It was then necessary to conduct sensitivity analyses of the data to determine the degree of sensitivity of the rankings to changes in the weightings of the criterion measures and situations.

For example, Mix SC (seven Stoner rifles and two Stoner machineguns) ranks in the top position in combined target effects across all rifle situations. Sensitivity analysis showed that it also ranks at least third in every situation and was superior in target effects to every US 7.62mm mix in each of the six situations. Therefore, it does not matter how much any given situation is weighted, the mix composed of seven Stoner rifles and two Stoner machineguns always comes out superior to every one of the US 7.62mm mixes. It may therefore be concluded that Mix SC is superior to any 7.62mm weapon mix in target effects.

Analysis of the quantitative differences between weapon mixes (or systems), judged by the quality of the differences as indicated by various statistical measures including probabilities (statistical significance of the differences), provided the mathematical context from which USACDCEC SAWS conclusions were evolved.

As stated previously, the end results are relatively insensitive to varying the weights of the different situations and effectiveness criteria. No matter how much weight is assigned, the same weapon systems consistently come out ahead of the others in target effects, sustainability, and overall effectiveness.

Despite the numerous presentations in this volume, the data base has scarcely been touched. The quantity and nature of the SAWS data is sufficient to evoke and feed a thoughtful and fruitful analytical endeavor for many years. For example, the brief discussion describing the graphical and histogram presentations of data (paragraphs 6 and 7 of this section) provides the basis for an entire anatomy of analysis. Reflective examination of the time histories of fire effects, ammunition consumption, and distribution of fire effects provide keener insights into the use of small arms. There are numerous ways in which the data can be synthesized or combined to provide further insight into weapon choice, organization, and doctrine.

BLANK PAGE

SECTION IV

TRAINING RESULTS

The primary measures of training performance were firing scores on the various ranges. Firing scores were taken at fixed points in the training program. At each of the times firing scores were taken, each weapon system group had the same amount of training of the same kind under comparable conditions.

Thus, the scores obtained reflect, in part, any weapon system differences that might have existed when the measures were taken. However, these scores were also affected by such factors as weather, time of day, visibility, and motivation, all of which often differed from day to day. Their exact quantitative influence is often not assessable in precise measurable terms, and they must be often accepted as sources of uncontrolled variation. Where there were differences in group scores, the differences may have resulted from differences in ease or effectiveness of training, or from some other weapon system characteristics that are not affected by training, or from uncontrolled factors of the type mentioned above. The fact that the scores may have reflected more than one factor does not invalidate the results of the training assessment, but it makes for a less precise interpretation of results than would otherwise be the case. The interpretation of results also depends on the assumption that the selection process produced weapon system groups that were comparable in learning ability and trainability in small arms firing. There were no known sources of selection bias.

A. RIFLE

1. Disassembly and Assembly

Four tests were carried out to determine the ability to disassemble and assemble the different weapons. For each test, the men were required to disassemble the rifle, and their performances were timed. Times required for all men to disassemble their weapons on the first trial of each test were averaged for each weapon system group. Assembly tests were carried out in the same manner. The first trial of each of the four tests was timed and weapon system group averages were computed. The average times for each test are presented in Table 4-1. When a man had difficulty in disassembling or assembling a part or parts of the weapon, he received assistance from the instructor. These periods of assistance are reflected in longer disassembly and assembly times. It is notable that as the men equipped with the Stoner and M16E1 became more familiar with their weapons they required less assistance, and their times rapidly decreased

Table 4-1

RIFLE
DISASSEMBLY AND ASSEMBLY TEST
(Average Times)

Weapon	Test	Average Disassembly Time (Seconds)	Average Assembly Time (Seconds)
M14 (1)	1 2 3 4	47 31 23 20	75 54 53 51
M16E1	1 2 3 4	119 72 50 30	207 124 99 50
Stoner Rifle	1 2 3 4	116 79 69 27	172 115 99 50
M14 (2)	1 2 3 4	42 29 26 23	69 52 52 49
M14E2	1 2 3 4	47 38 29 24	74 60 57 56
AK47 (1)	1 2 3 4	27 22 12 10	50 33 25 24
AK47 (2)	1 2 3 4	36 24 16 15	63 37 30 28

to approximate that of the M14 group (which had received training in their weapon before the training experiment). On the first test, the differences in performance times for the various weapons were quite marked: the AK47 times were shortest, followed by the M14 and M14E2, the Stoner rifle, and the M16E1. On each succeeding test, the differences were reduced, and by the fourth test they were small. These trends are presented graphically in Figures 4-1 and 4-2. The fourth test did not include removal of the Stoner forestock assembly or the Colt handguard assembly. Therefore, the times for the fourth Stoner and Colt test are not comparable to the results obtained on the earlier Stoner and Colt rifle tests or the other weapons tests.

The least difficult weapon to disassemble and assemble proved to be the AK47. Subjects also were able to disassemble or assemble this weapon more quickly than any other.

Although tight fitting parts caused initial difficulty with some US weapons, this situation was later corrected. It is concluded that there are no tactically significant differences among US weapons regarding ease of disassembly or assembly, or the times required for disassembly or assembly after equivalent training.

2. <u>Trainfire Record Range</u>

Two ranges were used in these firings. All groups fired the record ranges twice. On the second record firing, half of each weapons group fired on each of the two Fort Ord Record Ranges (Range 18 and 19) to balance out range differences. Each man fired about 96 rounds on the record range. Individual hit tabulations were made, and the scores were based on the average number of hits achieved by each weapon system group. The average scores for each group, and for each firing on each range are presented in Table 4-2. The scores range from 44.00 for an AK47 group on their second firing (Range 19) to 57.71 for an M14E2 group on their second firing (Range 18). It should be noted that all record firings were made in semiautomatic fire.

Only four groups of firings by different weapons are directly comparable. M14 Groups K and L are comparable to Colt Groups M and N. For all other record firings, condition of camouflage on the ranges, weather, time of day and other factors were different. Because of time and range limitations a balancing of record firings was not possible. However, it was clearly determined that record scores secured by firers were more a function of the particular range used and the time of day than of differences in either firing ability or weapons. For example, firers who fired on Range 18 in the afternoon always did extremely well and achieved a relatively large number of expert qualifications, regardless of the personnel or weapon used. In contrast, firers who fired on Range 19 in the early

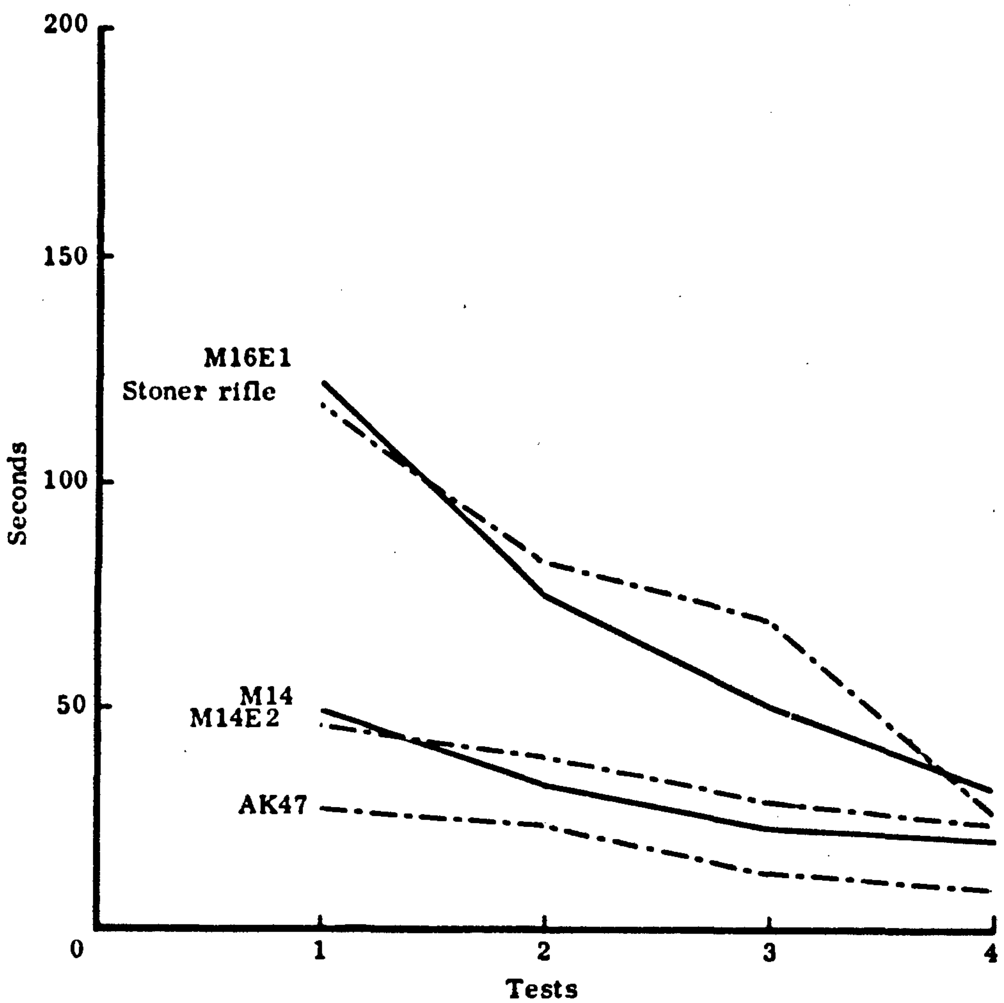


Figure 4-1

DISASSEMBLY TIME OF RIFLES

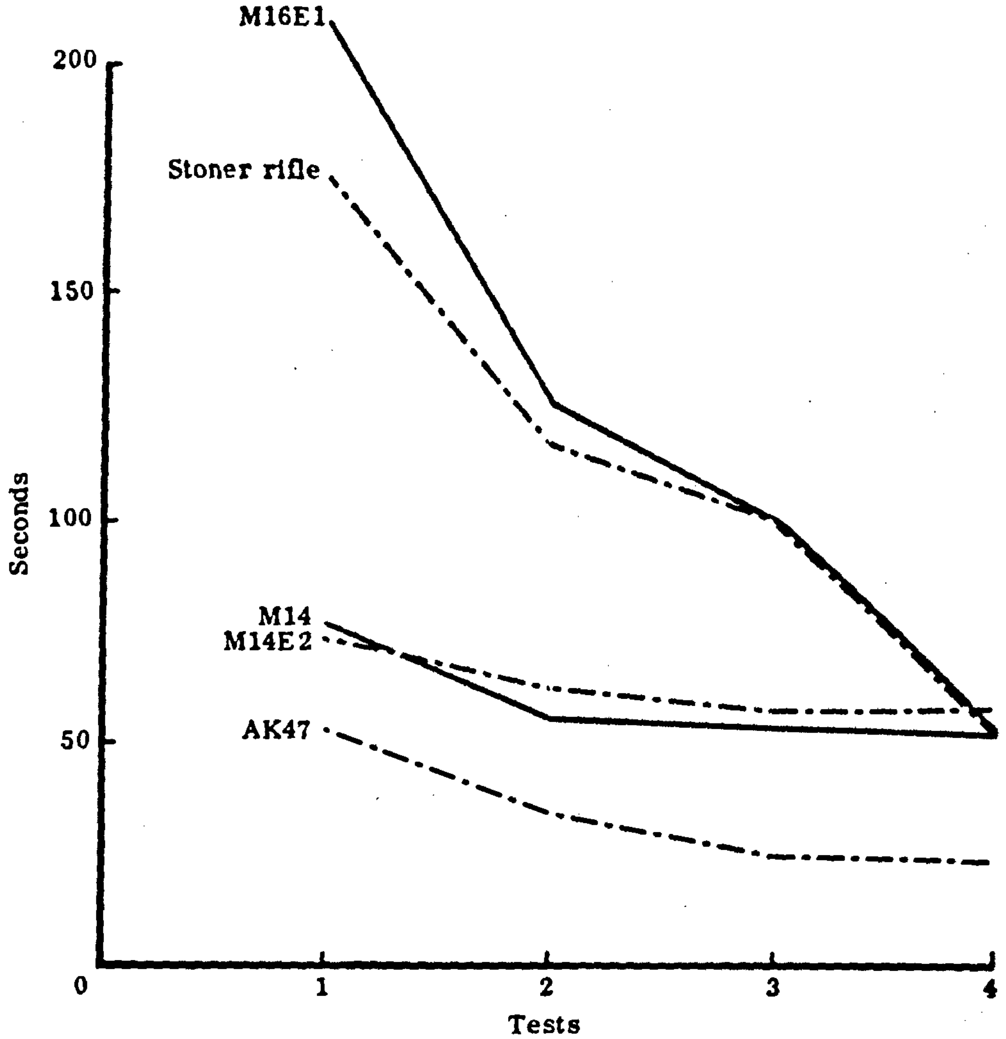


Figure 4-2
ASSEMBLY TIME OF RIFLES

Table 4-2

RIFLE RECORD FIRE QUALIFICATION SCORES

Weapon	Range	GP	N	Avg	σ	Date (1965)	Range	GP	N	Avg	σ	Date (1965)
M14 (128)	19	A	127	45.36	8.99	28 Aug	19	K	60	48.60	8.56	29 Sep
							18	L	55	50.27	8.61	29 Sep
M16E1 (128)	18	B	127	52.66	8.71	28 Aug	19	M	60	54.61	9.11	29 Sep
							18	N	62	56.81	8.16	29 Sep
Stoner (184)	19	C	84	44.45	10.65	7 Sep	19	O	39	48.64	8.54	25 Sep
							18	P	36	52.14	9.09	25 Sep
	18	D	86	54.20	9.48	7 Sep	19	Q	28	51.71	11.74	25 Sep
							18	R	56	54.92	9.83	25 Sep
M14 (56)	19	E	26	48.58	7.63	22 Sep	19	S	14	53.36	6.65	2 Oct
							18	T	12	56.50	6.14	2 Oct
	18	F	27	50.11	7.02	22 Sep	19	U	13	52.77	5.70	2 Oct
							18	V	14	55.93	6.85	2 Oct
M14E2 (72)	19	G	36	52.50	7.48	22 Sep	19	W	18	55.44	7.12	2 Oct
							18	X	17	51.24	9.26	2 Oct
	18	H	36	54.25	10.35	22 Sep	19	Y	16	51.56	5.89	2 Oct
							18	Z	17	57.71	7.53	2 Oct
AK47 (21)	18	I	21	47.38	7.78	22 Sep	19	AA	21	52.57	7.94	2 Oct
AK47 (35)	18	J	39	46.67	8.82	9 Oct	19	BB	34	44.00	7.69	23 Oct

NOTE:

Because of different range conditions, weather, and other factors, these scores are not comparable except as discussed in the text.

CODE: GP Group Designation
N Number of Personnel in Group
AV Average Record Score
σ Standard Deviation

morning did poorly and were seldom able to qualify as experts, regardless of their marksmanship ability or the weapon used.

After the two groups had received equivalent training, the M14 combined group average score (K and L) was 49.4, and the group average score for the Colt rifles (M and N) was 55.71. A level of significance of .001 is attached to this difference. The fact that these Colt rifle scores were higher than the M14 scores is particularly significant when it is considered that, in addition to the SAWS training, the M14 firers had all previously qualified with the M14 and most of them had been using an M14 for more than two years, where the Colt firers first fired the M16E1 during the training period immediately preceding the record firings.

As in the experiment itself, the AK47 scores were low compared to scores of other weapons. This is attributed to the AK47's short barrel (short distance between sights) on the weapons, to varying lots and characteristics of ammunition, to low visibility (fog) conditions on the ranges during the last firing, to the relatively excessive amount of barrel wear of the weapons, and to the fact that the 13 experimental weapons (through 24 December 1965) were shared by all AK47 firers, which necessitated continuous zeroing adjustments. Because both front and rear sights are adjustable this weapon sharing problem may have had more significance for the AK47 than it would have had for other weapons.

3. 25 Meter Rifle in Automatic Mode

Each man fired 20 rounds in each of three positions--hip, underarm, and standing. The average number of hits for each weapon group in each position is given in Table 4-3. Two groups of M14 firers and two groups of AK47 firers fired at different times, and their scores are tabulated separately. Scores varied greatly, and the large difference between scores for different groups assigned to the same weapon type is unexplainable. For example, one AK47 group finished first in two of three positions, but the other AK47 group finished last in the same two positions.

4. 200 Meter Rifle in the Automatic Mode

Two exercises were repeated three times for this test: in the first, 20 rounds were fired at point targets in 40 seconds; in the second, 30 rounds were fired at point targets in 50 seconds. All firings were in the prone position, but the M14E2, M16E1, and Stoner rifle used their integral bipods, and the M14 and AK47 fired without bipod. Averages for each weapon group in each exercise are given in Table 4-4.

Table 4-3

AVERAGE NUMBER OF HITS BY RIFLE IN AUTOMATIC MODE
(25-meter Range)

Weapon	Firing Position						N
	Hip		Underarm		Standing		
	Rank Order	Score	Rank Order	Score	Rank Order	Score	
M14 (sample)	6	2.21	5	3.12	3	9.81	124
M14 (sample)	4	3.46	3	3.44	6	9.56	54
Stoner rifle	2	4.34	2	4.11	1	10.60	160
M16E1	5	2.73	4	3.32	2	10.52	126
M14E2	3	4.12	6	2.41	7	7.60	68
AK47 (sample)	1	5.95	1	4.24	4	9.71	21
AK47 (sample)	7	2.16	7	2.32	5	9.61	38

Table 4-4

AVERAGE NUMBER OF HITS BY RIFLE IN AUTOMATIC MODE
(200-meter Range)

Weapon	Exercise 1[A]			Exercise 2[A]			N
	1	2	3	1	2	3	
M14 (sample 1)[B]	4.32	3.66	3.68	4.28	4.53	4.49	123
M14 (sample 2)[B]	4.02	3.43	3.22	4.24	4.80	4.76	51
Stoner rifle[C]	6.34	6.60	6.51	8.53	9.05	7.71	166
M16E1[C]	7.28	7.47	7.43	9.61	9.17	9.22	126
M14E2[C]	7.30	8.72	9.00	9.71	10.61	10.77	69
AK47 (sample 1)[B]	2.67	2.48	4.33	2.95	4.38	3.95	21
AK47 (sample 2)[B]	2.67	3.26	3.92	4.36	5.05	5.46	39

[A] Two exercises were each run three times. Exercise 1: 20 rounds, 40 seconds. Exercise 2: 30 rounds, 50 seconds.

[B] No bipod

[C] Bipod-supported

B. AUTOMATIC RIFLE

1. Disassembly and Assembly

Four separate tests were conducted exactly like the rifle tests. The times required to complete each test successfully are given in Table 4-5. Trends are similar to trends for the rifle; that is, differences in time were relatively large on the first test, but they narrowed on each succeeding test until they were quite small by the fourth (Figures 4-3 and 4-4). The Stoner weapons showed the longest times and the M14E2 showed the shortest. On Test 4, the Stoner task was performed only up to the carrier cap assembly, which accounts in part for the shorter Stoner times.

2. Interim Transition Record

For this test, each weapon was fired in each of three lanes: in Lane 1 (foxhole position), 24 rounds were fired in 28 seconds; in Lane 2 (prone position), 36 rounds were fired in 36 seconds; in Lane 3 (prone), 14 rounds were fired in 28 seconds. Scores were tabulated separately for both hits and targets hit. The averages for each weapon group are given in Table 4-6.

3. 25-meter Automatic Rifle

In this test, each man fired 20 rounds in each of two positions (underarm unsupported and hipsling supported). The averages for each weapon are given in Table 4-7.

C. MACHINEGUN

1. Assembly and Disassembly

The four tests used for the rifle and automatic rifle, were repeated for the machinegun. The times and numbers completing the first trial on each of the four tests are given in Table 4-8. The Stoner times were generally the longest for both assembly and disassembly, and the RPD times were the shortest. Also as before, the time differences on the first test were relatively large, but they were reduced as testing progressed. Figures 4-5 and 4-6 indicate the trends.

2. Record Firing, Tables II, III, and IV

For this test, each man fired 104 rounds on each table (course). The average number of hits for each of the weapon groups is given in Table 4-9. These results are not comparable because firing conditions for the various groups differed. The RPD and DPM were fired with bipods, and the others with tripods. The second M60 machinegun group and the second Stoner machinegun group consisted of retrained riflemen. This

Table 4-5

AUTOMATIC RIFLE
DISASSEMBLY AND ASSEMBLY TESTS

Weapon	Test	Average Disassembly Time (Seconds)	Average Assembly Time (Seconds)
M14E2	1	42	59
	2	29	55
	3	27	58
	4	26	50
Colt AR	1	59	108
	2	39	72
	3	36	56
	4	34	61
Stoner AR	1	151	207
	2	117	178
	3	103	154
	4	53	104
Stoner Bipod MG (AR role)	1	162	263
	2	124	185
	3	69	164
	4	56	109
RPD (AR role)	1	43	124
	2	33	90
	3	28	75
	4	31	78
M60 MG (AR role)	1	62	90
	2	52	96
	3	43	75
	4	41	75
RPD (AR role)	1	52	118
	2	42	70
	3	29	71
	4	25	72

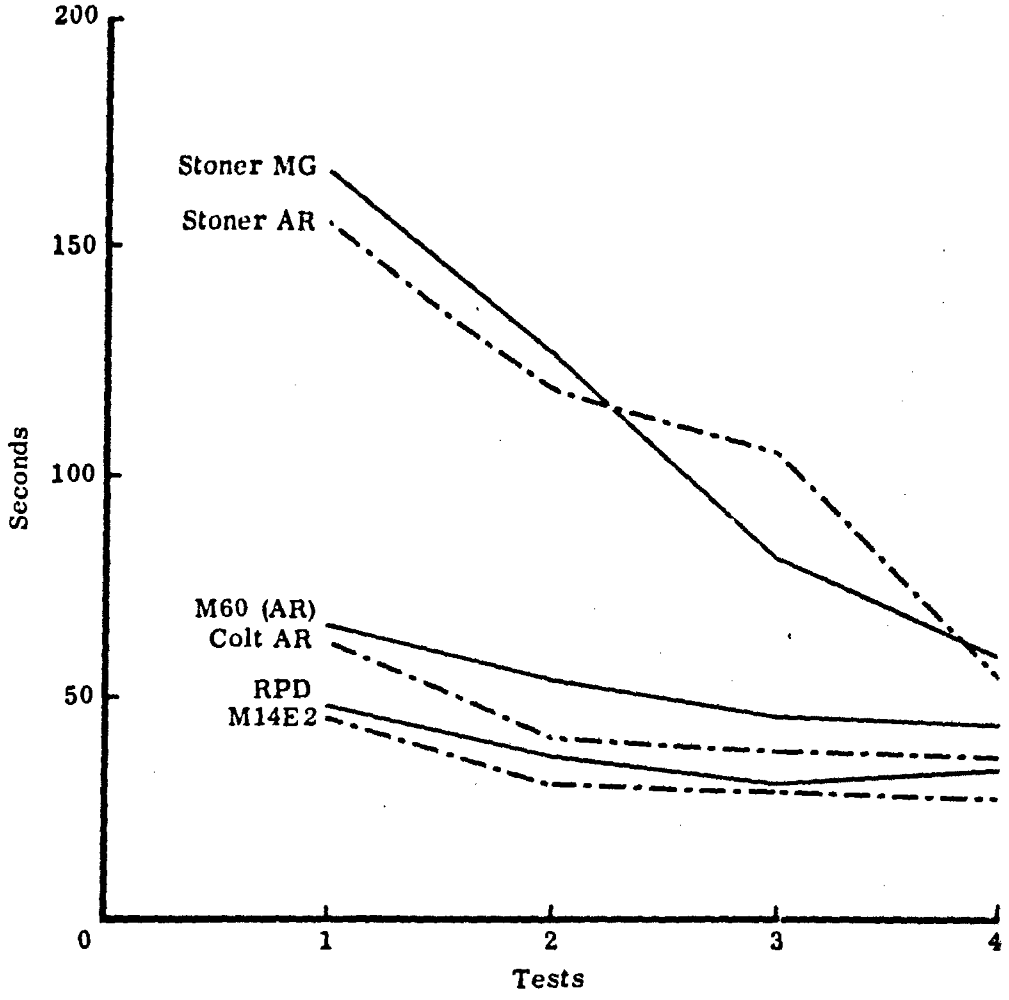


Figure 4-3
DISASSEMBLY TIME OF AUTOMATIC RIFLES

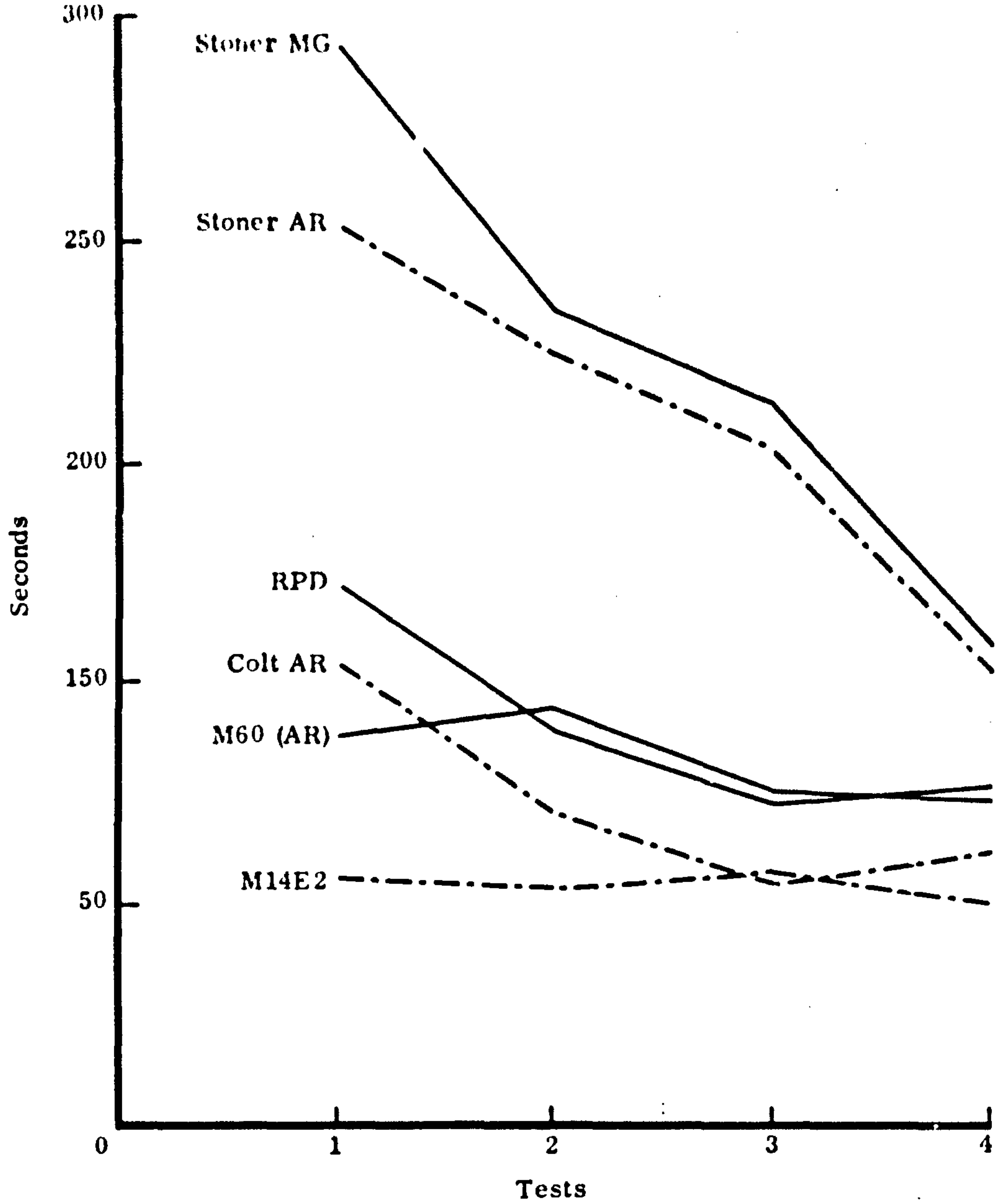


Figure 4-4

ASSEMBLY TIME OF AUTOMATIC RIFLES

Table 4-6

AUTOMATIC RIFLE
INTERIM TRANSITION RECORD

Weapon	Average Hits	Average Targets Hit	N
Colt AR	30.69	11.25	16
M60 (AR role)	26.87	10.87	16
Stoner Bipod MG (AR role)	26.44	10.75	16
M14E2	25.53	10.46	13
RPD (AR role)	23.17	10.10	6
RPD (AR role)	22.00	10.00	10
Stoner AR	21.94	9.94	16

Table 4-7

AUTOMATIC RIFLE AVERAGE HITS
UNDERARM (UNSUPPORTED) AND HIPSLING POSITIONS
(25-meter Range)

Weapon	Firing Positions		N
	Underarm	Hipsling	
Colt AR	2.88	1.94	16
M60 (AR role)	3.38	4.44	16
Stoner bipod MG (AR role)	3.75	3.75	16
M14E2	1.56	1.50	16
RPD (AR role)	2.50	3.83	6
RPD (AR role)	2.90	2.70	10
Stoner AR	4.21	3.71	14

Table 4-8

MACHINEGUN
DISASSEMBLY AND ASSEMBLY TESTS

Weapon	Test	Average Disassembly Time (seconds)	Average Assembly Time (seconds)
Stoner MG (bipod)	1	167	230
	2	138	168
	3	103	126
	4	109	148
Stoner MG (tripod)	1	168	246
	2	90	131
	3	100	134
	4	69	127
M60 MG (bipod)	1	89	115
	2	53	85
	3	46	71
	4	50	75
M60 MG (tripod)	1	95	131
	2	58	85
	3	49	73
	4	49	73
Stoner MG (bipod) Retrained Riflemen	1	113	195
	2	89	174
	3	78	159
	4	75	139
Stoner MG (tripod) Retrained Riflemen	1	99	159
	2	84	133
	3	70	127
	4	65	137
M60 MG (bipod) Retrained Riflemen	1	67	116
	2	70	107
	3	54	84
	4	55	85
M60 MG (tripod) Retrained Riflemen	1	78	106
	2	77	103
	3	54	84
	4	56	82
RPD	1	34	53
	2	35	54
	3	28	53
	4	25	39
DPM	1	68	128
	2	53	89
	3	42	87
	4	32	61

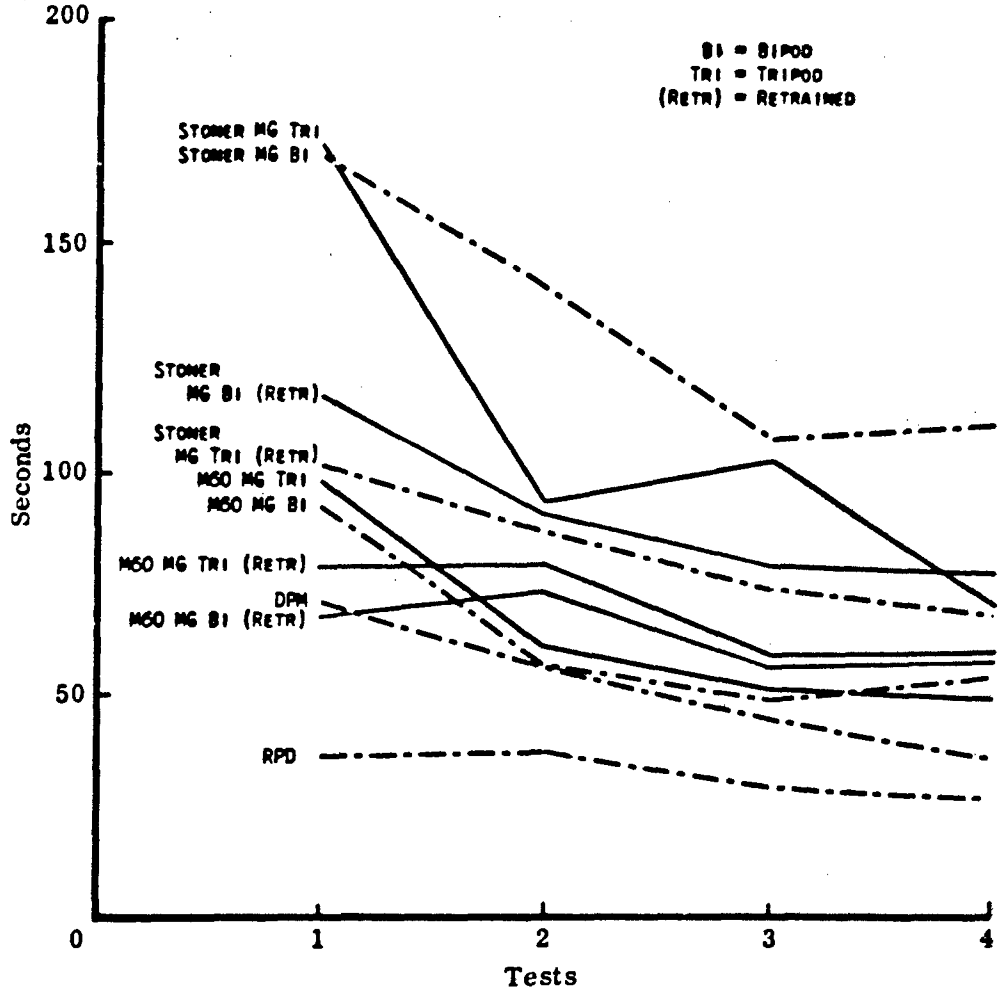


Figure 4-5

DISASSEMBLY TIME OF MACHINEGUNS

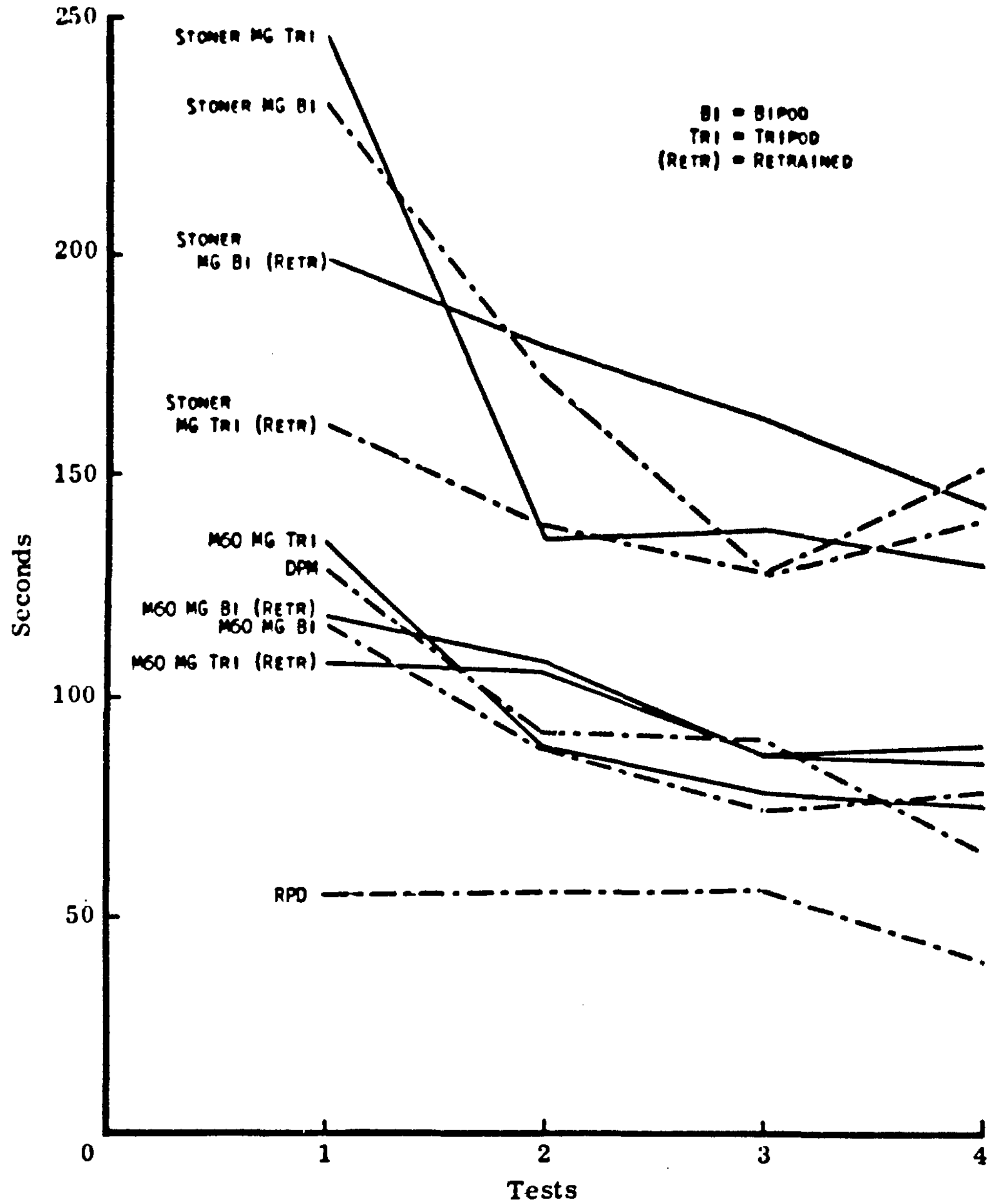


Figure 4-6

ASSEMBLY TIME OF MACHINEGUNS

Table 4-9

MACHINEGUN TABLES II, III, IV
AVERAGE NUMBER OF HITS

Weapon	Table II	Table III	Table IV	N		
				II	III	IV
Stoner MG tripod	64.53	64.64	68.29	32	35	33
RPD bipod	62.13	68.87	72.40	15		
M60 MG tripod	66.77	70.46	74.20	35		
DPM bipod	57.50	57.25	63.13	8		
M60 tripod Retrained Riflemen	67.33	69.29	75.02	48		
Stoner MG tripod (butt stock) Retrained Riflemen	72.96	73.09	74.38	47		

may have given them a special advantage. In addition, the second Stoner machinegun group fired with buttstocks attached.

D. CONTAMINATION OF TRAINING SCORES BY WEATHER

It was recognized before the experiment that weather conditions, particularly light conditions, would affect the firing scores. It was determined from exploratory firing runs with all weapons before the start of training, that these effects were particularly highly correlated with firings against visible point targets where aimed fire was involved, with minimal effects in those situations where area fire was employed.

It was possible during the experimentation runs on the three SAWS experimentation ranges to balance out the schedule of runs so that the same number of squads from each weapon mix ran the same number of times at each time of day. However, during the training phase due to constraints of time, the limited number of range personnel, and limited access to the Fort Ord Training Center ranges, it was not possible, except in rare instances, to balance out weather and time of day effects. Consequently, although training was standardized and although each group received equivalent amounts of training, the record firings on the record ranges are often not comparable.

The effects of time of day and position of the sun are illustrated in Figure 4-7 below. This figure shows the record firing scores of 11 consecutive firing orders of M14 riflemen, the first order having fired at 0800 in the morning and the last order at 1615 in the afternoon. The day was clear and sunny. At 0800 hours, however, for Order No. 1, the sun was in front of the firers, shining behind the targets and into the firers' eyes. On the 1230 hour run, however, the sun was behind the firers. Furthermore, the sun now shone on the front of the targets, and in many instances the targets reflected the sun like a mirror. The difference between the average scores for mixes firing at different times of day was sometimes greater than the difference between the best and worst men within each group. Thus, the difference between the average score of Order No. 1 (37.6) and Order No. 10 (50.8) may not be attributed to any difference in marksmanship ability, but instead must be attributed to differences in visual target acquisition resulting from the position of the sun.

In contrast to Range 19, the effects of visibility on Range 18 are illustrated in Figure 4-8 below. At 0800 hours it was too foggy to see the targets. By 0930 hours, it had cleared enough for range personnel to see the targets and firing was started, but thin fog and haze were still present. The day steadily cleared until for the fourth AK47 order at 1155 hours, all haze had disappeared, and the day was clear and sunny with unlimited visibility.

Following the completion of basic marksmanship training, rifle and machinegun squads were given separate transition training as explained in Section II, paragraph 4B2. The ranges on which this training occurred are presented as follows in diagrammatic form, Figures 4-9 through 4-15.

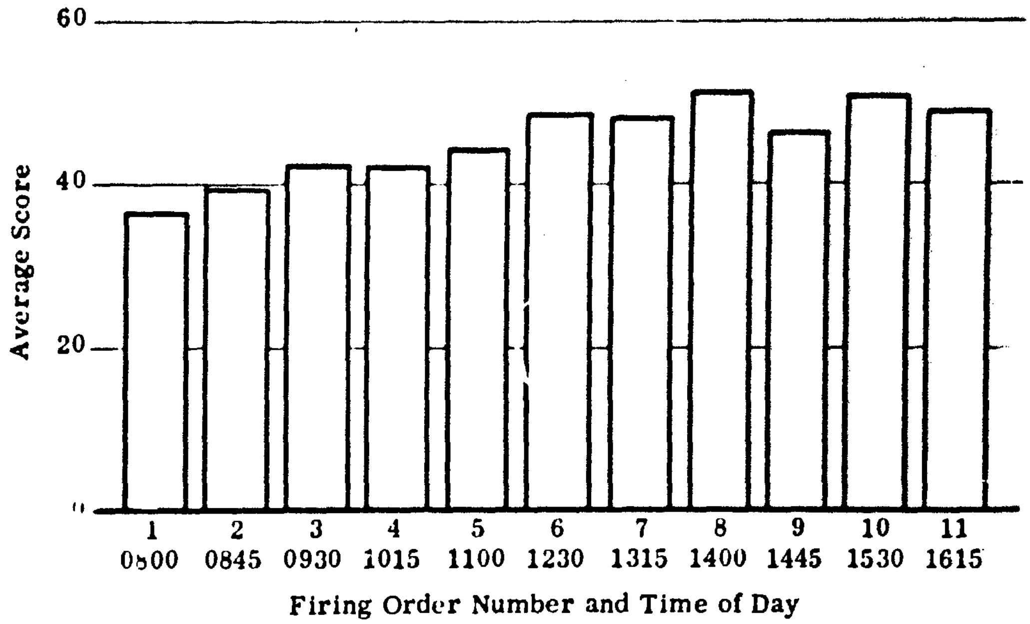


Figure 4-7 RANGE 19 RECORD SCORES AS A FUNCTION OF TIME OF DAY (Position of Sun)

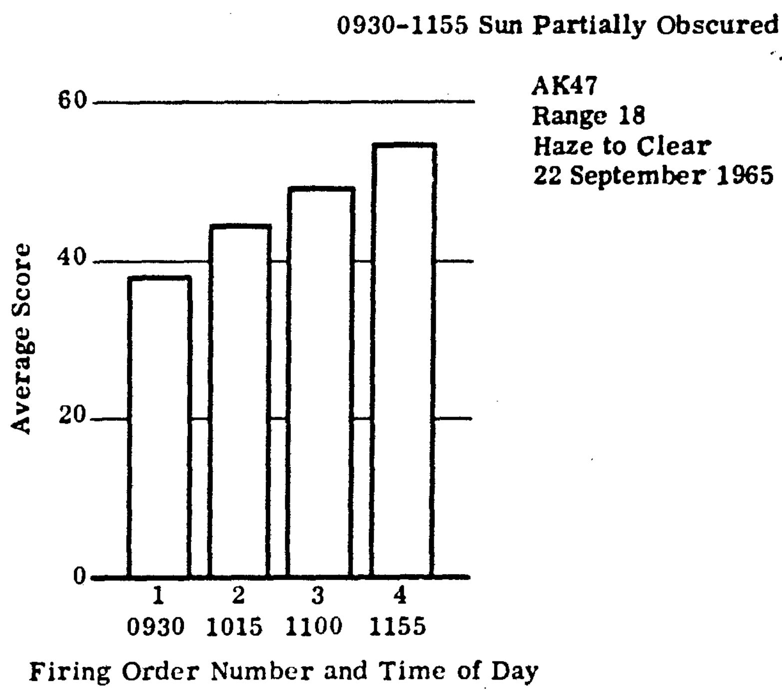


Figure 4-8 RANGE 18 RECORD SCORES AS A FUNCTION OF HAZE CONDITIONS

Rifleman: 10 Rounds
Automatic Weapons: 20 Rounds

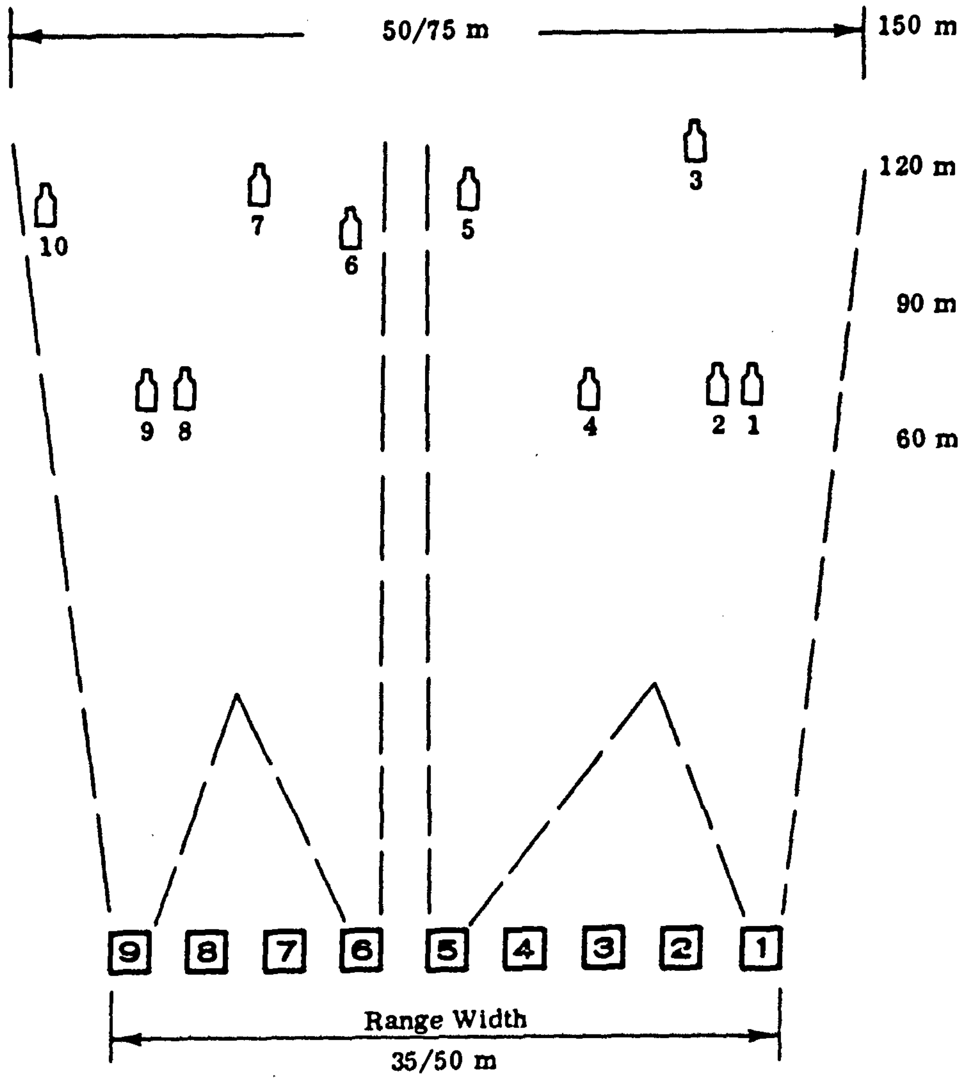


Figure 4-9

RIFLE SQUAD TECHNIQUE OF FIRE RANGE (Linear Targets)

Rifleman: 10 Rounds
Automatic Weapons: 20 Rounds

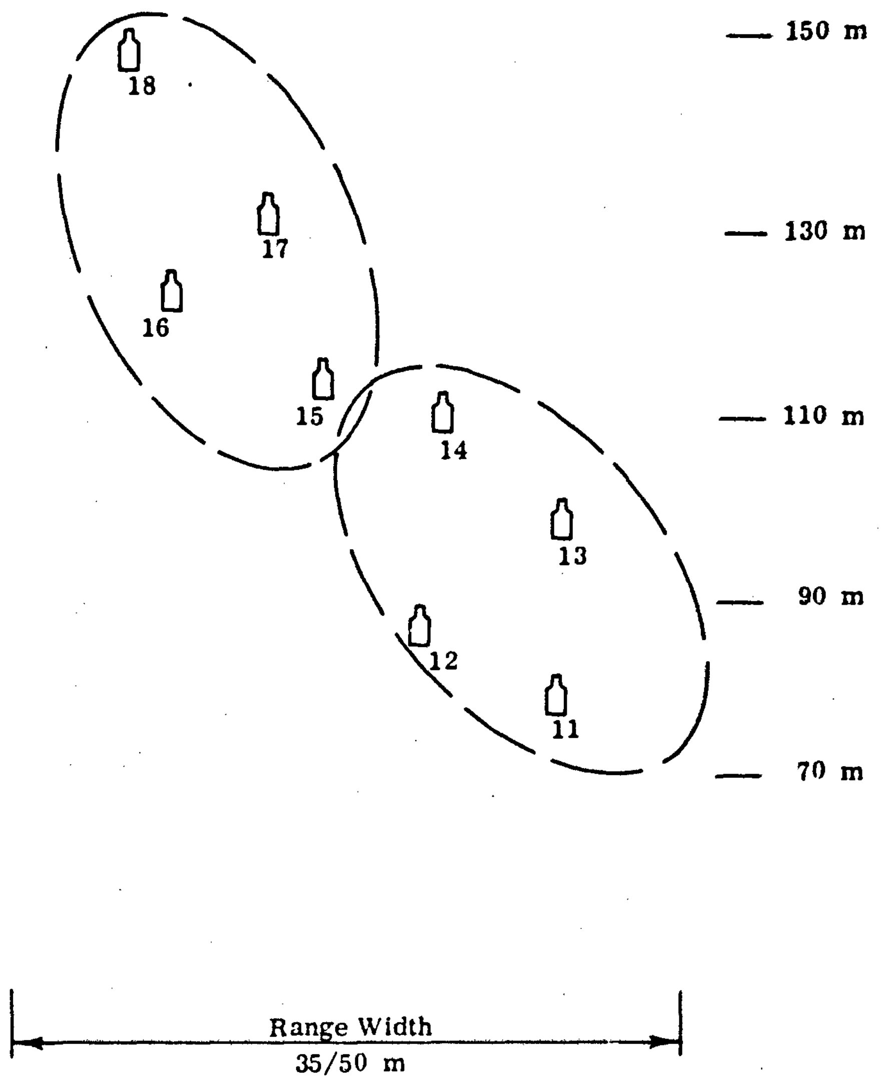


Figure 4-10

RIFLE SQUAD TECHNIQUE OF FIRE RANGE (Oblique Targets)

Target No.	Type
1.	Kneeling
2.	Head and Shoulders
3.	Kneeling
4.	Kneeling
5.	Standing
6.	Standing
7.	Kneeling
8.	Standing

Target No.	Type
9.	Kneeling
10.	Kneeling
11.	Head and Shoulders
12.	Kneeling
13.	Head and Shoulders
14.	Kneeling
15.	Kneeling
16.	Standing

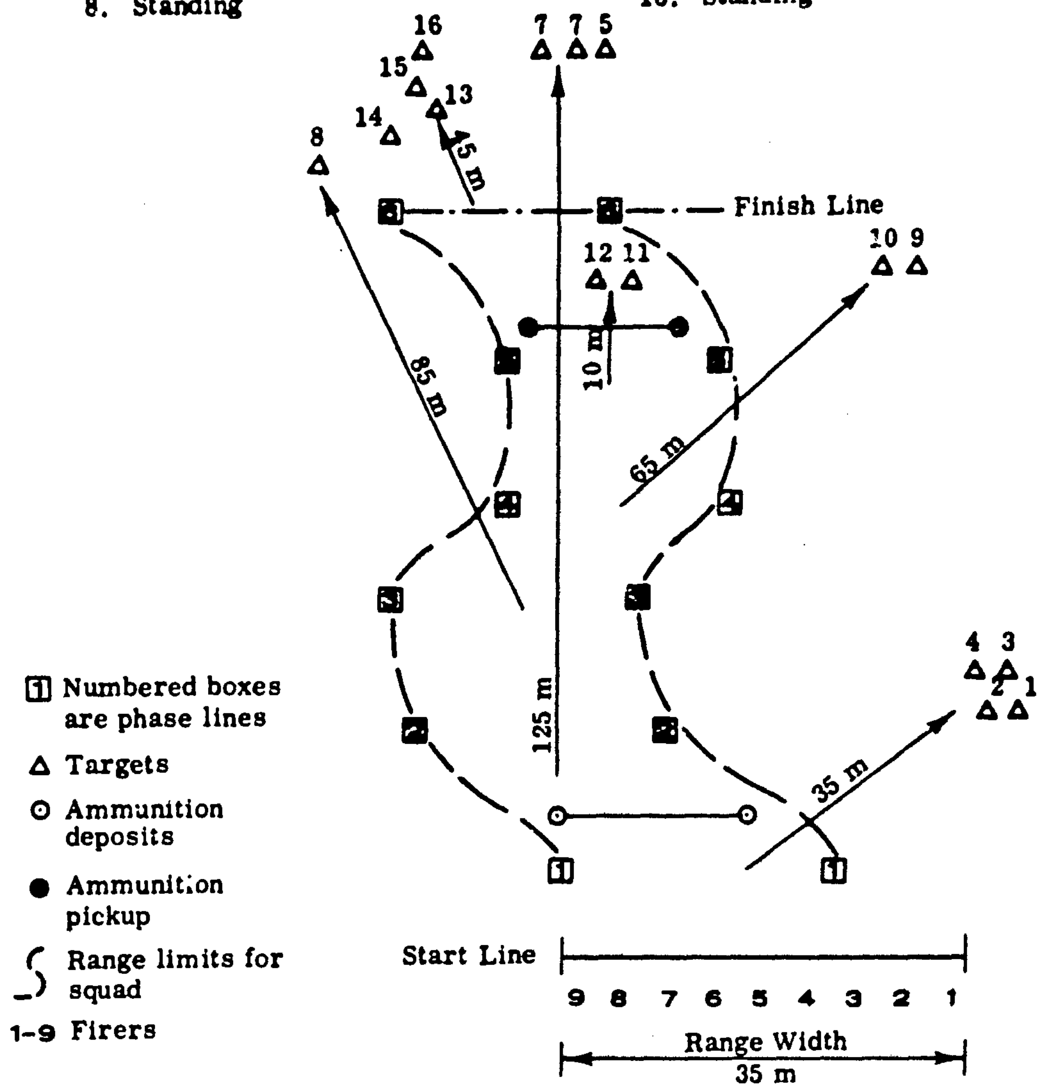


Figure 4-11

RIFLE SQUAD IN APPROACH TO CONTACT RANGE

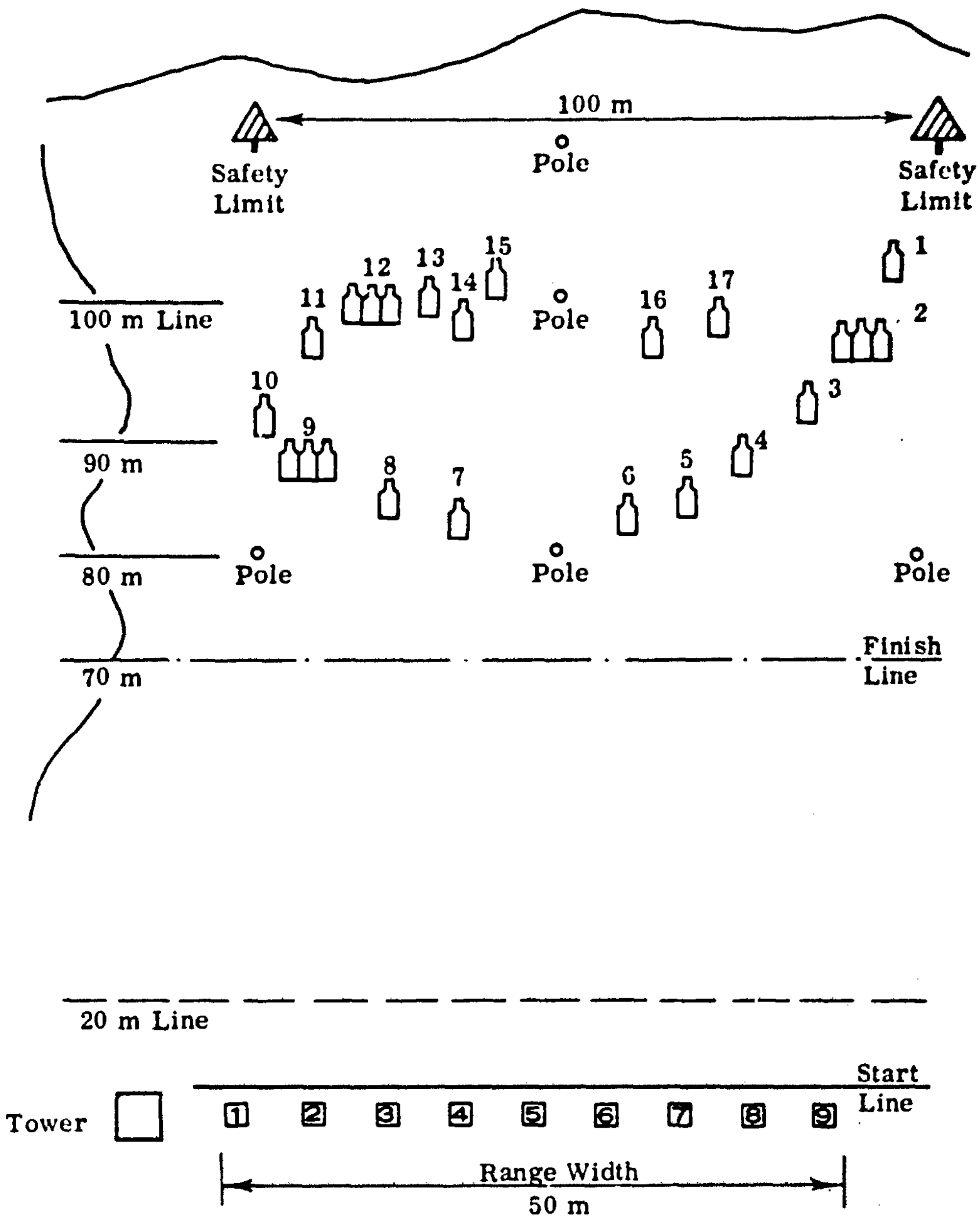


Figure 4-12

RIFLE SQUAD IN ASSAULT RANGE

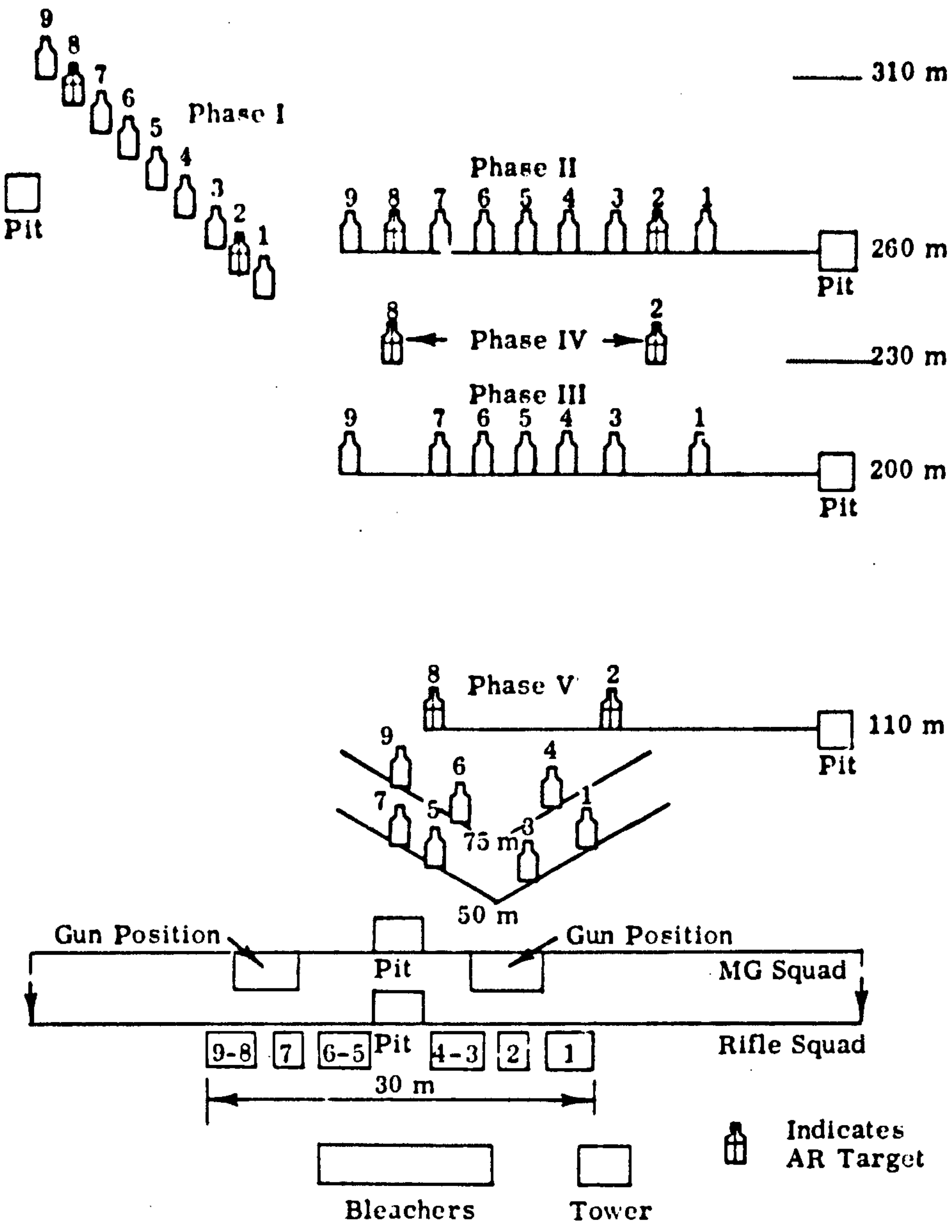


Figure 4-13

SQUAD IN DEFENSE RANGE (Rifle or Machinegun)

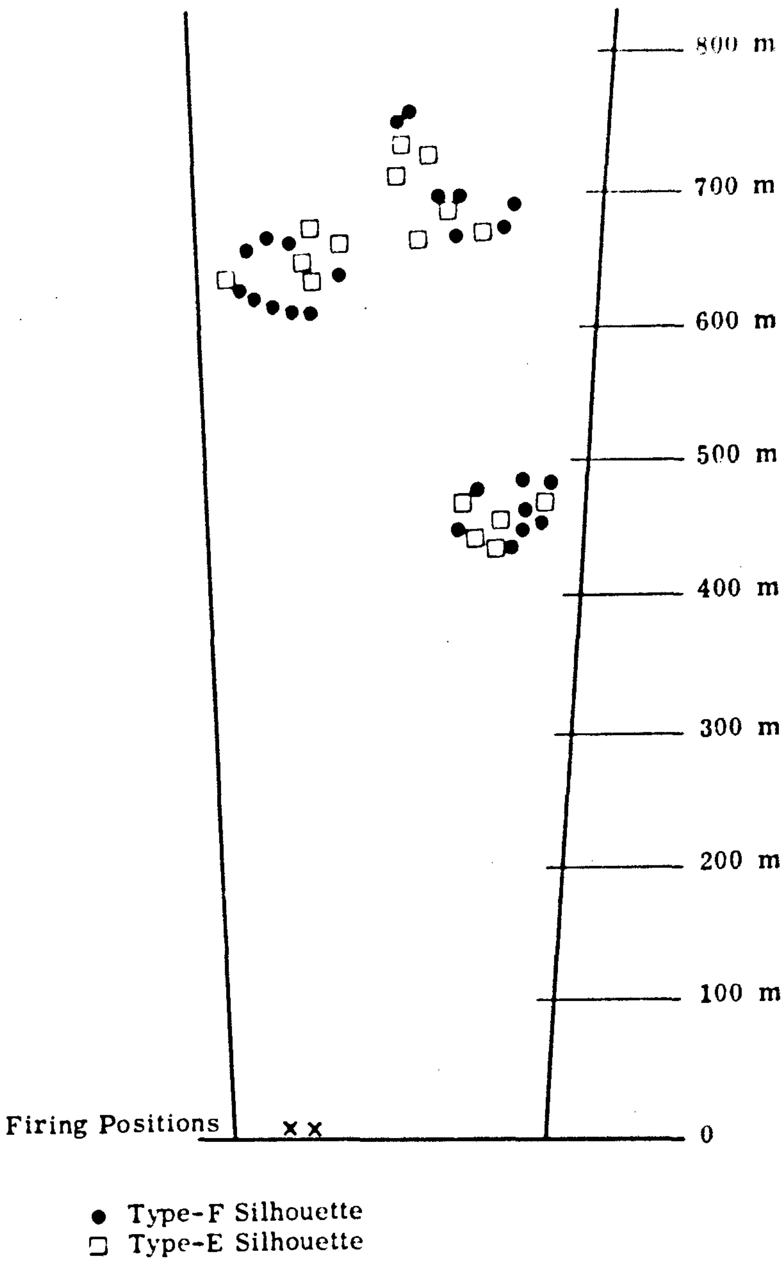


Figure 4-14

MACHINEGUN SUPPORT OF ATTACK RANGE

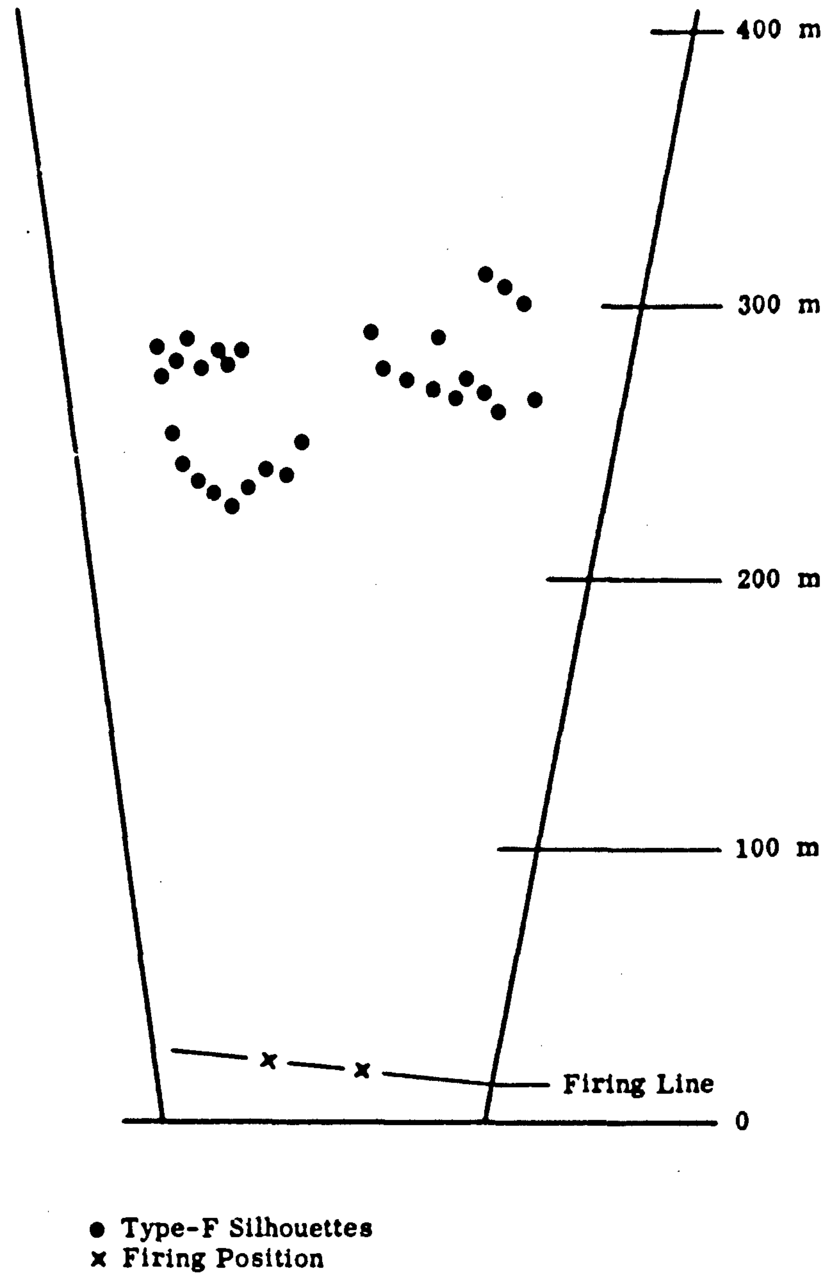


Figure 4-15

MACHINEGUN SUPPORT OF ASSAULT RANGE

SECTION V

MATERIEL RELIABILITY RESULTS

Reliability results are based on data recorded during training, exploratory, and field experimentation firing (Table 5-1), on investigations made to isolate major causes of malfunctions affecting the experiment, and on observations by technical personnel supervising weapons.

Included are indications of the purpose of reliability data, types of data, methods of collection, and results, including the major causes of malfunctions in certain weapons and the effects of materiel reliability on other results of the experiment.

A. PURPOSE OF RELIABILITY DATA

Reliability data were collected and observations were made for the following reasons:

1) To meet requirements of the USACDC directive which specified that reliability data be collected

2) To provide information and data that would assist in interpreting fire effectiveness data obtained in the experiment; for example, to obtain an indication of the effects of weapon stoppages occurring during the experiment on the level of target effects achieved by different squad weapon mixes

3) To assist in making judgments within the SAWS program, regarding the relative reliability of experimentation weapons as to whether there are any fundamental design reasons that might cause one weapon to be less reliable than another*

* The weapons should not be directly compared on the basis of current reliability performance, because they represent different stages of development and of production experience. For example, the AK47 has been standardized for 18 years and probably more than 15 million have been produced. The M14 has been standardized for eight years and about 1,400,000 have been produced. The M16E1 and M16 have been standardized about two years and about 173,000 have been produced for US military forces. This figure does not include production for foreign or commercial customers. The Colt automatic rifle is a developmental weapon, although an adaptation of the M16E1; and the Stoner weapons are test prototypes.

4) To provide detailed reliability data for development, procurement, and logistic agencies for such use as they may have.

B. DATA COLLECTED AND OBSERVATIONS

Detailed reliability data were collected throughout the SAWS experiment--in the training phase, during exploratory firing, and in field experimentation. These data related to malfunctions, time out of action because of stoppages, and replacements of parts and accessories. They were recorded to relate weapon, firer, ammunition lot, weapon zero, rounds fired, trial and trial conditions, and date. Functioning of the weapons and ammunition was also closely observed by supervisory personnel. An attempt was made throughout the experiment to isolate major causes of materiel malfunctions. An AMC technical representative was attached to USACDCEC throughout.

Technical weapon officers and trained armorer artificers supervised the security, safety, maintenance, issue, and troop cleaning of weapons, as well as the storage, inspection, loading of magazines and belts, and issue of ammunition. Weapons were inspected at the time of issue to squads from the storage vans, at the range before the firing run, immediately after the run, after cleaning, and before they were stored again in the van. Two armorer artificers collected reliability data during each squad firing run and debriefed each squad immediately after the run for additional information on malfunctions.

The candidate weapons, ammunition, and spare parts for the experiment were selected and provided by AMC. The weapons, except for the Soviet-types, were in new condition when received by USACDCEC. The ammunition lots provided for the candidate weapons were selected by AMC as typical of ammunition in stock. The Soviet-type weapons were not new, were manufactured in several countries, did not have spare parts (other than by cannibalization), and used a variety of ammunition of varying condition and serviceability.

Data were taken during the experiment on bench rest accuracy of a sample of each weapon-ammunition combination. A summary of these data is given in Annex C.

C. RELIABILITY RESULTS AND FINDINGS

Summary data on malfunctions and stoppages are shown in Table 5-1, by weapon family, weapon, and experiment phase. Further summary of these data, showing malfunctions per thousand rounds fired for each type weapon for the entire experiment and for the field experimentation only, is presented in Table 5-2.

Table 5-1 MALFUNCTIONS A

Malfunctions and Stoppages	US Weapons Family									Colt Weapons Family					
	M14			M14E2			M60			M16E1			Auto Rifle		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	Tng	Expl	Expm	Tng	Expl	Expm	Tng	Expl	Expm	Tng	Expl	Expm	Tng	Expl	Expm
1 Failure to feed	4	11	74	1	2	25	1	3	12	44[b]	33	[illegible]	16	[illegible]	[illegible]
2 Failure to eject		1	3			1	1	[illegible]	45	120	94	[illegible]	[illegible]	[illegible]	[illegible]
3 Failure to extract	1	1	3	1		3	1	[illegible]	4	1	27	222		6	[illegible]
4 Failure to fire[a]	[illegible]	9	64			11	2	1	16	4	33	[illegible]		[illegible]	[illegible]
5 Failure of bolt to remain at rear after firing last round in magazine	2			2	3	2		4		59	169	94	2	21	9
6 Failure of bolt to sear off															
7 Short recoil									3						
8 Bolt underrode base of round in magazine			2					3	2						
9 Double feed										40[c]	24	267	14[b]	13	74
10 Failure of magazine to lock in rifle										3			1		
11 Failure to remain in assembly	3						9		3	1	1	6		2	
12 Partial stripping of round from link									2						
13 Failure of bolt to lock	1		4									16			1
14 Failure to chamber	3							1	1			[illegible]			4
15 Failure of bolt to go forward			3		2				4			4			
16 Failure of bolt to sear															
17 Bolt jammed	1														
18 Bolt overrode base of round in feeding			5								56	119		23	27
19 Link belt separation								3	11						
20 Failure on closure of bolt			3			2						4			[illegible]
21 Bolt catch engaged before last round in magazine was fired			1									4			
22 Total Malfunctions	16	22	164	4	7	44	14	31	104	[illegible]	[illegible]	2476	[illegible]	226	[illegible]
23 Total Rounds Fired. Tng / Expl / Expm	156,549	47,899	116,049	14,165	18,964	79,538	170,336	61,985	95,401	105,313	66,822	265,557	13,328	24,559	104,788
24 Total Rounds Fired[a]	320,527			116,667			327,722			437,692			142,675		
25 Malfunctions per 1000 rounds	.10	.46	1.41	.22	.37	.55	.08	.50	1.09	3.40	6.84	9.32	2.63	9.20	4.30
26 Number of weapons used	120	59	120	22	33	64	44	21	40	120	35	120	16	17	16
27 Average number of rounds fired per weapon	1305	812	968	826	575	1243	3871	2952	2385	878	1909	2213	833	1445	6549

NOTE: Some training and exploratory firing was concurrent with field experimentation.

Tng: Training
Expl: Exploratory Firing
Expm: Field Experimentation

[a] Most misfires with 5.56mm weapons apparently were due to the ammunition.

[b] Eighty-two failures to feed were not attributable to the weapon (they were caused by magazine lips bent in a magazine loader designed for another weapon).

ƆPPAGES OF WEAPONS

Stoner Weapons Family							Soviet-Type Weapons								
	Auto Rifle			MG			AK47			RPD MG			DPM MG		
R	S	T	U	V	W	X	Y	Z	71	72	73	74	75	76	77
Expm	Tng	Expl	Expm	Tng	Expl	Expm	Tng	Expl	Expm	Tng	Expl	Expm	Tng	Expl	Expm
29	5	3	4	27	57	21			26			49		13	114
54	2	4	3	5	35	71		1	7						4
49	2	7	0	57	29	138	3	1	74		2	7			8
57		14	26	73	291	768	4	5		2	2	24	1	135[a]	93
90															
		1													
				1		40							1		
		9	16	100	24	47			2						4
111	1	1	4									1			
							2								
		1		9		3									
						32				4					
7						2			2						
4	2	1	1	1		5		1	1		3				17
9				53	4	12						1	2		
		4												1	
29															
				143	339[a]	212[a]					1	1			
4															
457	12	45	66	549	774	1349	9	4	112	6	10	43	4	149	242
150,884	13,371	23,542	19,994	122,002	44,922	41,862	94,704	18,091	55,041	56,614	1,428	22,183	14,364	2,302	12,042
	56,907			252,546			171,876			80,225			28,708		
1.05	.90	1.91	3.30	4.50	15.42	16.52	.09	.44	2.03	.11	7.00	3.74	.28	64.73	20.10
120	16	17	16	44	19	40	26	10	28	7	4	7	3	3	3
1257	836	1383	1250	2773	2575	2042	3796	1809	2119	4088	357	3169	4788	767	4014

ances of firer not removing magazine when
liate action.

ances of firer not removing magazine when applying
on

[d] Includes 67 instances of bad primers in ammunition.

[e] Due to faulty manufacture of belt links.

[f] Total rounds fired for the experiment: 2,306,940 with experimentation weapons (an additional 542,587 rounds were expended in nonexperimentation firing).

Table 5-2

MALFUNCTION RATES

Weapons [A]	Number of Weapons Used	Malfunctions per 1000 Rounds Fired		Average Number of Rounds Fired per Weapon	
		Total Experiment [B]	Field Experimentation Phase	Total Experiment [C]	Field Experimentation Phase
Rifles					
M14	120	0.63	1.41	3,085	968
M16E1	120	7.50	9.32	5,000	2,213
Stoner Rifle	120	1.90	3.03	5,127	1,257
AK47 [D]	26	0.75	2.03	7,724	2,119
Automatic Rifles					
M14E2 [E]	64	0.47	0.55	2,644	1,243
Colt AR	16	4.99	4.30	8,827	6,549
Stoner AR	16	2.16	3.30	3,471	1,250
Machineguns					
M60 MG	40	0.46	1.09	9,208	2,385
Stoner MG	40	10.58	16.52	7,390	2,042
RPD	7	1.23	3.74	11,614	3,169
DPM	3	13.76	20.10	9,569	4,014

[A] All weapons provided for the experiment were new, except the Soviet weapons

[B] Training phase, exploratory firing, and field experimentation

[C] The average number of rounds fired per weapon during the training, exploratory firing, and field experimentation phases

[D] The majority of the AK47 malfunctions occurred after 5000 rounds had been fired during the experiment. Thirteen weapons averaged more than 10,000 rounds apiece. In addition an unknown number of rounds had been fired from the weapons before they were forwarded to USACDCEC. However, the AK47 had significantly fewer malfunctions per weapon than any other weapon at the time it had fired a comparable number of rounds during the experiment.

[E] Includes use as a rifle

Comparative data on parts attrition are shown in Tables C-8 through C-21, Annex C.

The following findings are drawn from the results presented in Tables 5-1, 5-2, and Annex C, with respect to the level of reliability demonstrated in the experiment by candidate and Soviet weapon-ammunition combinations:

1) The AK47 was more reliable than any of the other experimentation weapons*

2) The M14, M14E2, and M60 were more reliable than the Stoner and Colt Weapons

3) The Stoner machinegun and M16E1 showed the lowest reliability of the candidate weapons

4) The Stoner machinegun was least reliable of the candidate weapons, the remaining Stoner weapons ranked after the US 7.62mm weapons but ahead of Colt weapons in reliability

Causes of the principal malfunctions in the weapons are discussed in the following paragraphs.

---

* The AK47 averaged 0.75 malfunctions per 1000 rounds fired throughout the entire experiment, based on 26 weapons used after January 1966. However, the majority of firing with the AK47 was done prior to 24 December 1965 with 13 weapons which averaged only .30 malfunctions per 1000 rounds while averaging 8007 rounds fired per weapon at that time. The AK47s were not new, had been manufactured in three different countries (the Soviet Union, East Germany and Red China) and had unknown prior combat and training usage. In addition, there were insufficient spare parts (of the 29 available weapons three were used for spare parts). This lack of weapons and spare parts required an extensive sharing of the AK47s which had an overall average rounds fired of 7724 rounds during the entire experiment compared to only 3085 rounds for the M14. However, the average for the original 13 AK47s was 10,926 rounds per weapon. Although the M14 malfunction rate was 0.63 (0.12 malfunctions per 1000 less than the AK47), many of the M14s had parts replaced with new parts whereas the AK47s were forced to use worn and theoretically unserviceable parts. However, all parts replaced (with used parts from other weapons) were in the original 13 AK47s, and in only one case was a part replaced under 7500 rounds. Because the majority of AK47 malfunctions occurred after 5,000 rounds had been fired and because the weapons had fewer malfunctions per 1,000 rounds when compared with the M14 at the same number of rounds fired, it is concluded that the AK47 is a significantly more reliable weapon than any of the US 7.62mm or 5.56mm weapons.

1. Major Causes of Malfunctions in US 7.62mm Weapons

There were few malfunctions in the US 7.62mm weapons. The 74 failures to feed (Table 5-1, line 1, Column C) in the M14 rifle were attributed to dirty magazines and the magazine follower sticking (through distortion of the magazine spring). The 66 failures to fire were the result of light firing pin indentations in the primer that were considered to be the result of weapons not being completely in battery on activation of the trigger.

2. Major Causes of Malfunctions in 5.56mm Weapons*

Major causes of most malfunctions in the 5.56mm weapons are attributed to an interaction of ammunition (and belt link) deficiencies:

1) Weapon fouling, judged to be caused primarily by qualities of the propellant used in standard ball 5.56mm cartridge

2) Cycling of weapons in excess of design rates, judged to be caused by combinations of**:

   a) Pressure characteristics of the propellant used in the standard ball 5.56mm cartridge

   b) Factory calibration of M16E1 rifles for a propellant with different pressure characteristics than that in the standard ball 5.56mm cartridge

   c) Mismatch in internal ballistic (pressure) characteristics between the standard 5.56mm ball and tracer cartridges

3) Misfires caused by too low primer sensitivity and possibly (in the case of the Stoner machinegun) an interaction of low primer sensitivity with effects of too rapid weapon cycling caused by the pressure characteristics of the propellant

* These major causes do not account for all the malfunctions experienced by the 5.56mm weapons. For example, early in the experiment the Stoner machinegun had malfunctions caused by improperly fabricated feed trays that were replaced. Accurate attribution of causes for all malfunctions is difficult because some ammunition deficiencies magnified incipient malfunctions.

** Cyclic rates (upper limit) for the M16E1 rifle and Stoner machinegun are 800 and 850 rounds per minute respectively.

4) Incorrectly manufactured machinegun belt links

a. Fouling

Fouling in the 5.56mm weapons occurred throughout the experiment. Dirty chambers resulting from rapid carbon buildup caused most of the failures to extract (see Table 5-1, line 3, columns J through X) and some of the failures to chamber (line 14). Fouling remained a problem throughout the experiment, although cleaning and inspection of weapons were considered more stringent than would be possible during combat.

Inquiry to AMC determined that the propellant adopted for the standard 5.56mm ball cartridge is different from the original propellant used during the development and service testing of the M16E1 rifle and during the development of the Stoner weapons.* A USACDCEC test of samples from the lot of standard ammunition used in the experiment showed more fouling than an AMC provided sample containing the original propellant. This supplemental fouling test was conducted using ammunition lots WCC 6098 and RA 5074. This limited test firing of 12,620 rounds indicated a malfunctions rate of 5.6 per 1000 rounds for the cartridge loaded with ball propellant as opposed to 0.91 for IMR propellant loaded cartridges. Results of this fouling test are tabulated in Annex C.

b. Excessive Cyclic Rate

Excessive cyclic rates were noted early in the experiment. In addition, surging (uneven firing) was noted when ball and tracer were fired together. There was also an increasing incidence of malfunctions attributed to ammunition cycling the weapons beyond their design rates. The cyclic rates were higher than the design cyclic rates, particularly with the M16E1 rifle and Stoner machinegun.** Surging also was most noticeable with the Stoner machinegun. It is concluded that this excessive cyclic rate (through induced cyclic and impact problems***) caused, complicated, and multiplied such malfunctions as failures of the bolt to remain to the rear after the last round was fired from the magazine (see Table 5-1, line 5, columns J through X), failures to eject (line 2, columns J through X), and magazine feeding problems (lines 1, 9, and 18).

---

* Frankford Arsenal, Tenth Memo Report on AR-15, Rifle/Ammunition System Investigation of Alternate Propellants for Use in 5.56mm M193 Ball Ammunition, dated 15 May 1964

** Cyclic rate of up to 1000 rounds per minute

*** Impact forces increase with the square of the velocity

A concurrent propellant investigation by Frankford Arsenal showed that the propellant currently used in the 5.56mm ball cartridge cycles weapons faster than the original propellant.*

Inquiry to AMC determined that, to meet a Government acceptance requirement, M16E1 rifles are calibrated at the factory for the gas port pressure of the original propellant rather than that of the propellant currently used in standard ball 5.56mm cartridges. Interaction of the higher gas port pressure of the current propellant and the sizing of the gas port for a propellant with a lower gas port pressure is considered the reason for the excessive cyclic rate in the M16E1 rifle.

Regarding the excessive cyclic rate and surging of the Stoner machinegun, it was noted that the 5.56mm tracer and ball rounds contained different propellants** and cycled the 5.56mm weapons at different rates: tracer cartridges cycled the weapons at a slower rate than the ball cartridges. It is judged that because of this mismatch the gas port on the Stoner machinegun had to be sized for the slower cycling tracer cartridge to ensure weapons functioning. Since machinegun belt loadings normally are four ball and one tracer, the presence of the faster cyclic ball cartridges causes the gun to cycle above its design rate and to surge as the four faster and the one slower cartridges alternate through the gun. This mismatch also affects the functioning of the other 5.56mm weapons in automatic fire, but to a lesser extent than the machinegun, apparently because of the sustained automatic fire and more frequent use of tracers by the machinegun.

c. Primer Sensitivity

It was reported in a previous test of the Stoner weapons that there had been a high incidence of misfires, particularly in the machinegun***. These misfires were attributed by some to an insufficient primer sensitivity of the 5.56mm cartridge and by others to a lack of sufficient recoil power in the Stoner machinegun. However, if these misfires were due to insufficient recoil power and if the sensitivity of the cartridge primer was not marginal, then misfires with the 5.56mm cartridge would tend to be limited to the machinegun. This was not the case in the SAWS experiment. After

* USACDC Liaison Office, USA Weapons Command, Rock Island, Illinois, Liaison Report 385-65, 27 December 1965.

** Copies of Ammunition Lot Inspection sheets furnished by AMC to USACDCEC to show that the ball ammunition furnished contains ball propellant (WC846) and that the tracer ammunition furnished contains IMR type propellant (CR 8136 and EX 8136).

*** Stoner 63 Weapon System Final Report, Project No. 44-63-08 of 29 April 1965, Marine Corps Landing Force Development Center, MCS, Quantico, Virginia, page 17.

it was decided that the ammunition was causing the machinegun to misfire and cycle at an abnormal rate, it was also decided that a reduction in the buffer preload resulting from the pounding of the buffer might reduce firing pin energy. It was indicated that this in turn might cause the rate of misfires to increase sharply after the weapons had been fired in heavy sustained fire, especially if primer sensitivity were marginal. Inquiry to AMC disclosed that there had been a decrease* in primer sensitivity at the time of standardization of the 5.56mm ball cartridge, to overcome what was then considered a tendency of the round to fire on closure of the bolt in the M16E1 (then AR15) rifle. It was therefore desirable to examine the primer indentations of misfire cartridges. Therefore, provisions also were made to collect data regarding any instances of primers being too sensitive: that is, rounds firing when the bolt was closed without pulling the trigger. With respect to these points, the experiment produced the following information:

1) In 1,261,215 rounds fired by the 5.56mm weapons, there were no instances of cartridges firing when the bolt was closed without pulling the trigger and no cases where the primer indentations of misfire cartridges were sufficiently shallow to have clearly caused misfires.

2) Misfires occurred with all five of the 5.56mm weapons (see Table 5-1, line 4, columns J through X), rather than only with the Stoner machinegun. The four weapons other than the machinegun incurred 829 misfires in 1,008,629 rounds fired, or one per 1217 rounds.

3) Of the 1132 misfires experienced with the Stoner machinegun during the experimentation, 472 occurred during later sustained machinegun fire (Situations 3, 6, and 9). This could have been due to the reduction in the buffer preload, to the reuse of the belt links, or to some other cause. Measurements of the buffer taken after the completion of Situations 3, 6, and 9 showed that preloads were below the design minimum.**

* Primer sensitivity was decreased from "no fire" at 6 inch-ounces and "all fire" at 36 inch-ounces, to "no fire" at 12 inch-ounces and "all fire" at 48 inch-ounces. Ref: Frankford Arsenal - 1st Memo Report on AR15 Rifle Ammunition Systems, Investigation of Firing Pin Energy and Primer Sensitivity, data 4 April 1963 and Military Specification MIL-C-996-3D, dated 1 June 1964.

** The preload specification is 245 pounds minimum and 260 pounds maximum. The average preload after firing Situations 3, 6, and 9, was 221 pounds.

This information therefore indicates that misfires in the 5.56mm weapons were due to the function of primers that were too insensitive.

d. Belt Links

During the experiment, it was noted that a major cause of Stoner machinegun malfunctions was belt link separations. Separations occurred as often as ten times per belt, frequently causing other malfunctions.

Comparisons of the links against design drawings showed that the links deviated from design drawings dimensions. At USACDCEC request, 30,000 links made to design drawing dimensions were obtained from AMC. A comparison test of the "old" and "new" links produced the following results.

An average of seven separations per belt occurred when eight belts of 150 rounds were fired, each using the old links. The number of separations by belt were 8, 3, 18, 5, 8, 0, and 7. These separations also caused 24 failures to feed, one failure to strip (stubbed round resulted), and two failures of bolt to go forward. No separations occurred with the new links when firing with seven 150-round belts and one 200-round belt. The 200-round belt had links that were used a second time.

The 30,000 links manufactured to proper design were then substituted for the originally supplied links for the machinegun squad portion of the experiment (Situations 3, 6, and 9).* During this phase of the experiment (in which 28,000 rounds were fired) there were three belt separations, and these separations occurred with links that had been reused.

e. Other Ammunition Deficiencies

Although individuals adjacent to the firer normally could see both tracers, neither the US 7.62mm tracer cartridge nor the US 5.56mm tracer cartridge provided a trace that was visible enough to be used by the firer in adjusting fire, with or without sights, under daylight conditions. This deficiency negates the adjustment of fire for automatic weapons by the gunner observing his tracers.

The US 7.62mm duplex cartridge suffered pierced primers. This was judged to be caused by excessive chamber pressure.**

---

* Faulty type links already had been used with the Stoner machineguns throughout four of the six situations in the rifle squad portion of the experiment.

** Current chamber pressure, temperature, and waterproofing deficiencies of this cartridge are given in Memorandum Report, Preproduction Test of Cartridge, 7.62mm, Ball, Duplex, M198, April 1965, Frankford Arsenal

D. EFFECT OF MALFUNCTIONS ON EXPERIMENTATION

Malfunctions in the 5.56mm weapons attributed to faulty ammunition and belt links degraded the fire effectiveness of all 5.56mm weapons, especially the M16E1 rifle and Stoner machinegun. In one tactical situation, for example, the M16E1 rifle had a weapon downtime due to stoppages of 6.97 percent of the situation time. The effects on the Stoner machinegun were judged to be sufficiently severe to disqualify the machinegun squad portion of the experiment.

The AK47 was the most reliable of the experimentation weapons. The US 7.62mm weapons (M14, M14E2, and M60) demonstrated fewer malfunctions than the US 5.56mm weapons. The Stoner machinegun and M16E1 had the highest malfunction rate. The reliability of the Stoner machinegun with the ammunition provided for the experiment was judged to be sufficiently low to invalidate the machinegun squad portion of the experiment. Major causes of malfunctions in the 5.56mm weapons were attributed to:

1) An interaction of ammunition deficiencies caused by changes made in the ammunition propellant and primer sensitivity at the time of the standardization of the 5.56mm ball cartridge

2) Deviations from design specifications in the manfucature of the machinegun belt links

Until the deficiencies in the ammunition and belt links are corrected (and it is considered that they are readily correctable), it is impossible for the Stoner 5.56mm machinegun to function at its maximum potential.

Neither 7.62mm nor 5.56mm tracer rounds provide a trace that is visible enough to the firer under daylight conditions for him to use it in adjusting his fire. The duplex round suffered pierced primers, apparently caused by excessive chamber pressure in the M14 and M14E2 rifles.

SECTION VI

SQUAD WEAPON MIX FIRE EFFECTIVENESS RESULTS

A. RIFLE SQUAD EXPERIMENT

The results are presented on foldout sheets and in separate tables and graphs for each situation. Included are raw score averages, standard scores, probability (p) values, F values, X^2 values, ranges of scores for the measures of effectiveness and collateral measures, graphs of hits as a function of time and range where applicable, and histograms for the distribution of near misses by target where applicable.

The results for Mix RC (seven AK47 rifles and two RPD machineguns) are not included in the same tables and graphs as other mixes. Mix RC was fired later (January 1966). Because of differences in range conditions and weather, the RC results are not directly comparable to the other rifle squad mix results and are therefore presented separately.

1. Situation 1: Rifle Squad in Line Assault

This situation evaluated rifle squad mixes in marching fire against concealed and partially concealed enemy targets in foxholes. The length of the assault was 100 meters, and the duration was 2 minutes. Enemy targets were engaged 115 to 148 meters from the line at which the assault started, and at distances of 15 to 48 meters from the point where the assault ended. The target array occupied a position 50 meters wide and 30 meters deep with a differential in target elevations of about 4 meters.

Results for the assault are tabulated and presented graphically in Figure 6-1.

The average number of near misses for all mixes combined are presented as a function of target location and simulator type in Figure 6-2. This figure presents the vertical profile of the target array showing to scale the elevation and width of the array. The position of each target is shown. Because the assault is progressing up a slope, the difference in the elevation of the actual targets as seen by the firers is less than that shown in the figure. The number associated with each target on the profile shows the average number of near misses for all rifle mixes, the simulator cues associated with each target, and the width of the near miss zone at each target. Although not shown, the height of the near miss sensing zone extends in a 2-meter semicircle from the center of the target.

The tabulation below indicates the approximate distance of the squad from the middle of the target array (in depth and width) in relation to the time in minutes that the squad progressed up the assault course. Exploratory firings on the assault range indicated that squad movement across the assault range was generally at a constant rate. All squads took approximately 2 minutes to complete the course.

Time Traveled (minutes)	Average Distance from Targets (meters)
.00	131
.25	119
.50	105
.75	94
1.00	81
1.25	69
1.50	56
1.75	44
2.00	31

Figure 6-3 illustrate the average number of targets hit and average number of near misses plotted as a function of time and range for each mix in the assault situation. The cumulative average hits by each mix at each point along the assault course are indicated by the ordinates of the curve at that point. The start of the assault (131 meters from the targets) is indicated by the left end of the curve and the completion of the assault (31 meters from the targets) is indicated by the right end of the curve.

Figure 6-4 shows the number of near misses for each target and their distribution as a function of target location and simulator type. Target locations are provided for purposes of comparison in insert maps.

The rank order of weapon mixes (other than Mix RC) with associated standard scores are presented below.

Target Effects Only			Overall Effectiveness*		
Rank	Mix	Standard Score	Rank	Mix	Standard Score
1	SB	70.1	1	CB	65.8
2	SA	68.9	2	SB	65.6
3	SC	65.2	3	SA	63.5
4	UB	59.8	4	CA	59.7
5	CB	57.9	5	SC	56.2
6	CA	47.1	6	UB	54.4
7	UA	42.2	7	UA	43.8
8	RA	35.7	8	RA	35.3
9	UD	28.2	9	UD	32.4
10	UC	25.9	10	UC	24.3

* Sustainability weighted 1/3; Target effects 2/3

Key:

UA - 9 M14 Rifles

UD - 9 M14E2 Rifles

UB - 7 M14 Rifles and 2 M14E2 AR

UC - 5 M14 Rifles and 2 M60 MG

SA - 9 Stoner Rifles

SB - 7 Stoner Rifles and 2 Stoner AR

SC - 7 Stoner Rifles and 2 Stoner MG

CA - 9 Colt Rifles

CB - 7 Colt Rifles and 2 Colt AR

RA - 9 AK47 Rifles

Mix RC results for Situation 1 are presented below.

CET	Near Misses	Percent Ammo Remaining	Targets Hit	Total Hits
29.08	3.67	25	2.4	2.4

EFFECTIVENESS MEASURES

A — Cumulative Exposure Times

Mix	$\bar{X}$ CET	SD	Standard Score z'
UB	24.1	2.4	81.8
SB	24.4	1.7	73.4
SA	24.8	1.9	64.1
CB	25.1	2.0	56.3
SC	25.3	2.1	49.6
UA	25.5	1.2	47.2
UD	25.5	1.9	44.8
CA	25.8	1.4	38.2
RA	26.1	0.8	31.5
UC	26.8	2.4	14.9
$\bar{X}$	25.32		
SD	.80		

B — Number of Near Misses

Mix	$\bar{X}$ Near Misses	SD	Standard Score z'
SC	499.6	114.0	80.8
SA	469.8	68.9	73.8
SB	439.5	92.1	66.7
CB	409.2	89.6	59.6
CA	393.8	83.1	56.0
RA	324.4	26.1	39.8
UB	315.5	73.2	37.7
UA	312.8	59.4	37.1
UC	312.3	49.2	37.0
UD	203.3	30.4	11.5
$\bar{X}$	368.03		
SD	85.49		

C — Sustainability (% Ammo Remaining)

Mix	$\bar{X}$ % Remaining	SD	Standard Score z'
CA	72.2	5.2	85.0
CB	69.9	3.5	81.4
SB	52.8	6.0	56.4
SA	51.1	8.2	52.7
UA	47.5	6.7	47.3
UB	45.2	11.9	43.8
UD	43.4	10.3	41.0
SC	41.3	8.3	37.8
RA	39.2	2.9	34.6
UC	30.3	9.5	21.0
$\bar{X}$	49.29		
SD	13.10		

COLLATERAL PERFORMANCE MEA

D — Number of Targets Hit

Mix	$\bar{X}$ Targets Hit	SD	Standard Score z'
UB	5.1	1.8	79.3
SB	4.7	2.0	69.5
SA	4.4	0.8	62.4
CB	4.2	2.5	57.6
UA	4.0	1.1	53.8
SC	4.0	2.1	53.6
RA	3.1	1.7	31.9
CA	3.0	2.0	29.8
UD	2.9	1.4	27.4
UC	2.9	2.0	26.7
$\bar{X}$	3.86		
SD	.04		

E — Total Hits

Mix	$\bar{X}$ Hits
SB	5.2
UB	5.1
SA	4.5
CB	4.5
SC	4.4
UA	4.1
RA	3.1
UC	3.1
CA	3.0
UD	2.9
$\bar{X}$	3.98
SD	.887

F — Target Effects

Mix	Standard Score Target Effects
SB	70.05
SA	68.95
SC	65.20
UB	59.75
CB	57.95
CA	47.10
UA	42.15
RA	35.65
UD	28.15
UC	25.95

G — Overall Effectiveness

Mix	Overall Fire Effectiveness
CB	65.77
SB	65.50
SA	63.53
CA	59.73
SC	56.17
UB	54.43
UA	43.87
RA	35.30
UD	32.43
UC	24.30

H — Cumulative Exposure Time

	UB	SB	SA	CB	SC	UA	UD	CA	RA	UC
UB		.39	.26	.22	.19	.12	.13	,.08	.05	.04
SB			.32	.29	.22	.12	.14	.07	.04	.04
SA				.38	.29	.16	.20	.09	.02	.05
CB					>.40	.35	.34	.24	.16	.11
SC						>.40	>.40	.34	.25	.17
UA							>.40	.33	.17	.14
UD								>.40	.28	.18
CA									.35	.21
RA										.29

I — Number of Near Misses

	SC	SA	SB	CB	CA	RA	UB	U.
SC		.30	.18	.09	.06	.005	.005	.(
SA			.27	.11	.06	.002	.003	.(
SB				.29	.19	.02	.02	.'
CB					.38	.04	.04	.'
CA						.06	.06	.'
RA							>.40	.
UB								>.
UA								
UC								

J — Sustainability (% Ammo Remaining)

	CA	CB	SB	SA	UA	UB	UD	SC	RA	UC
CA		.19	.000	.000	.000	.000	.000	.000	.001	.000
CB			.000	.000	.000	.000	.000	.000	.001	.000
SB				.35	.09	.10	.04	.02	.001	.000
SA					.21	.17	.09	.04	.009	.002
UA						.35	.22	.10	.02	.?04
UB							.39	.28	.15	.02
UD								.36	.20	.02
SC									.31	.04
RA										.04

K — No. of Targets Hit

	UB	SB	SA	CB	UA	SC	RA	CA	UD	UC
UB		.36	.20	.25	.13	.19	.05	.04	.02	.04
SB			.37	.36	.25	.30	.10	.09	.05	.08
SA				>.40	.27	.34	.06	.07	.02	.06
CB					>.40	>.40	.22	.20	.15	.18
UA						>.40	.15	.15	.08	.13
SC							.23	.22	.16	.19
RA								>.40	>.40	>.40
CA									>.40	>.40
UD										>.40

L — Total Hits on Targets

	SB	UB	SA	CB	SC	UA	RA	I
SB		>.40	.20	.34	.25	.09	.03	
UB			.26	.36	.28	.13	.04	
SA				>.40	>.40	.19	.04	
CB					>.40	.36	.19	
SC						.37	.16	
UA							.14	
RA								:
UC								
CA								

Note: Standard Scores computed from raw scores using scores to three decimal places.

UA - 9 M14 Rifles
UB - 7 M14 Rifles/2 M14E2 AR
UC - 5 M14 Rifles/2 M60 MG
UD - 9 M14E2 Rifles
CA - 9 Colt Rifles

CB - 7 Colt Rifles/2 Colt AR
SA - 9 Stoner Rifles
SB - 7 Stoner Rifles/2 Stoner AR
SC - 7 Stoner Rifles/2 Stoner MG
RA - 9 AK47 Rifles

$\bar{X}$ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposu
z' - Standard Score (X =

COLLATERAL PERFORMANCE MEASURES

Number of Targets Hit

D

Mix	$\bar{X}$ Targets Hit	SD	Standard Score z'
UB	5.1	1.8	79.3
SB	4.7	2.0	69.5
SA	4.4	0.8	62.4
CB	4.2	2.5	57.6
UA	4.0	1.1	53.8
SC	4.0	2.1	53.6
RA	3.1	1.7	31.9
CA	3.0	2.0	29.8
UD	2.9	1.4	27.4
UC	2.9	2.0	26.7
$\bar{X}$	3.86		
SD	.84		

Total Hits on Targets

E

Mix	$\bar{X}$ Hits	SD	Standard Score z'
SB	5.2	2.1	76.5
UB	5.1	1.8	75.1
SA	4.5	0.8	62.7
CB	4.5	3.2	62.3
SC	4.4	2.1	58.9
UA	4.1	1.1	51.0
RA	3.1	1.5	30.2
UC	3.1	2.0	29.1
CA	3.0	2.0	28.2
UD	2.9	1.4	26.0
$\bar{X}$	3.98		
SD	.887		

Number of Near Misses

I

UC		SC	SA	SB	CB	CA	RA	UB	UA	UC	UD
.04	SC		.30	.18	.09	.06	.005	.005	.004	.004	.001
.04	SA			.27	.11	.06	.002	.003	.002	.001	.001
.05	SB				.29	.19	.02	.02	.01	.009	.001
.11	CB					.38	.04	.04	.03	.02	.001
.17	CA						.06	.06	.04	.04	.001
.14	RA							>.40	.35	.32	.001
.18	UB								>.40	>.40	.004
.21	UA									>.40	.002
.29	UC										.001

Total Hits on Targets

L

UC		SB	UB	SA	CB	SC	UA	RA	UC	CA	UD
.04	SB		>.40	.20	.34	.25	.09	.03	.04	.03	.02
.08	UB			.26	.36	.28	.13	.04	.05	.04	.02
.06	SA				>.40	>.40	.19	.04	.06	.05	.02
.18	CB					>.40	.36	.19	.18	.18	.14
.13	SC						.37	.16	.16	.15	.10
.19	UA							.14	.16	.15	.08
.40	RA								>.40	>.40	>.40
.40	UC									>.40	>.40
.40	CA										>.40

: Colt AR
/2 Stoner AR
/2 Stoner MG

$\bar{X}$ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposure Time
z' - Standard Score ($\bar{X}$ = 50, SD = 20)

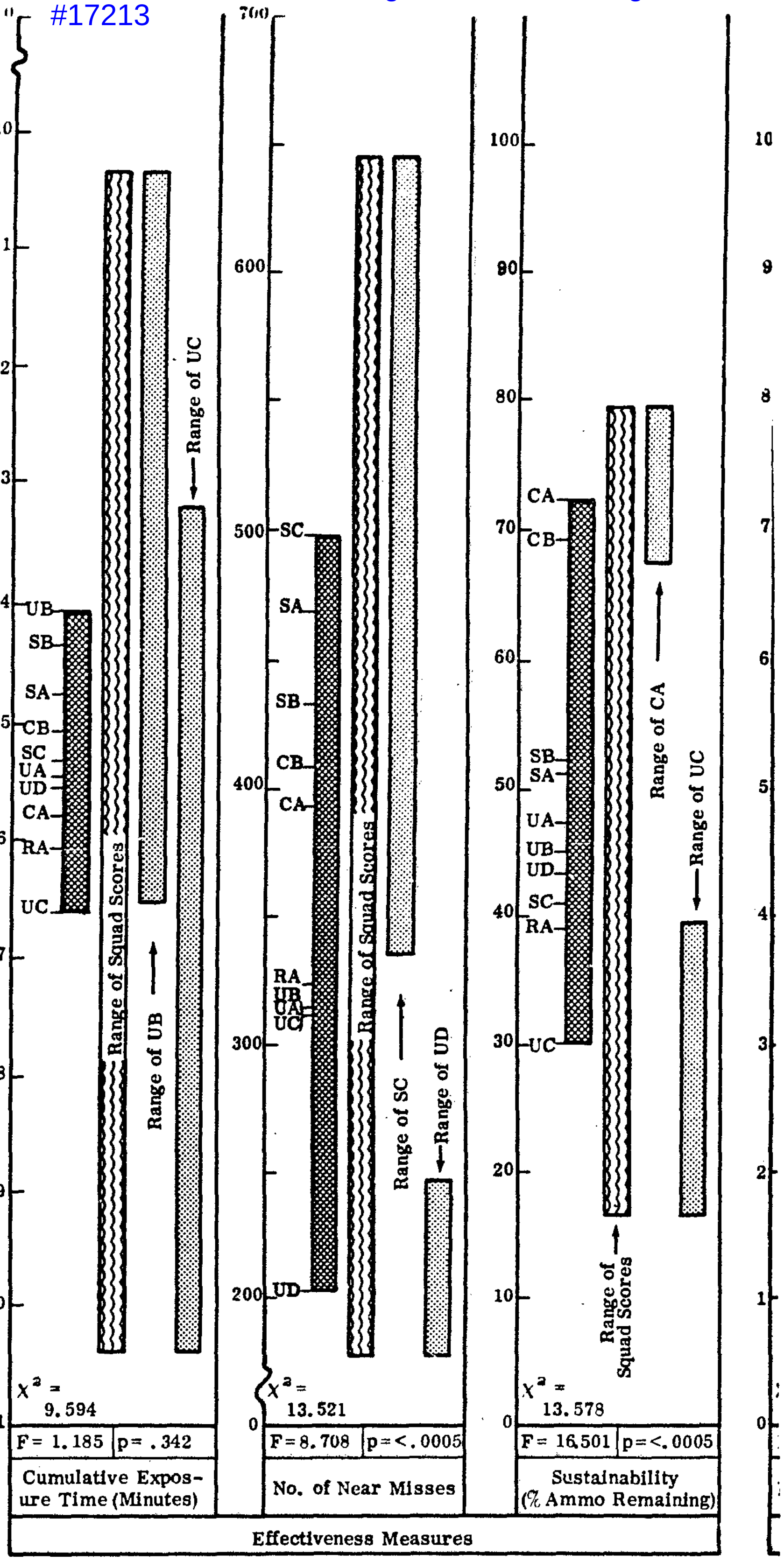


Figure 6-1 SUMMARY OF RESULTS--

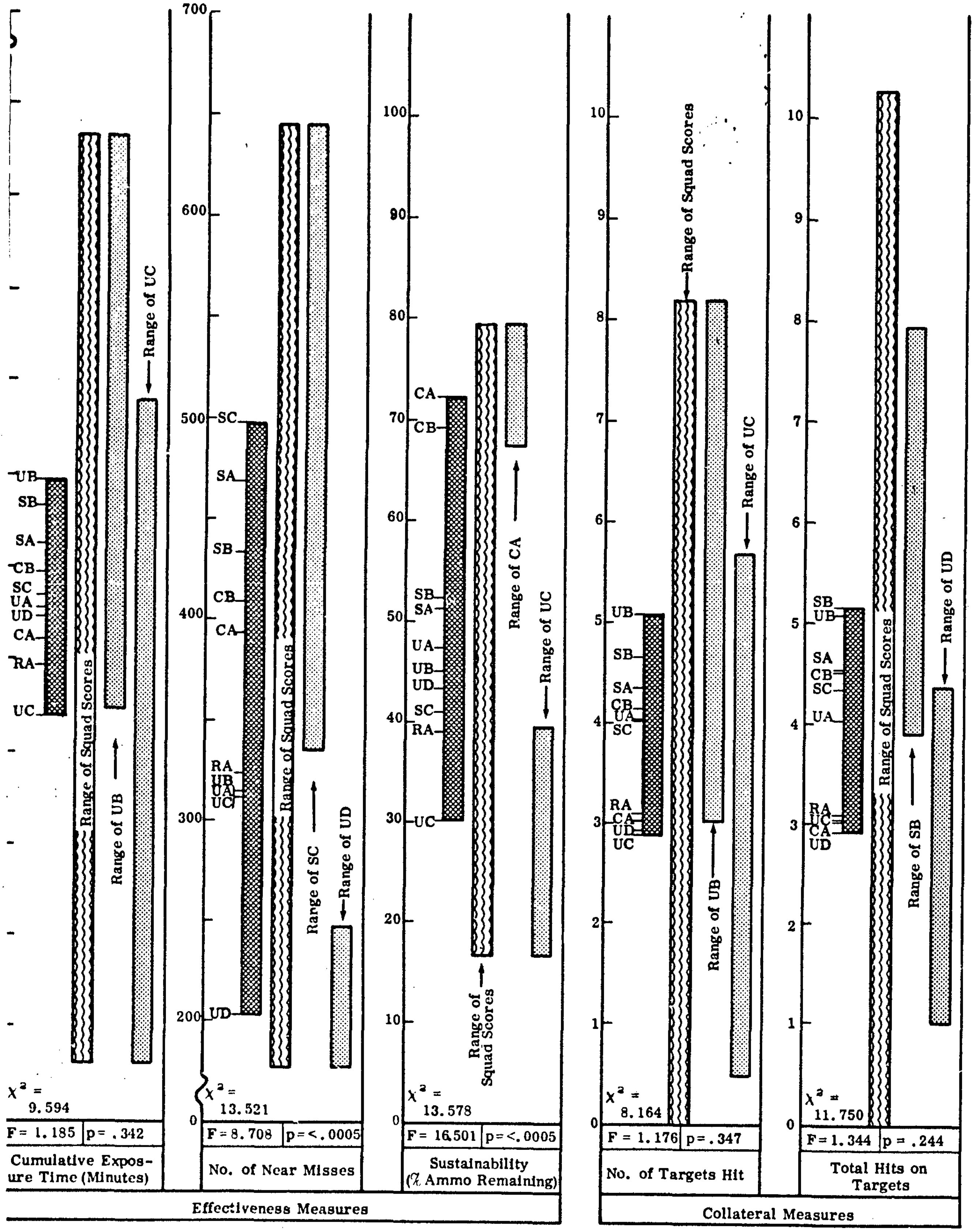


Figure 6-1 SUMMARY OF RESULTS--SITUATION 1

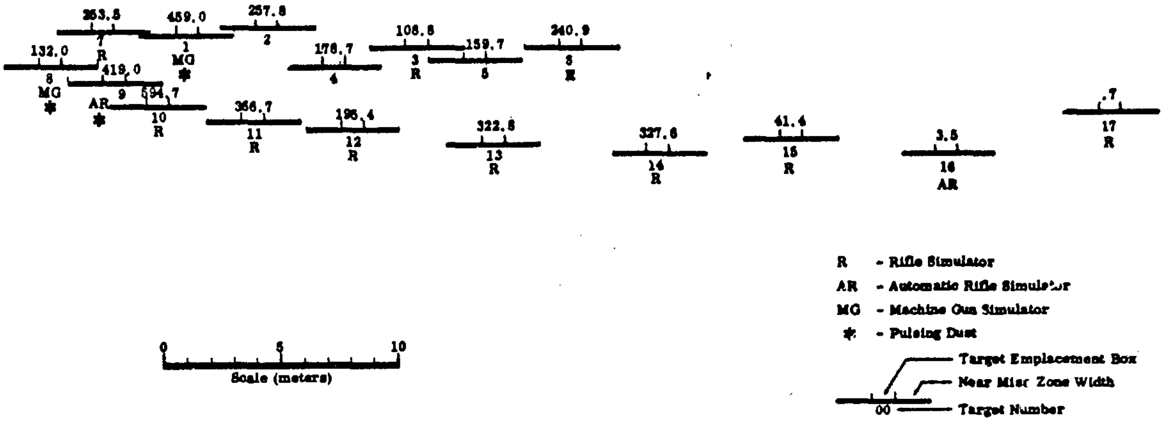


Figure 6-2

VERTICAL PROFILE--SITUATION 1

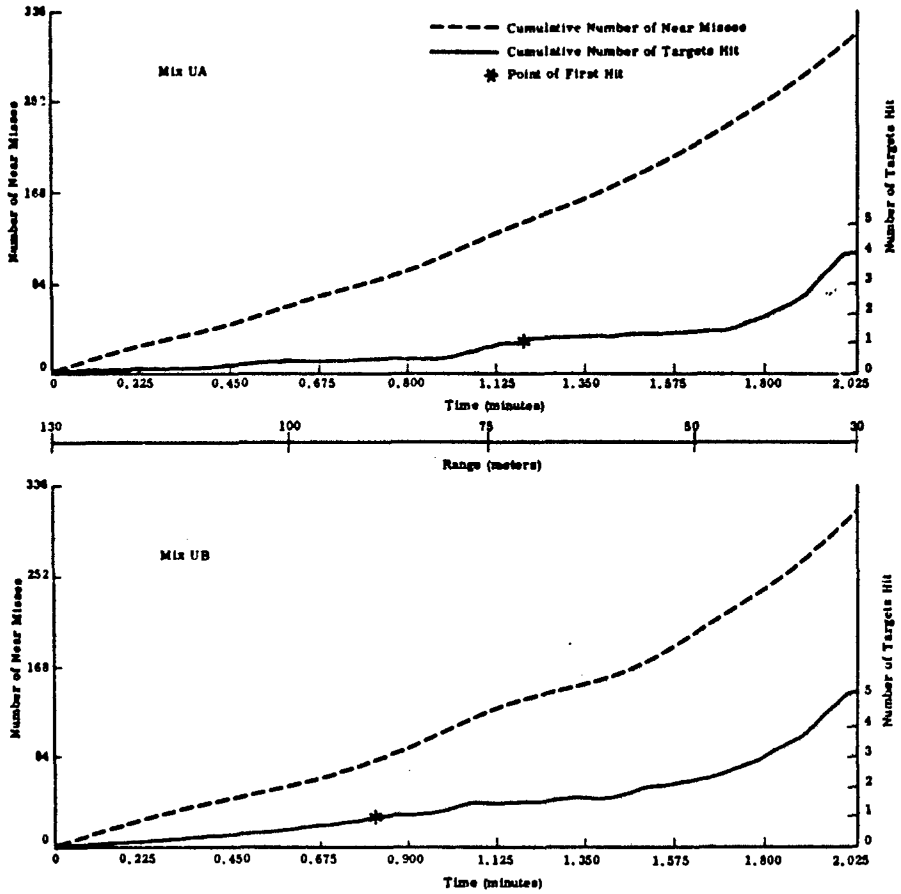


Figure 6-3 CUMULATIVE NUMBER OF NEAR MISSES AND TARGETS HIT--SITUATION 1

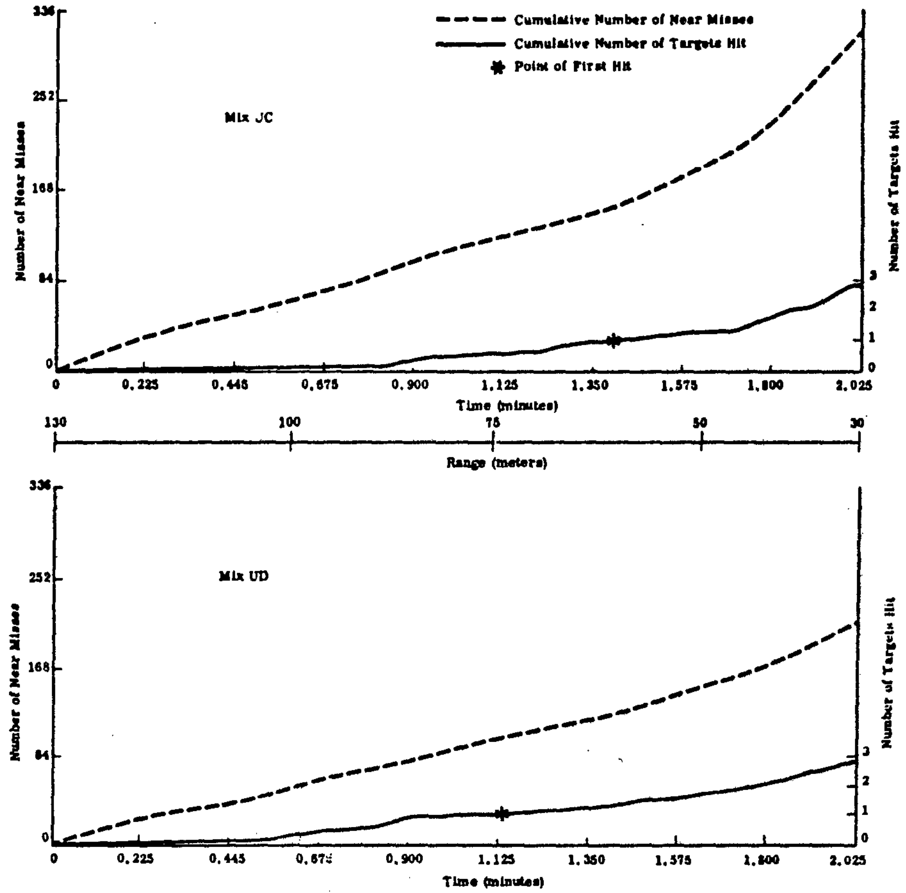


Figure 6-3 (Continued) CUMULATIVE NUMBER OF NEAR MISSES AND TARGETS HIT--SITUATION 1

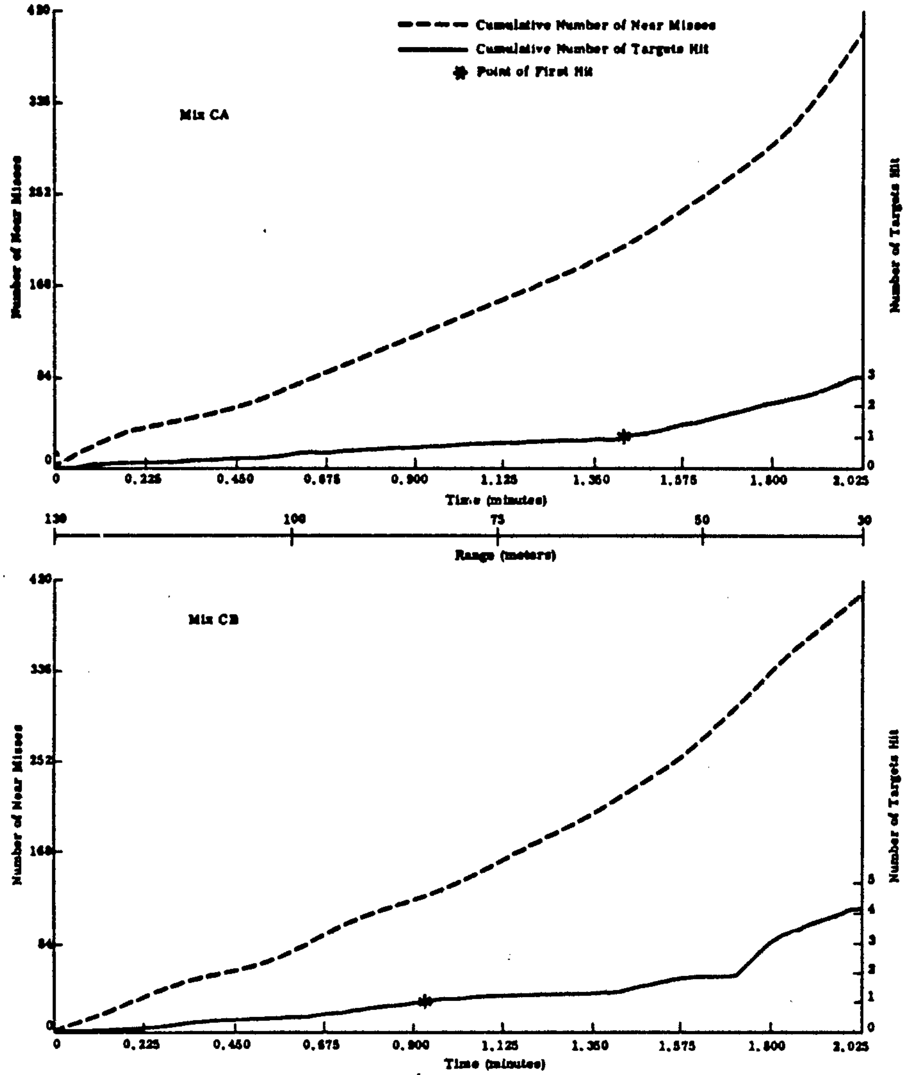


Figure 6-3 (Continued) CUMULATIVE NUMBER OF NEAR MISSES AND TARGETS HIT--SITUATION 1

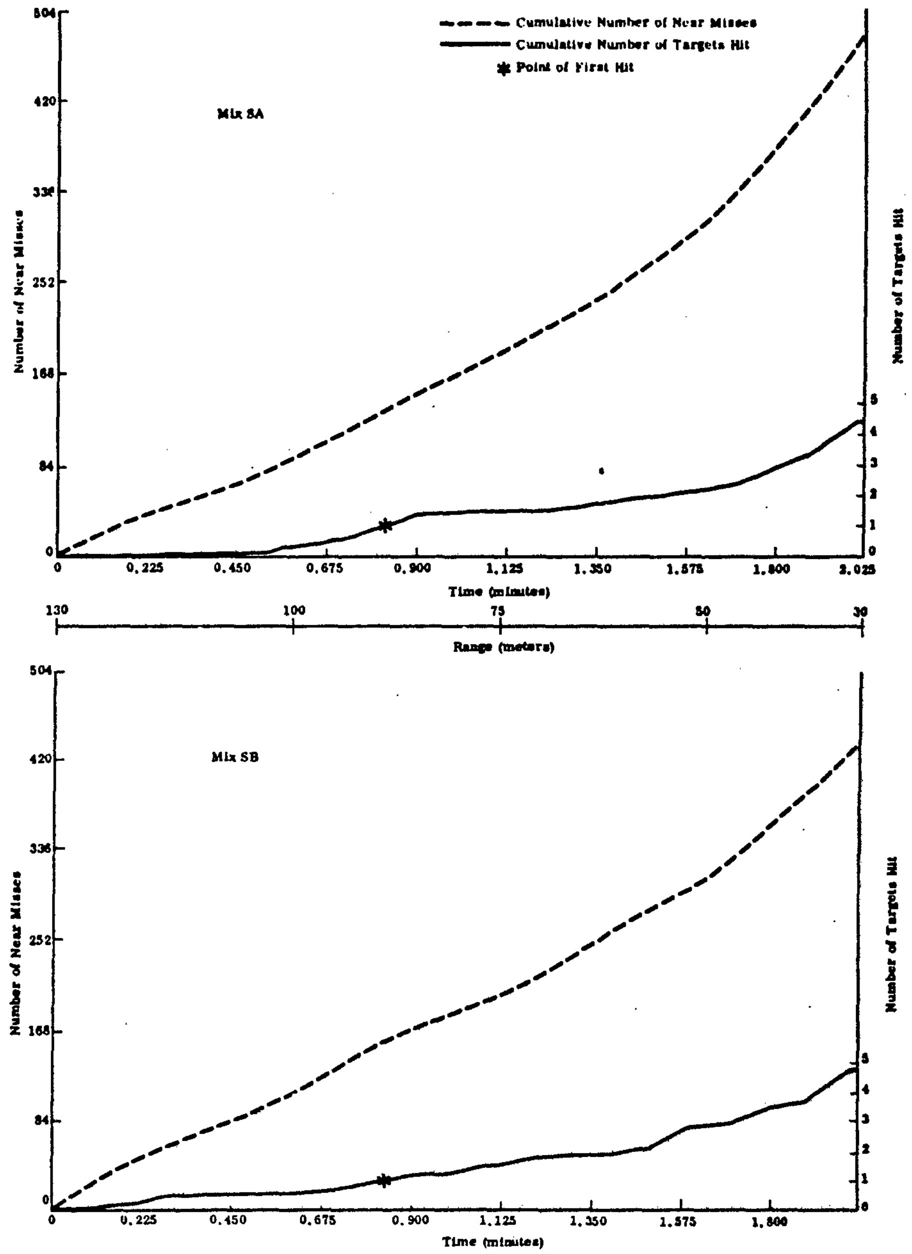


Figure 6-3 (Continued) CUMULATIVE NUMBER OF NEAR MISSES AND TARGETS HIT--SITUATION 1

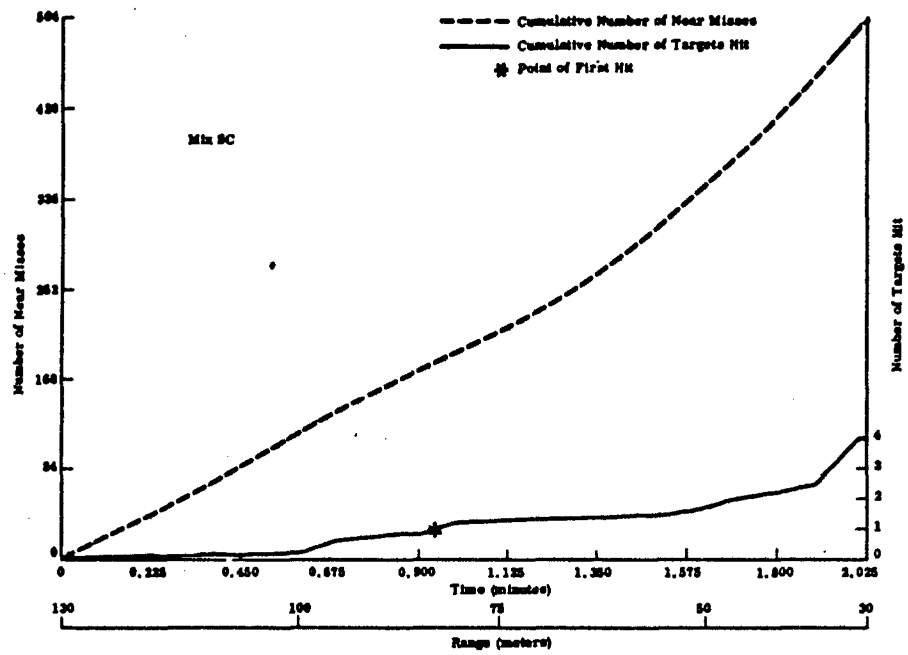


Figure 6-3 (Continued) CUMULATIVE NUMBER OF NEAR MISSES AND TARGETS HIT--SITUATION 1

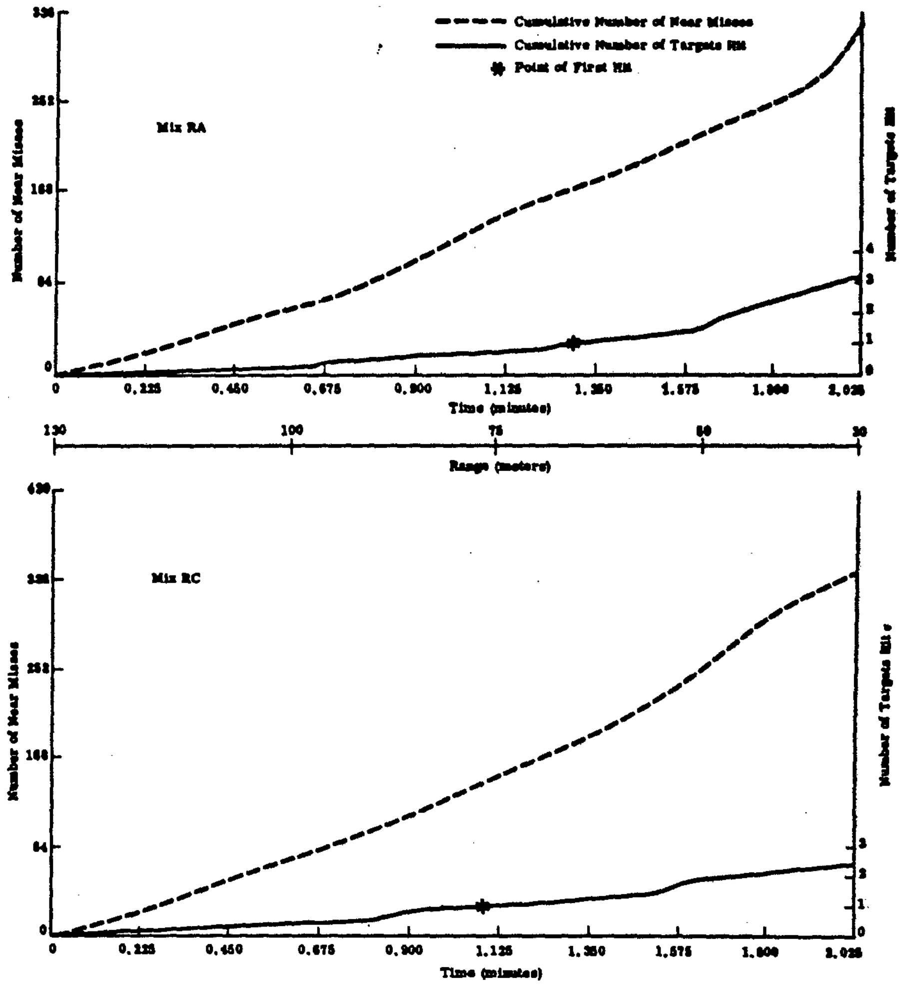


Figure 6-3 (Concluded) CUMULATIVE NUMBER OF NEAR MISSES AND TARGETS HIT--SITUATION 1

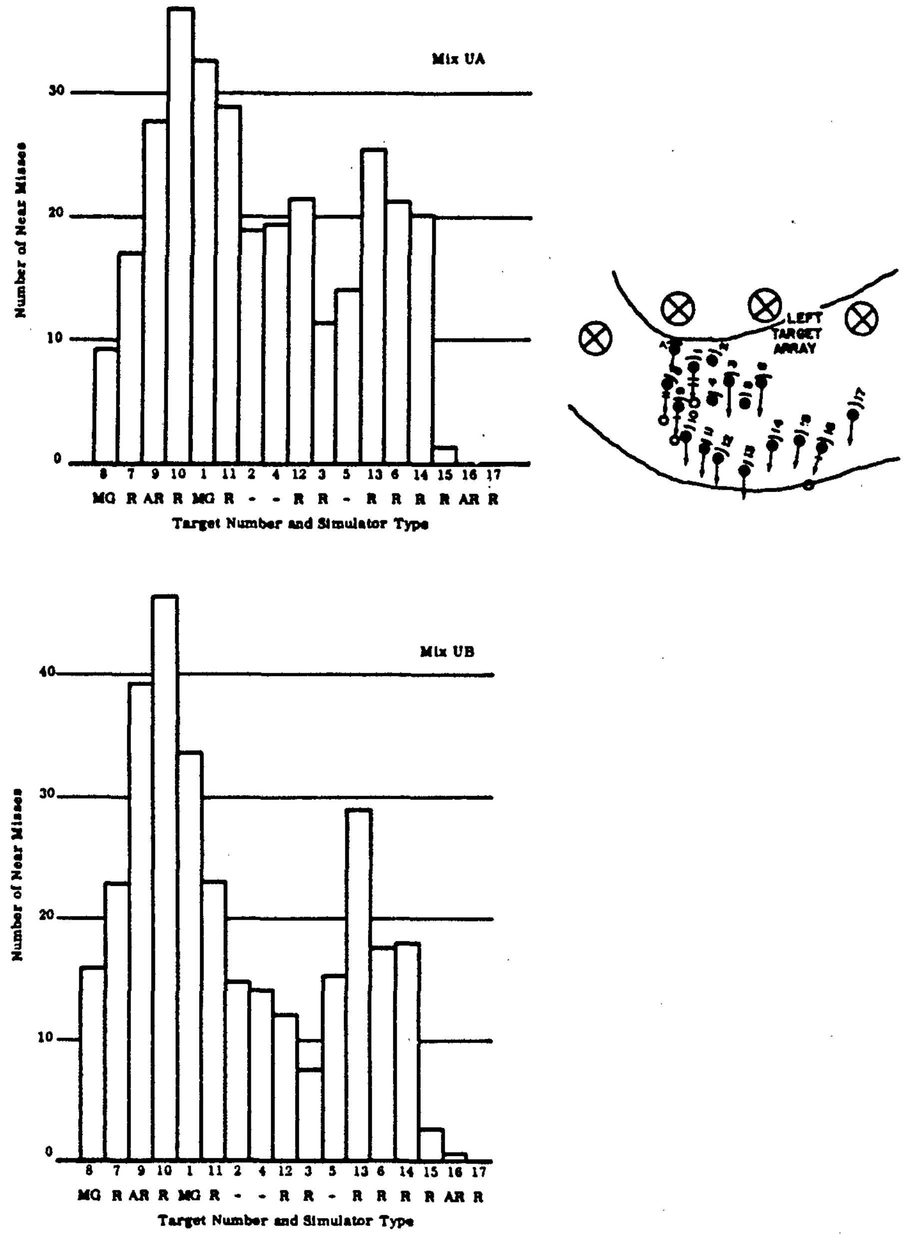
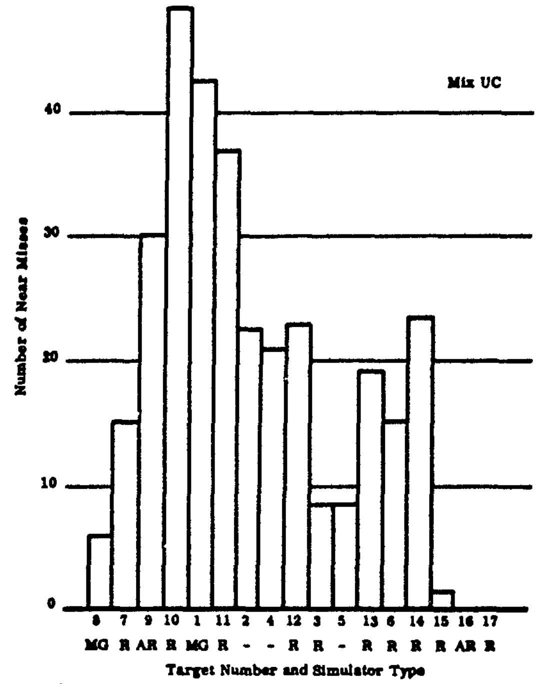


Figure 6-4 NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 1



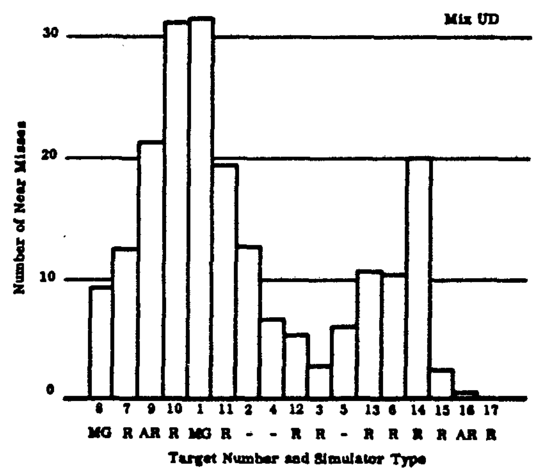


Figure 6-4 (Continued) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 1

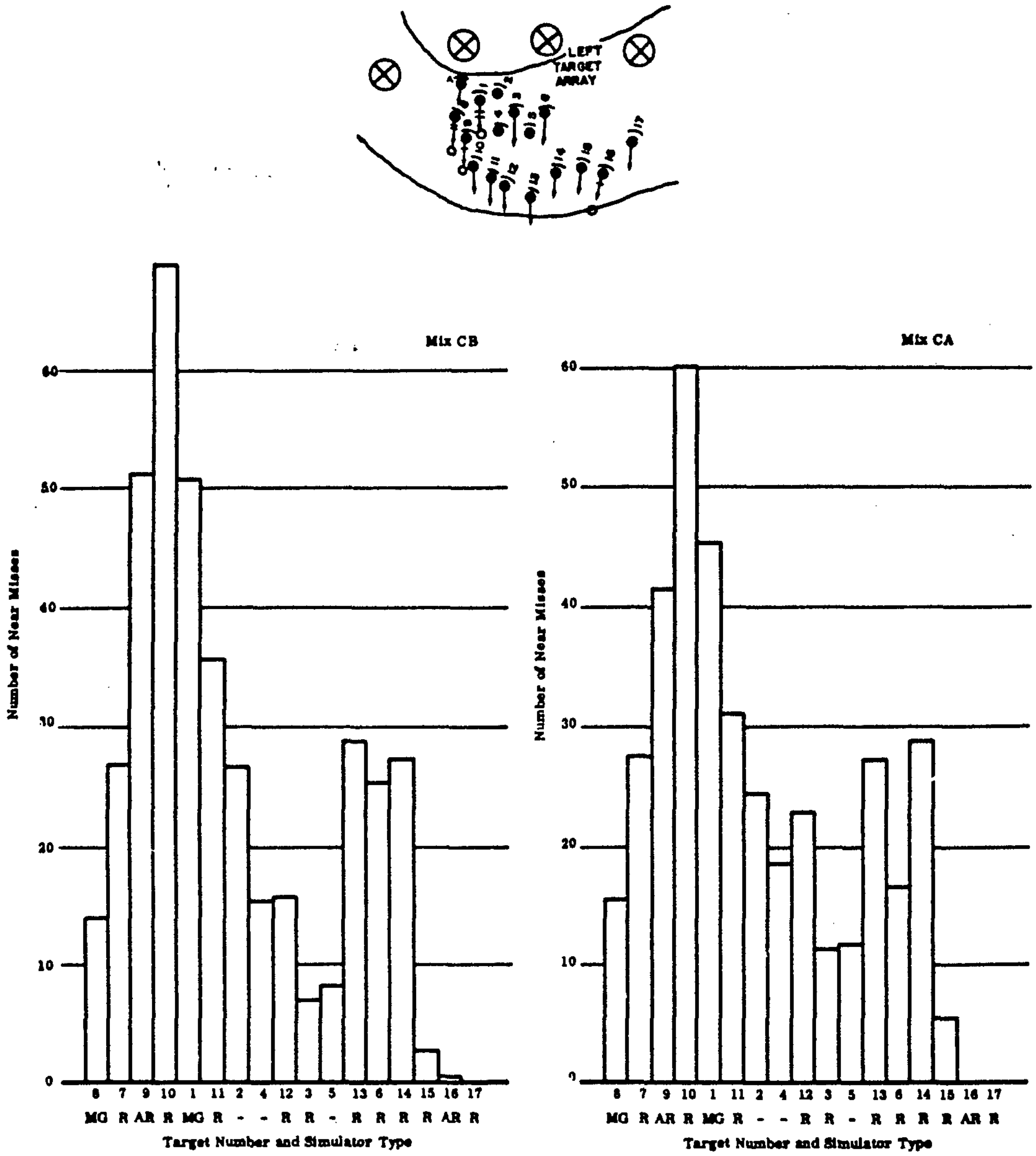


Figure 6-4 (Continued) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 1

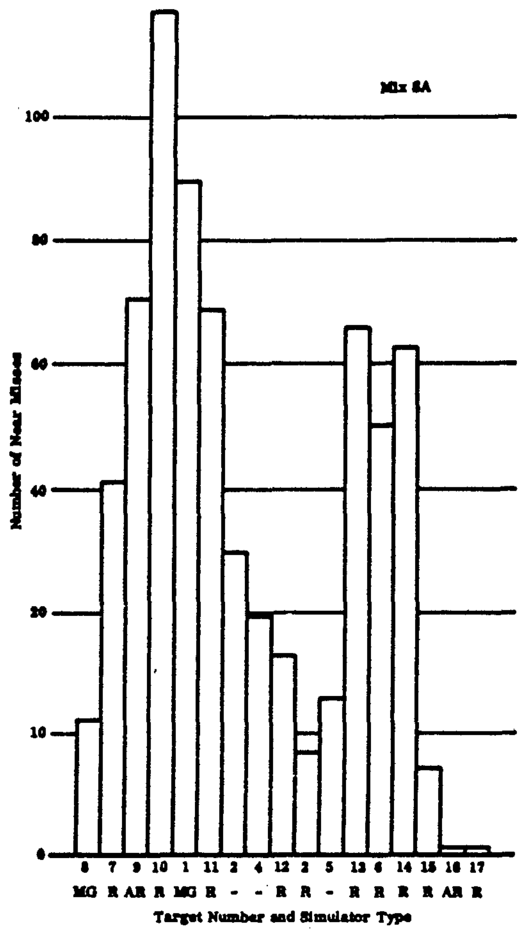


Figure 6–4 (Continued) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 1

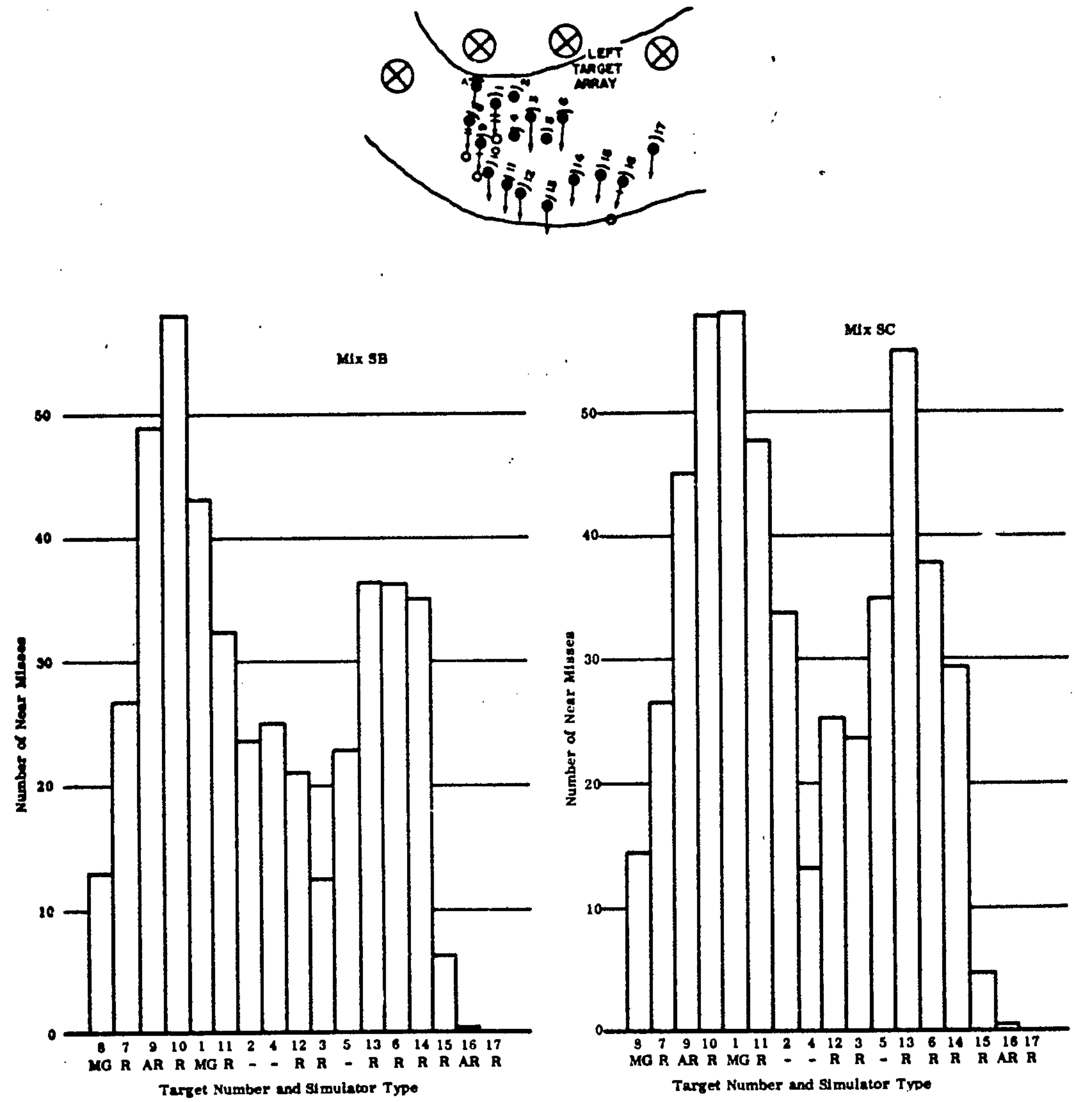


Figure 6-4 (Continued) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 1

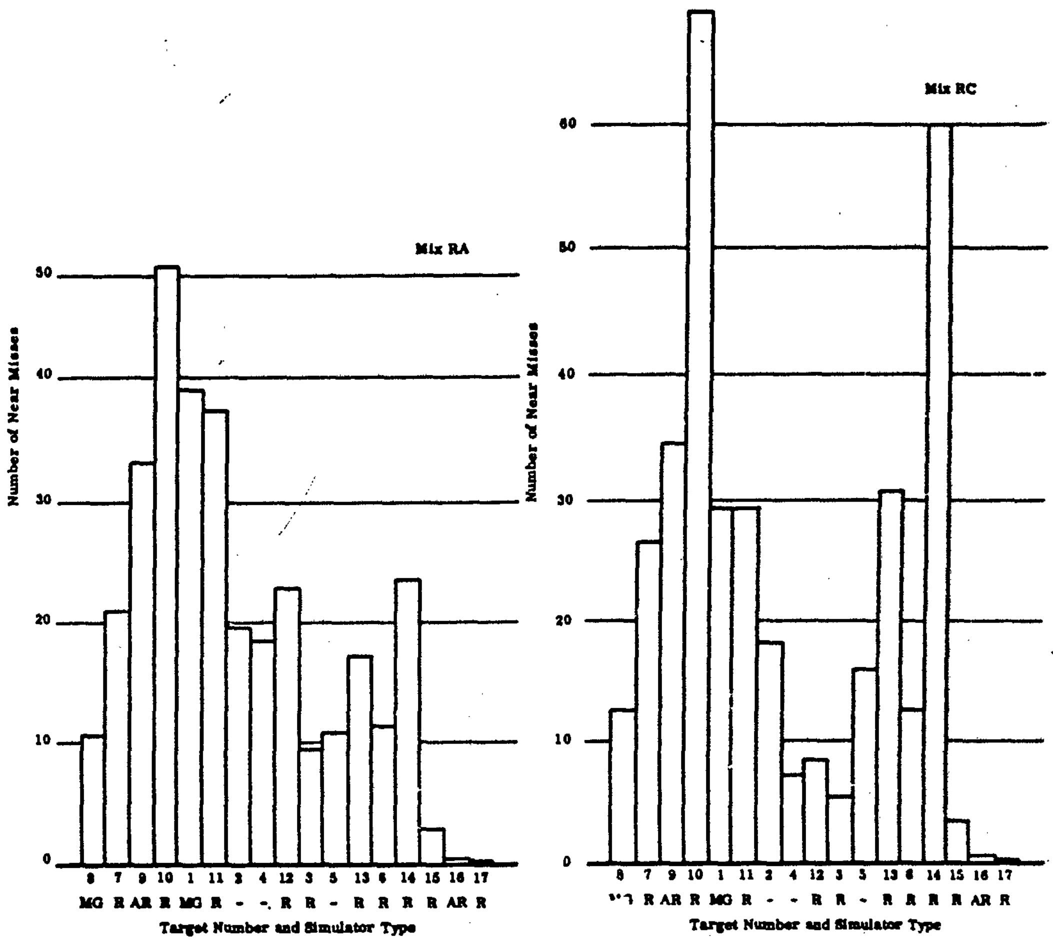


Figure 6-4 (Concluded) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 1

2. Situation 2: Rifle Squad as Base of Fire Supporting the Assault

This situation evaluated rifle squad weapon mixes firing supporting fire from hastily prepared foxholes. Range from the foxholes to enemy targets was from 269 to 326 meters. There were 30 concealed or partially concealed enemy targets occupying a position 100 meters wide and 35 meters deep. The duration of fire was 4 minutes. For the first 2 minutes, fire was directed at the left 50 meters of the enemy array (the 17 targets used in Situation 1 Assault). Fire was then shifted 50 meters to the right, to an area containing 13 targets. The technique of fire provided area fire distributed throughout the sector with point fire employed when a target was seen, or when weapon simulators gave detected cues to a particular target location.

Results for Situation are tabulated and presented graphically in Figure 6-5.

Vertical profiles of the target arrays appear in Figure 6-6, showing positions and relative differences in elevation as seen from the support positions. The average number of near misses for all rifle mixes (not including special weapons mixes or duplex) is given by the number over each target. Also indicated are the simulator cues associated with each target and the total width of the 2-meter radius semicircular zone in which near misses were sensed.

Figure 6-7 illustrates the cumulative number of near misses for each array, the percent of ammunition remaining, targets hit, and ammunition used as a function of time. For Mix RC, only cumulative number of hits is presented. Figure 6-8 shows the number of near misses and their distributions as a function of target location and array. Target locations are provided for purpose of comparison in insert maps.

The rank order of the ten weapons mixes with associated standard scores is presented below.

Target Effects Only			Overall Effectiveness*		
Rank	Mix	Standard Score	Rank	Mix	Standard Score
1	CA	68.2	1	CA	73.6
2	SC	60.1	2	CB	62.6
3	UB	59.9	3	UA	55.4
4	UA	58.9	4	SC	54.8
5	CB	57.0	5	UB	51.2
6	UD	56.9	6	UD	48.2
7	SB	47.1	7	SA	46.5
8	UC	43.5	8	SB	45.5
9	SA	36.5	9	UC	36.4
10	RA	11.6	10	RA	29.8

* Sustainability weighted 1/3; Target effects 2/3

Key:

UA - 9 M14 Rifles

UD - 9 M14E2 Rifles

UB - 7M14 Rifles and 2 M14E2 AR

UC - 5M14 Rifles and 2 M60 MG

SA - 9 Stoner Rifles

SB - 7 Stoner Rifles and 2 Stoner AR

SC - 7 Stoner Rifles and 2 Stoner MG

CA - 9 Colt Rifles

CB - 7 Colt Rifles and 2 Colt AR

RA - 9 AK47 Rifles

Mix RC results for Situation 2 are presented below.

Mix	CET	Percent Ammo Remaining	Near Misses	Targets Hit	Total Hits
RC	80.70	0	354.80	10.00	10.4

EFFECTIVENESS MEASURES

COLLATERAL PERFORMANCE

A Cumulative Exposure Times

Mix	$\overline{X}$ CET	SD	Standard Score z'
UA	77.5	2.3	77.1
CA	78.2	10.0	71.2
UD	78.6	8.3	68.3
UB	80.0	6.6	59.0
SC	80.4	9.4	53.8
SB	81.0	10.1	48.9
SA	82.0	9.1	41.4
CB	82.1	4.6	40.4
UC	84.2	7.2	23.6
RA	85.1	10.9	16.6
$\overline{X}$	80.9		
SD	2.52		

B Number of Near Misses

Mix	$\overline{X}$ Near Misses	SD	Standard Score z'
CB	345	57.9	73.6
SC	326	76.3	66.4
CA	323	90.7	65.2
UC	318	34.4	63.4
UB	312	46.7	60.8
UD	272	52.3	45.6
SB	271	72.1	45.2
UA	259	36.1	40.6
SA	236	61.3	31.8
RA	173	22.0	6.6
$\overline{X}$	283.7		
SD	52.18		

C Sustainability (% Ammo Remaining)

Mix	$\overline{X}$ % Remaining	SD	Standard Score z'	Sustainability Time (Min)
CA	50.5	9.2	84.4	8.1
CB	42.2	1.6	73.9	6.9
RA	36.0	6.1	66.1	6.3
SA	28.5	4.3	56.7	5.6
UA	22.0	6.7	48.5	5.1
SB	17.2	6.8	42.5	4.8
SC	16.2	8.5	41.2	4.8
UB	10.3	5.6	33.8	4.5
UD	7.8	6.7	30.6	4.3
UC	1.2	1.5	22.3	4.1
$\overline{X}$	23.8			
SD	15.9			

D Number of Targets Hit

Mix	$\overline{X}$ Targets Hit	SD	Standard Score z'
UA	10.7	1.7	82.2
CA	10.1	3.5	69.8
UB	10.0	1.6	67.8
SB	9.4	2.9	55.4
SC	9.1	3.2	49.2
SA	8.9	2.4	44.5
UD	8.8	3.2	43.0
CB	8.6	2.4	38.8
UC	8.5	2.9	36.8
RA	7.3	3.9	12.0
$\overline{X}$	9.14		
SD	.97		

E Tot

Mix
UA
UB
CA
SB
SA
UD
SC
UC
CB
RA
$\overline{X}$
SD

F Target Effects

Mix	Standard Score Target Effects
CA	68.2
SC	60.1
UB	59.9
UA	58.9
CB	57.0
UD	56.9
SB	47.1
UC	43.5
SA	36.5
RA	11.6

G Overall Effectiveness

Mix	Overall Fire Effectiveness
CA	73.6
CB	62.6
UA	55.4
SC	54.8
UB	51.2
UD	48.2
SA	46.5
SB	45.5
UC	36.4
RA	29.8

H Cumulative Exposure Times

	UA	CA	UD	UB	SC	SB	SA	CB	UC	RA
UA		>.40	.38	.22	.24	.21	.14	.03	.03	.07
CA			>.40	.38	.35	.32	.26	.20	.13	.15
UD				>.40	.37	.33	.26	.19	.12	.15
UB					>.40	>.40	.32	.24	.15	.17
SC						>.40	.39	.35	.23	.23
SB							>.40	>.40	.27	.27
SA								>.40	.32	.31
CB									.28	.28
UC										>.40

I Number of Near Mi

	CB	SC	CA	UC	UB	UD
CB		.35	.33	.25	.22	.06
SC			>.40	>.40	.35	.09
CA				>.40	.39	.11
UC					.39	.06
UB						.10
UD						>
SB						
UA						
SA						

J Sustainability (% Ammo Remaining)

	CA	CB	RA	SA	UA	SB	SC	UB	UD	UC
CA		.03	.01	.001	.001	.001	.001	.001	.001	.001
CB			.02	.001	.001	.001	.001	.001	.001	.001
RA				.02	.004	.001	.002	.001	.001	.001
SA					.04	.004	.005	.001	.001	.001
UA						.12	.11	.005	.003	.001
SB							>.40	.04	.02	.001
SC								.10	.05	.002
UB									.25	.003
UD										.02

K No. of Targets Hit

	UA	CA	UB	SB	SC	SA	UD	CB	UC	RA
UA		.35	.23	.18	.15	.08	.11	.05	.07	.04
CA			>.40	.36	.31	.25	.26	.20	.21	.12
UB				.34	.28	.20	.23	.14	.15	.08
SB					>.40	.37	.37	.30	.30	.16
SC						>.40	>.40	.39	.37	.21
SA							>.40	>.40	>.40	.21
UD								>.40	>.40	.24
CB									>.40	.25
UC										.28

L Total Hits on Ta

	UA	UB	CA	SB	SA	UD
UA		.11	.15	.11	.07	.10
UB			>.40	.39	.24	.31
CA				>.40	.34	.36
SB					>.40	>.40
SA						>.40
UD						
SC						
UC						
CB						

Note: Standard Scores computed from raw scores using scores to three decimal places.

UA - 9 M14 Rifles
UB - 7 M14 Rifles/2 M14E2 AR
UC - 5 M14 Rifles/2 M60 MG
UD - 9 M14E2 Rifles
CA - 9 Colt Rifles

CB - 7 Colt Rifles/2 Colt AR
SA - 9 Stoner Rifles
SB - 7 Stoner Rifles/2 Stoner AR
SC - 7 Stoner Rifles/2 Stoner MG
RA - 9 AK47 Rifles

$\overline{X}$ - Mean (Averaş
SD - Standard Dev
CET - Cumulative E
z' - Standard Scoı

COLLATERAL PERFORMANCE MEASURES

D — Number of Targets Hit

Mix	$\bar{X}$ Targets Hit	SD	Standard Score z'
UA	10.7	1.7	82.2
CA	10.1	3.5	69.8
UB	10.0	1.6	67.8
SB	9.4	2.9	55.4
SC	9.1	3.2	49.2
SA	8.9	2.4	44.5
UD	8.8	3.2	43.0
CB	8.6	2.4	38.8
UC	8.5	2.9	36.8
RA	7.3	3.9	12.0
$\bar{X}$	9.14		
SD	.97		

E — Total Hits on Targets

Mix	$\bar{X}$ Hits	SD	Standard Score z'
UA	12.6	4.0	93.9
UB	10.3	1.4	59.9
CA	10.2	3.3	58.4
SB	9.9	3.0	54.0
SA	9.6	2.0	49.6
UD	9.5	3.6	48.1
SC	9.1	3.2	42.2
UC	9.0	3.5	40.7
CB	8.8	2.3	37.7
RA	7.3	3.9	15.6
$\bar{X}$	9.63		
SD	1.35		

Number of Near Misses

I

		CB	SC	CA	UC	UB	UD	SB	UA	SA	RA
)7	CB		.35	.33	.25	.22	.06	.07	.02	.02	.002
15	SC			>.40	>.40	.35	.09	.12	.04	.02	.002
15	CA				>.40	.39	.11	.14	.05	.03	.003
17	UC					.39	.06	.09	.01	.01	.001
23	UB						.10	.14	.03	.02	.001
27	UD							>.40	.31	.15	.003
31	SB								.36	.19	.01
28	UA									.23	.001
10	SA										.03

Total Hits on Targets

L

		UA	UB	CA	SB	SA	UD	SC	UC	CB	RA
)4	UA		.11	.15	.11	.07	.10	.07	.07	.04	.03
.2	UB			>.40	.39	.24	.31	.21	.20	.10	.05
)8	CA				>.40	.34	.36	.28	.27	.20	.10
.6	SB					>.40	>.40	.33	.32	.24	.12
21	SA						>.40	.38	.37	.27	.12
21	UD							>.40	>.40	.35	.18
24	SC								>.40	>.40	.21
25	UC									>.40	.23
28	CB										.22

Colt AR

2 Stoner AR
2 Stoner MG

$\bar{X}$ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposure Time
z' - Standard Score (X = 50, SD = 20)

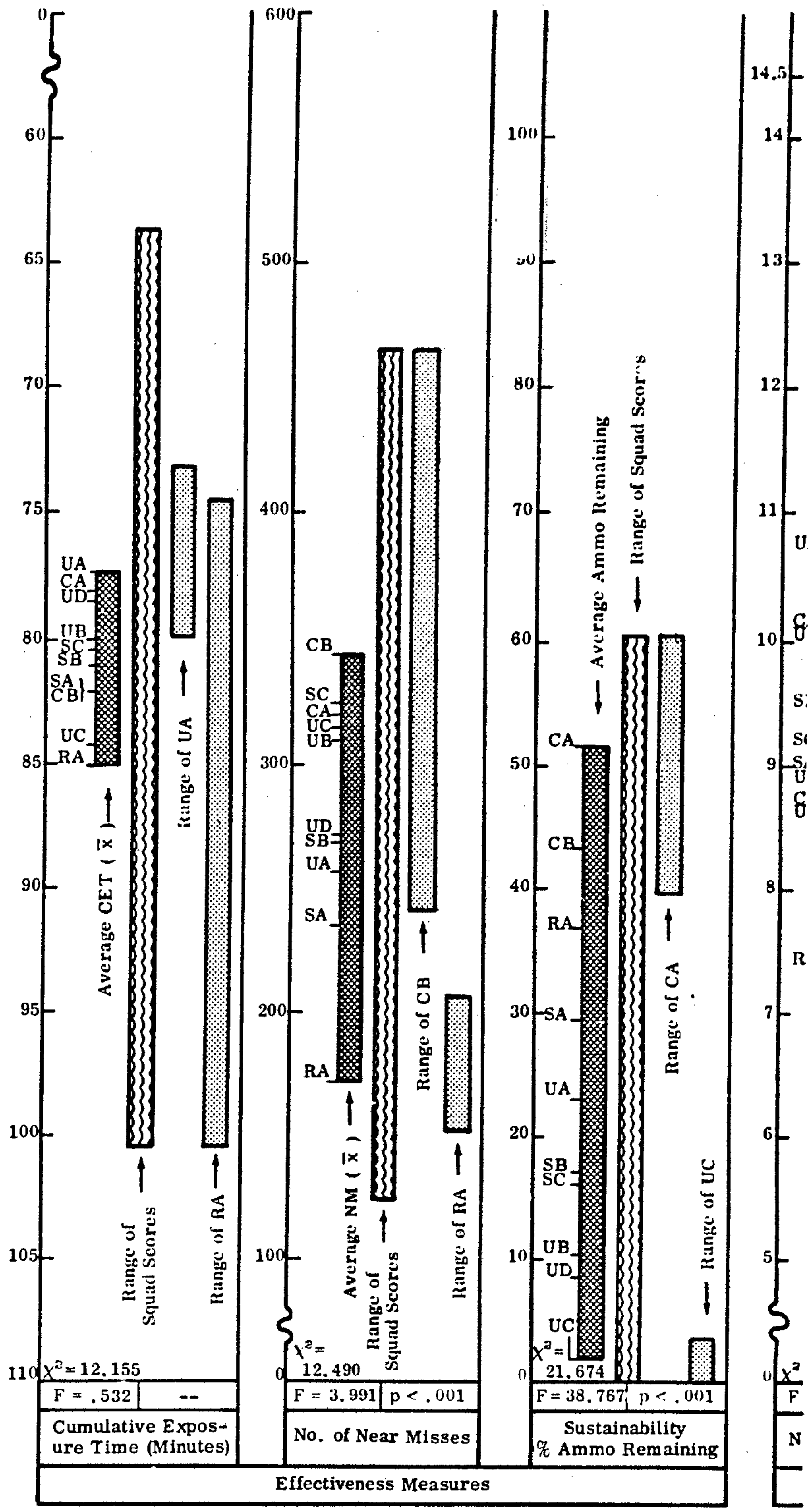


Figure 6-5 SUMMARY OF RESULTS--S

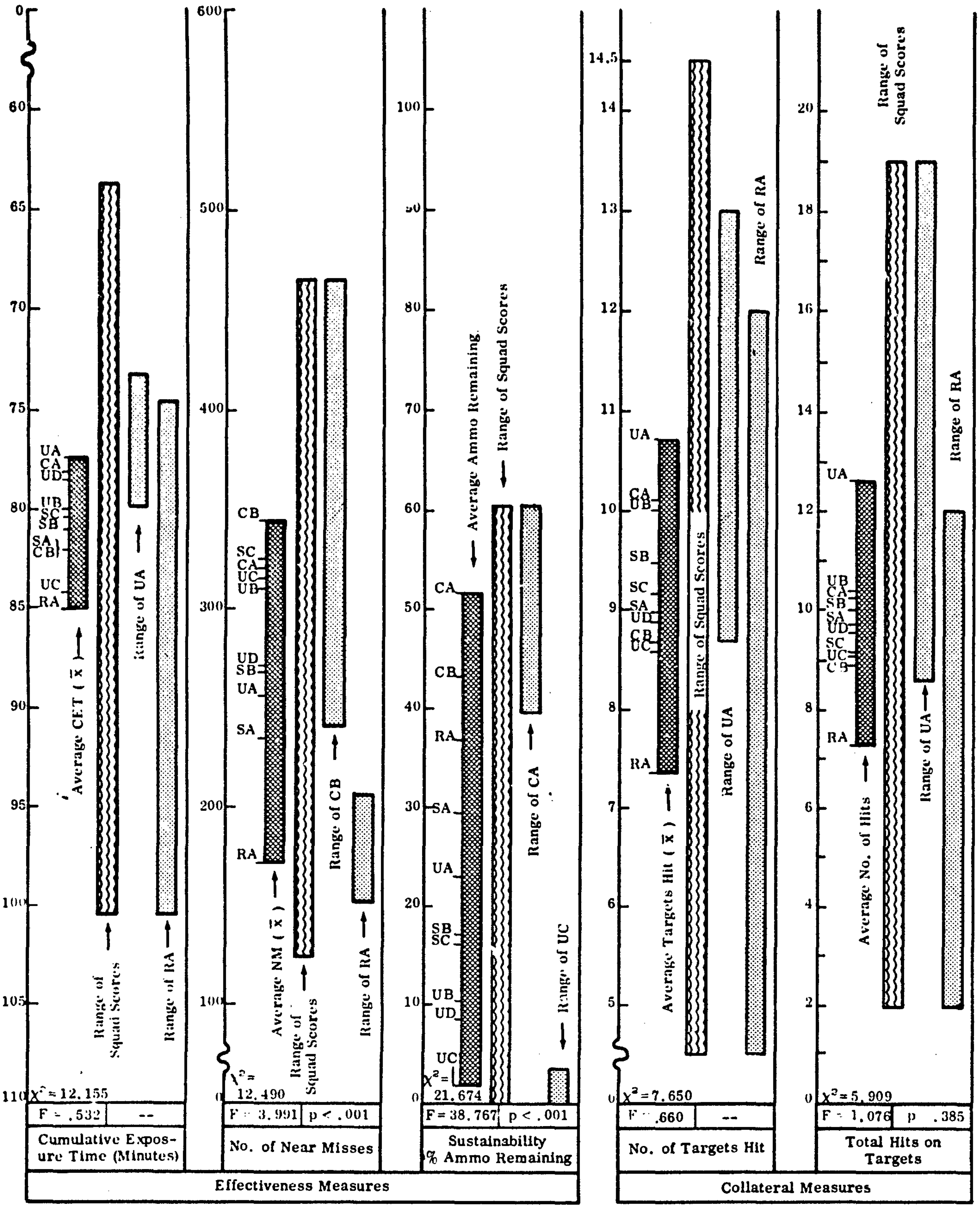
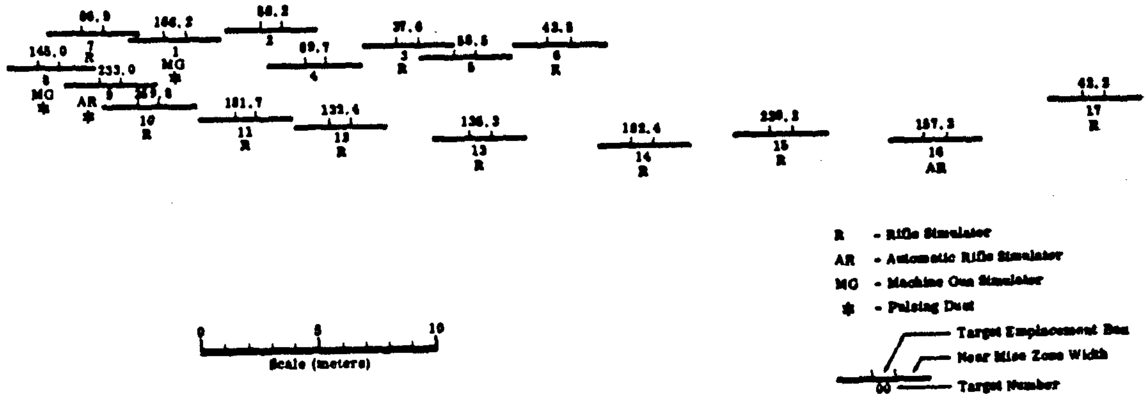
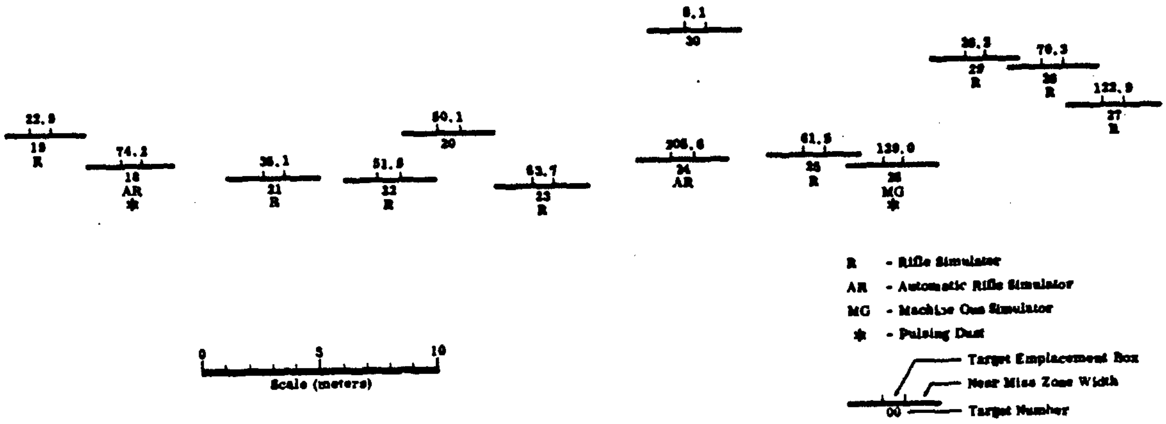


Figure 6-5 SUMMARY OF RESULTS--SITUATION 2



Left Array



Right Array

Figure 6-6 VERTICAL PROFILES--SITUATION 2

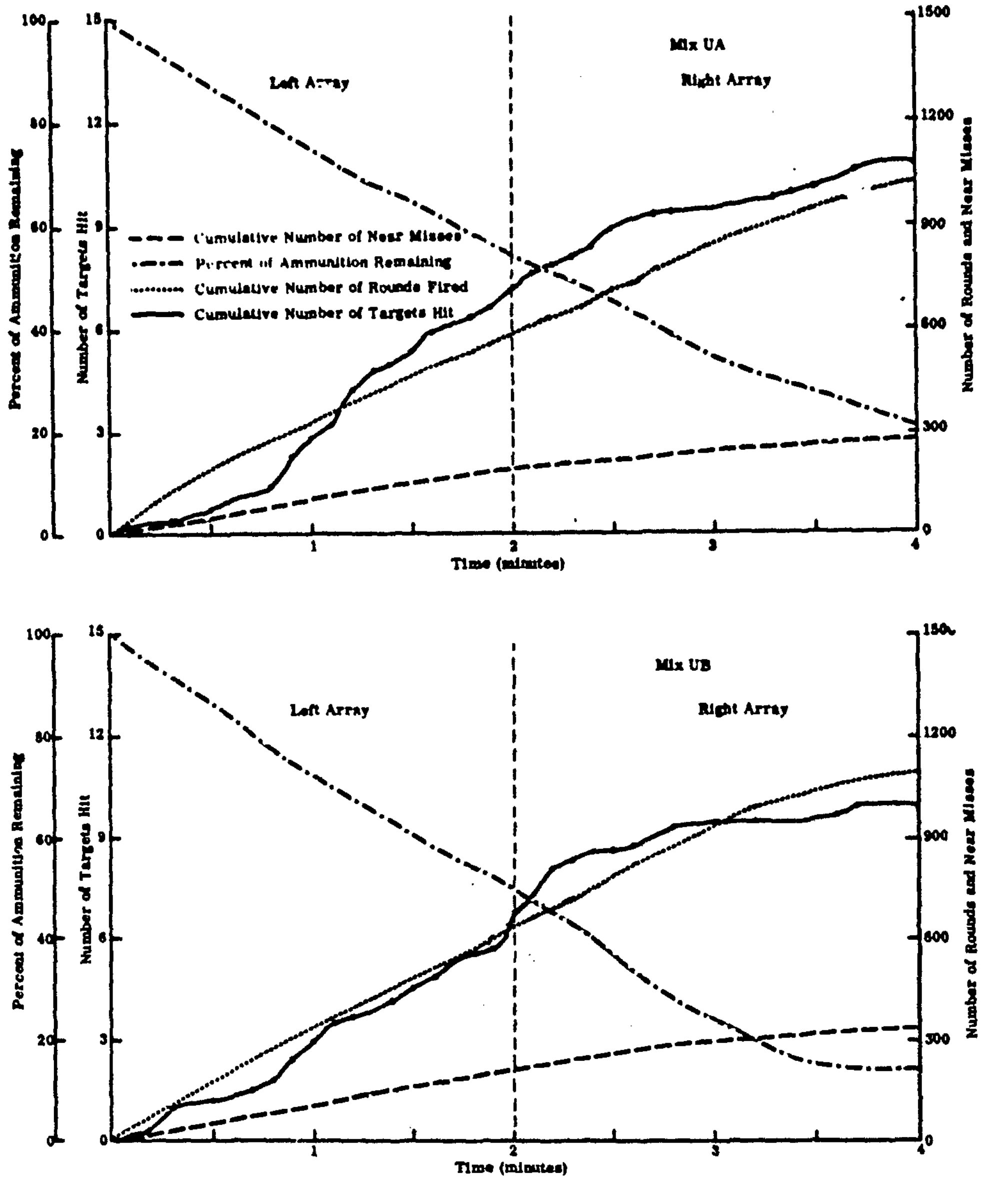


Figure 6-7 CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 2

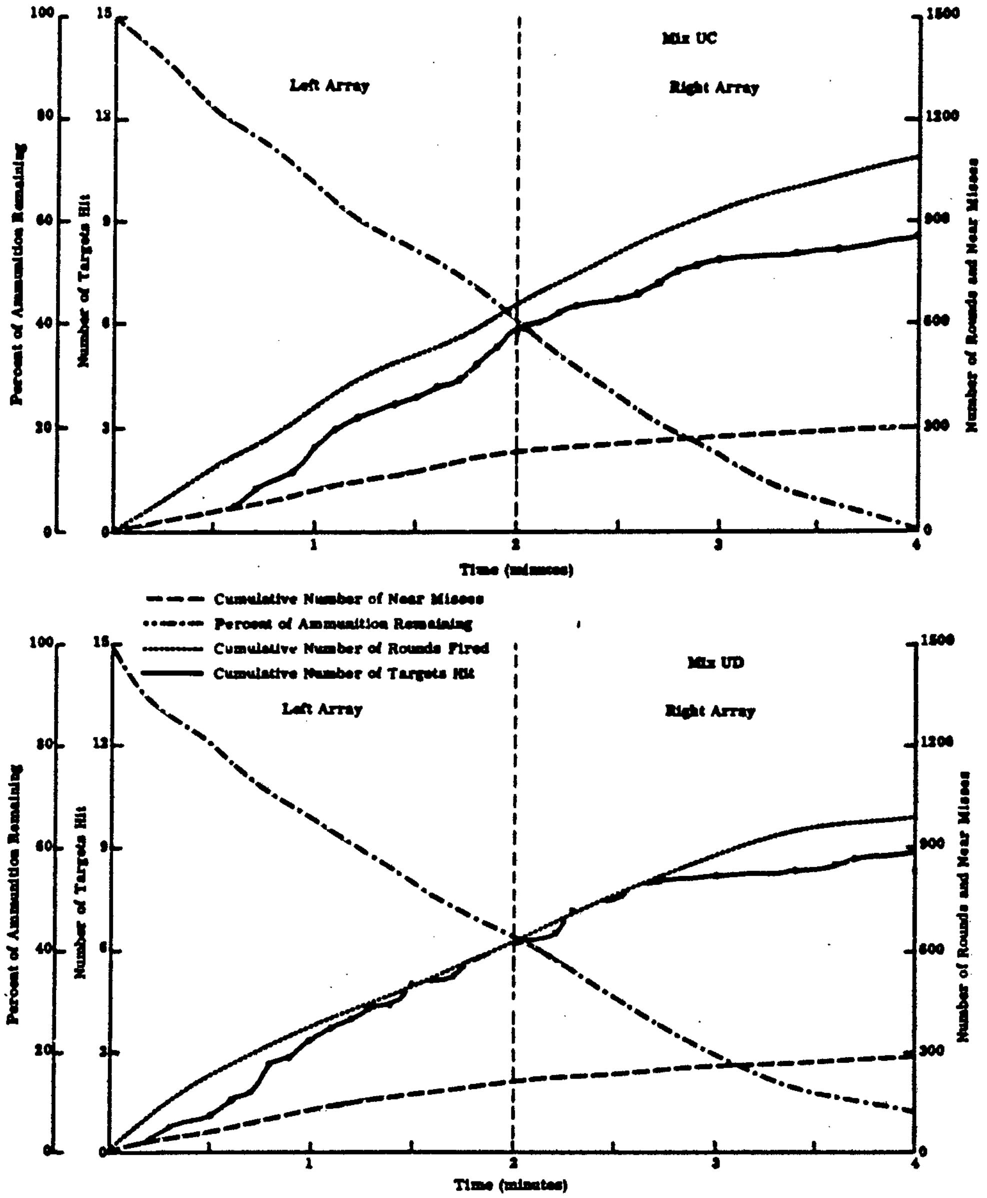
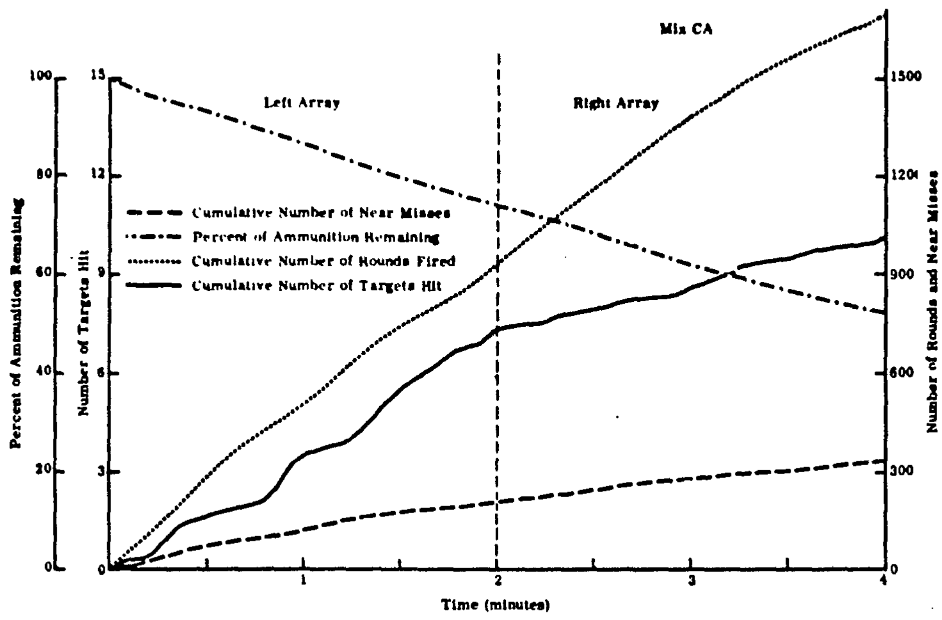


Figure 6-7 (Continued) CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 2



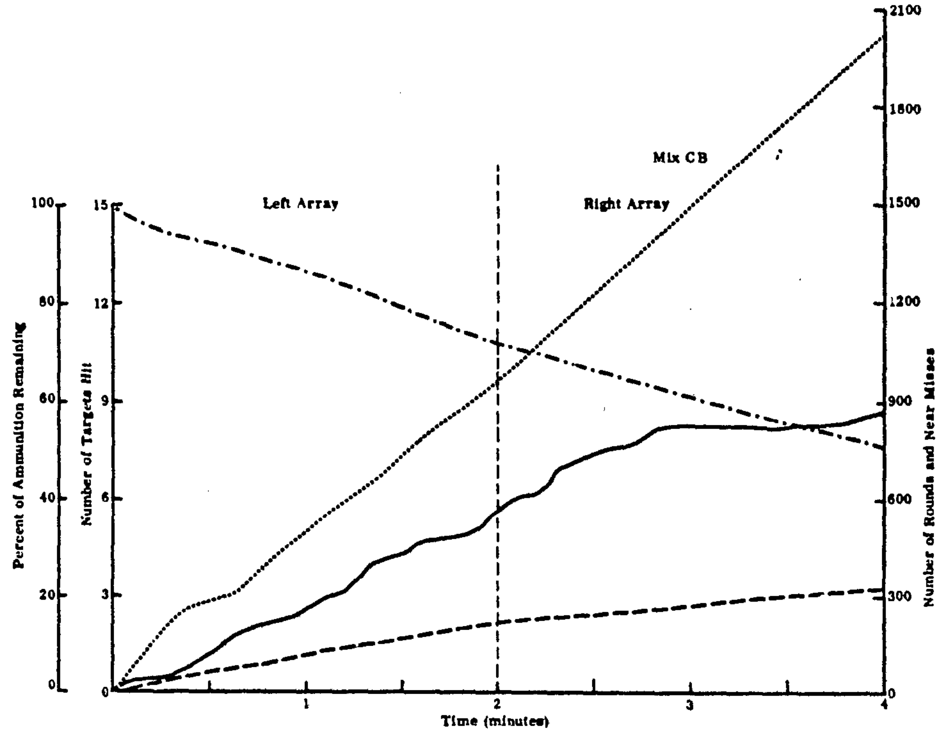


Figure 6-7 (Continued) CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES AND PERCENT OF AMMUNITION REMAINING--SITUATION 2

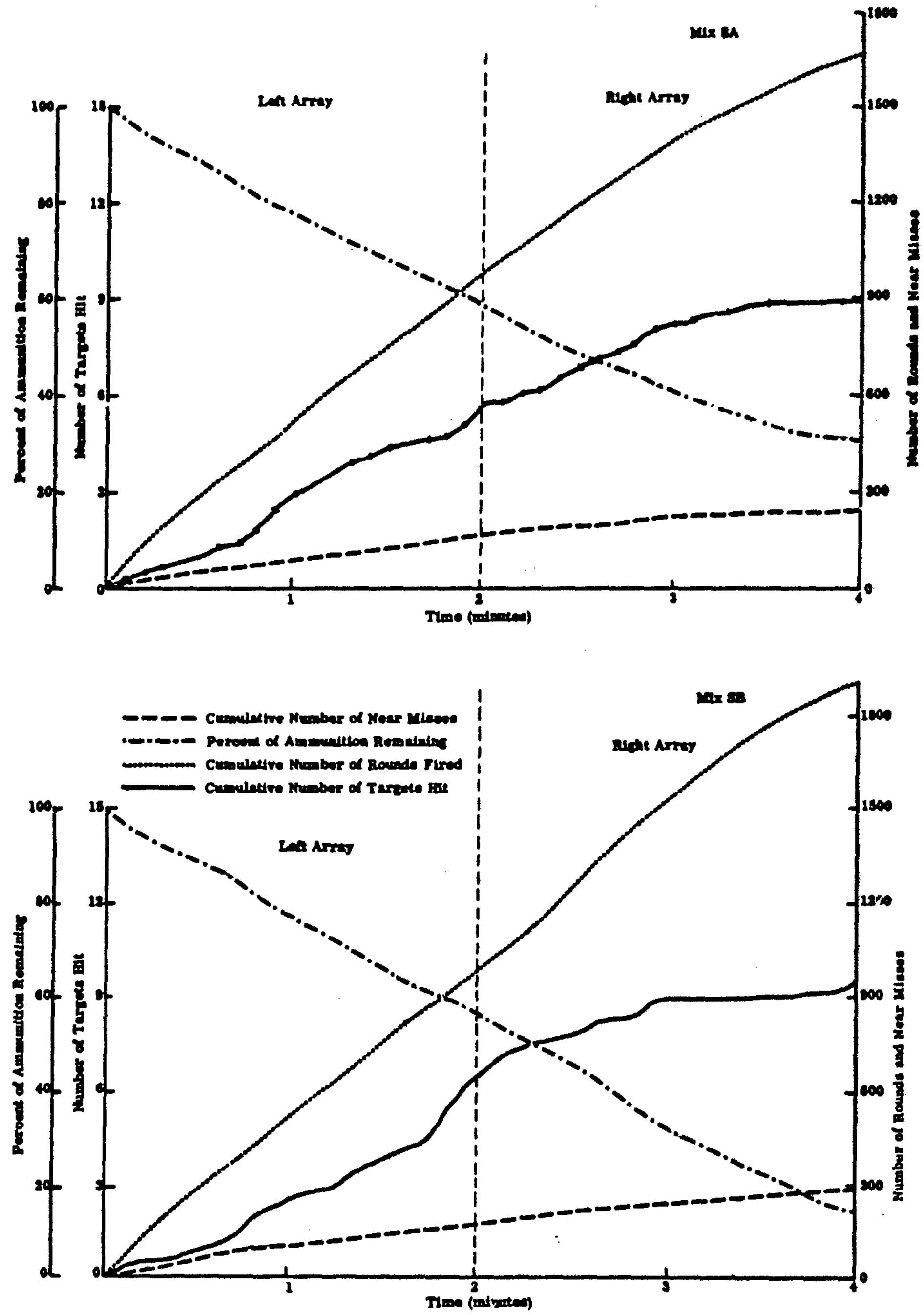


Figure 6-7 (Continued) CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 2

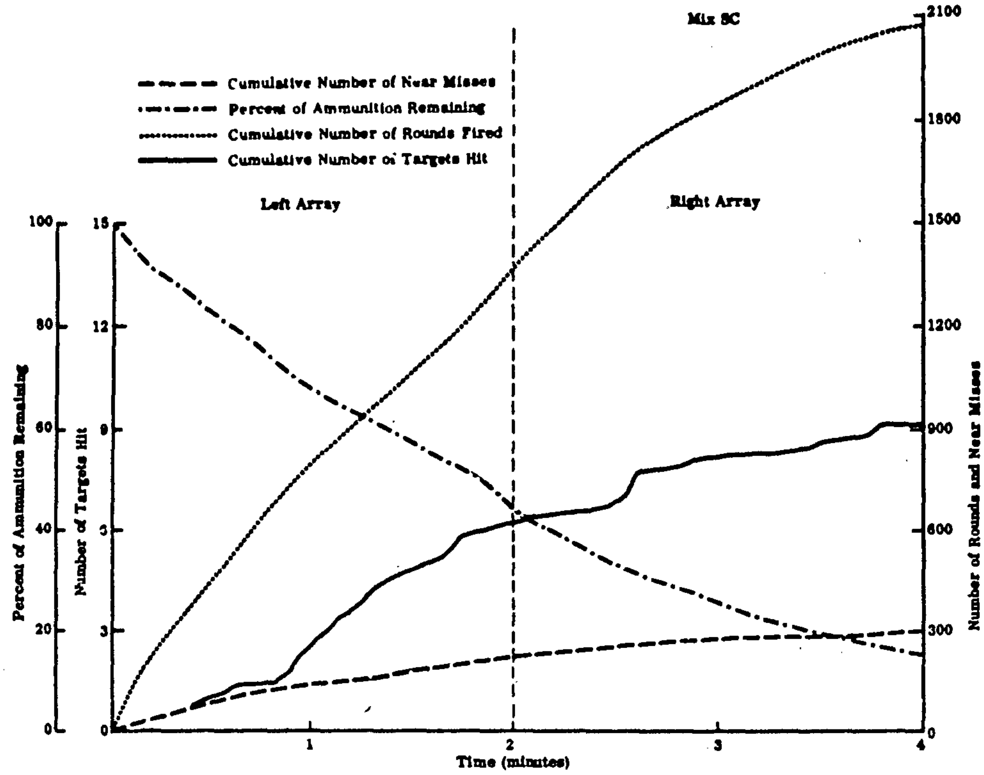
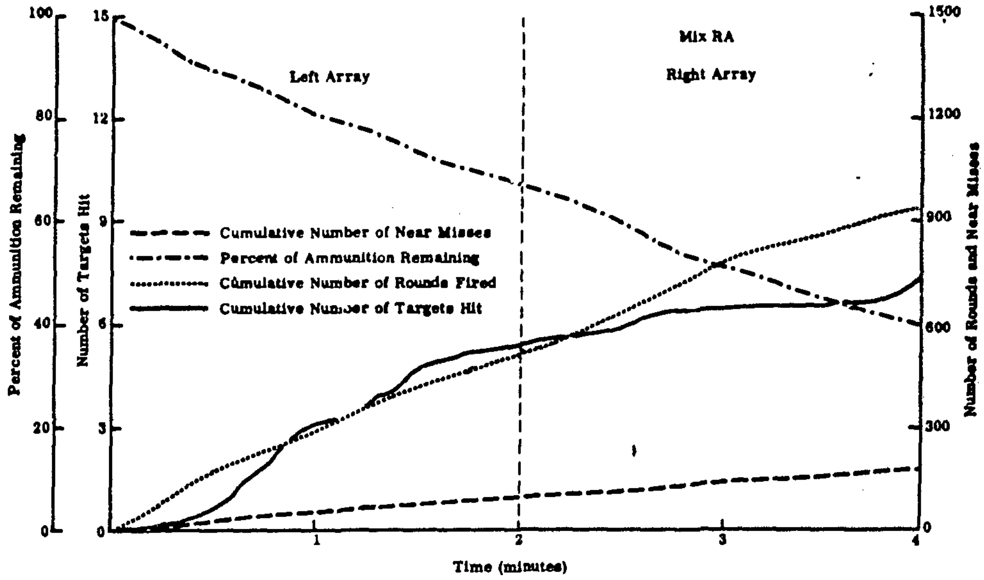


Figure 6-7 (Continued) CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 2



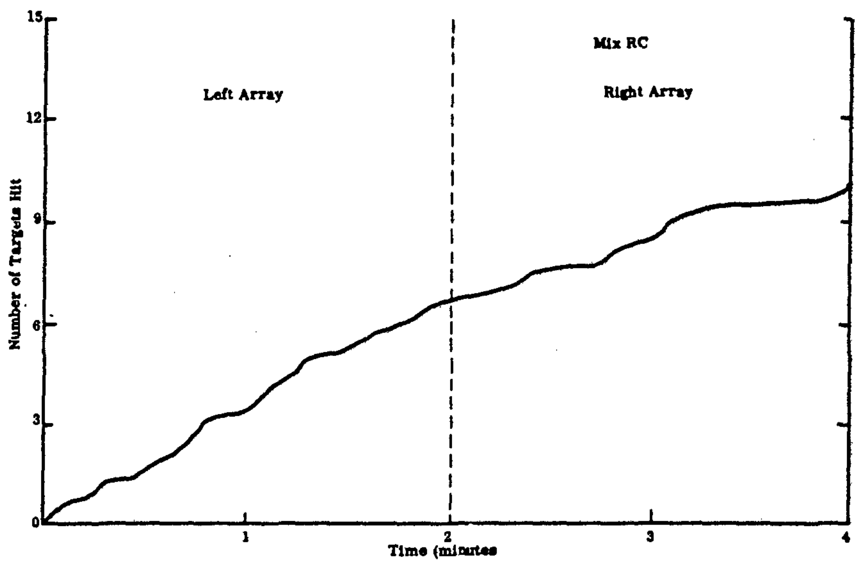


Figure 6-7 (Concluded) CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 2

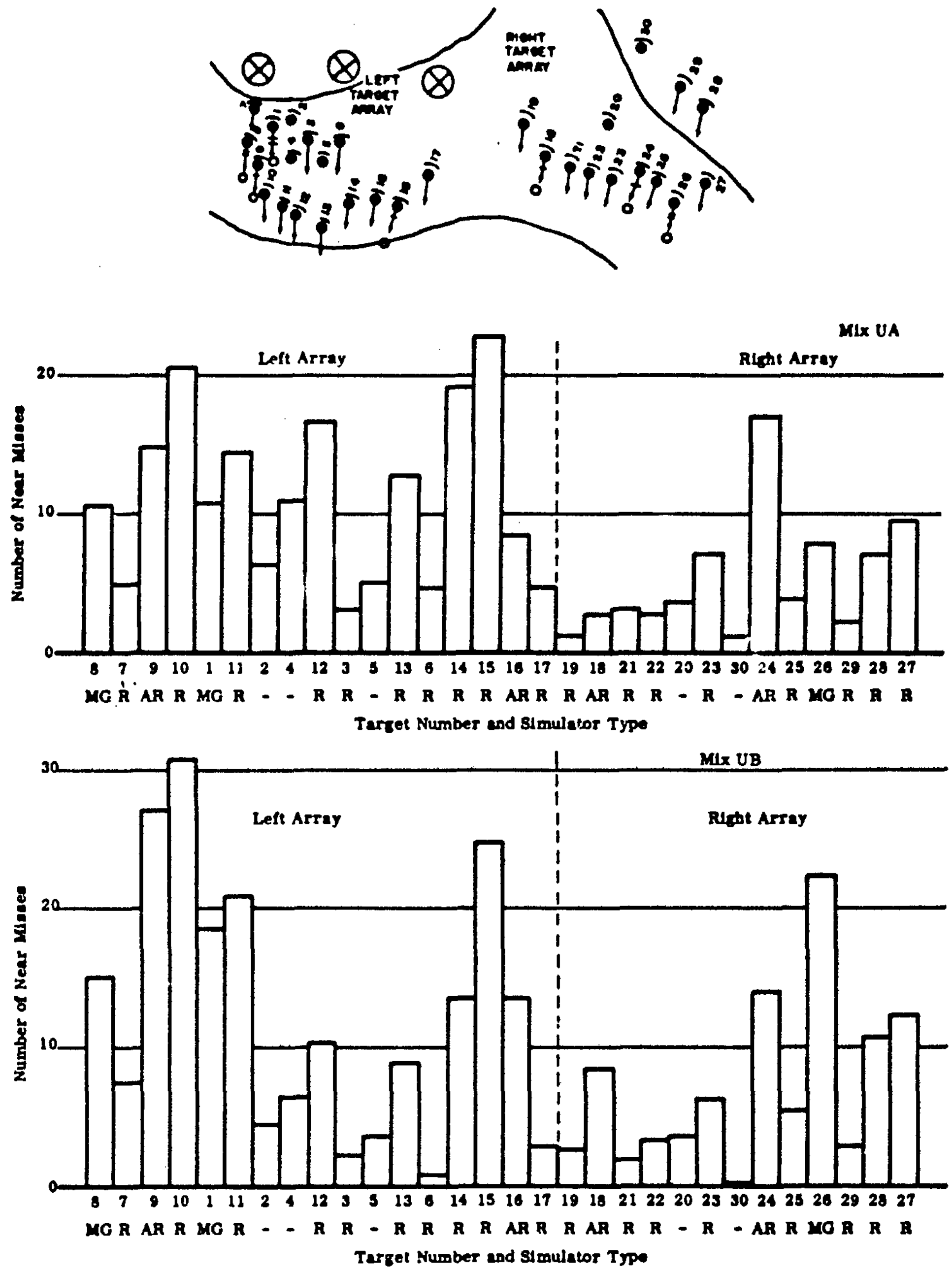


Figure 6-8

NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 2

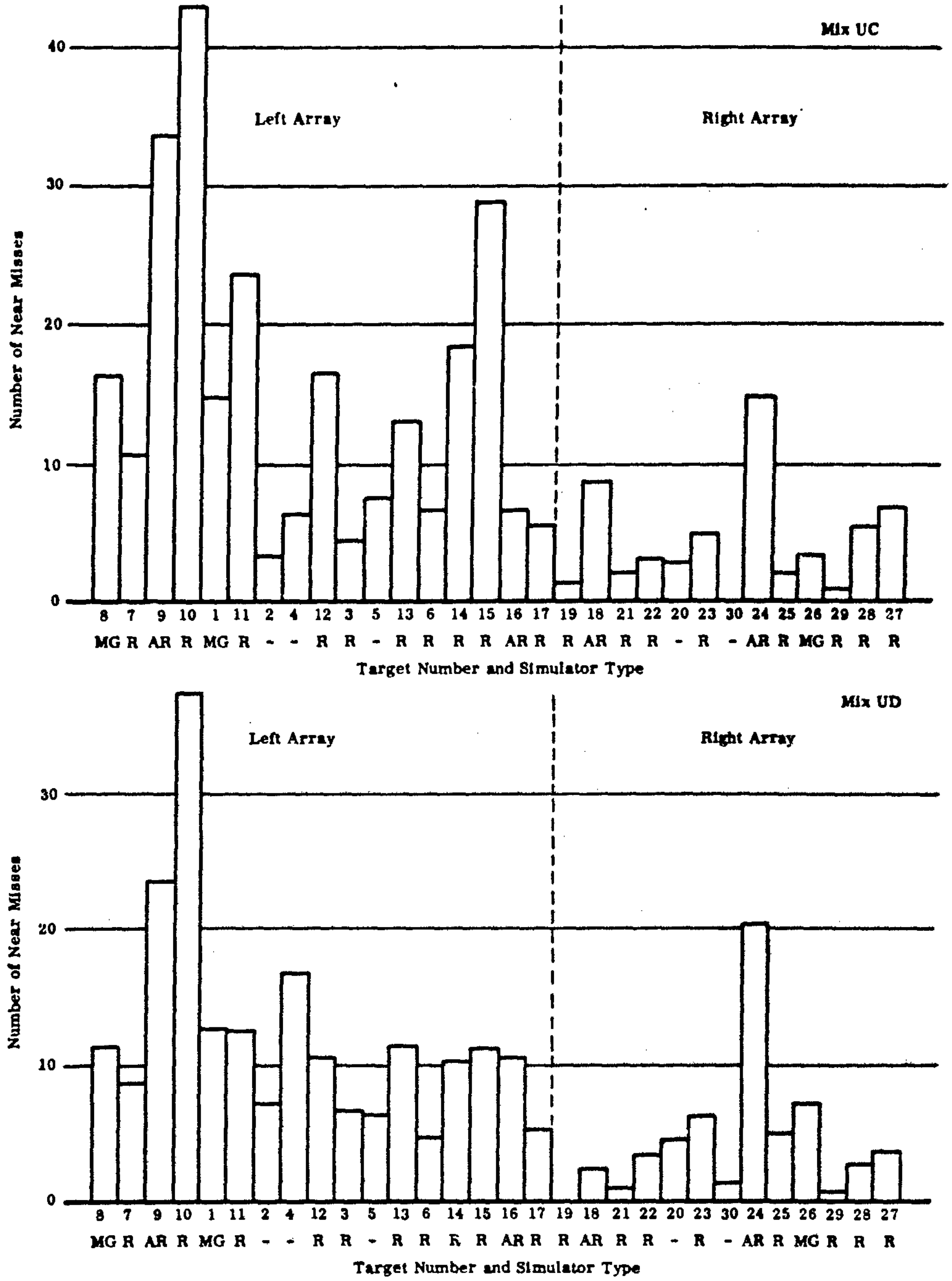


Figure 6-8 (Continued)

NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 2

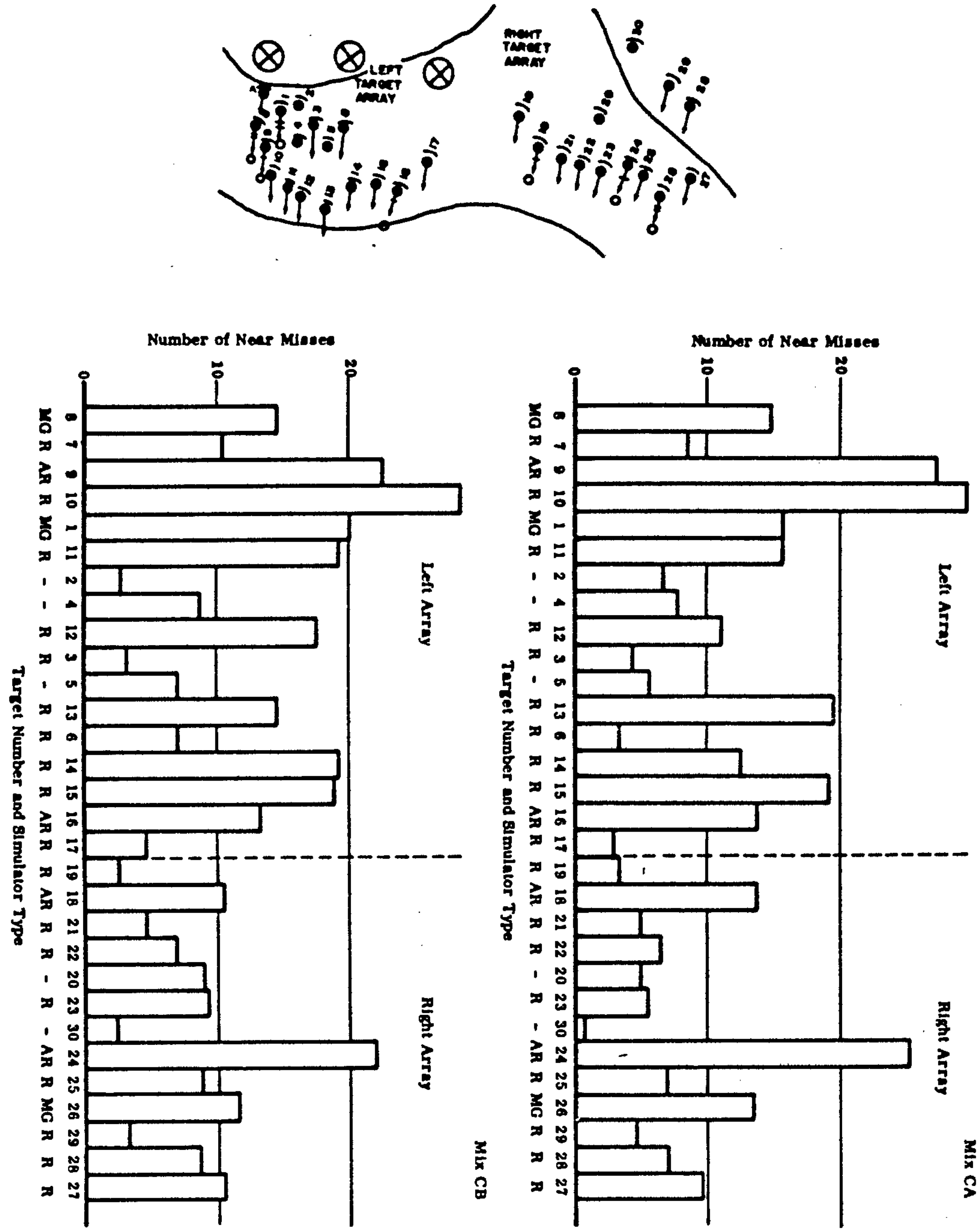


Figure 6-8 (Continued)

NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 2

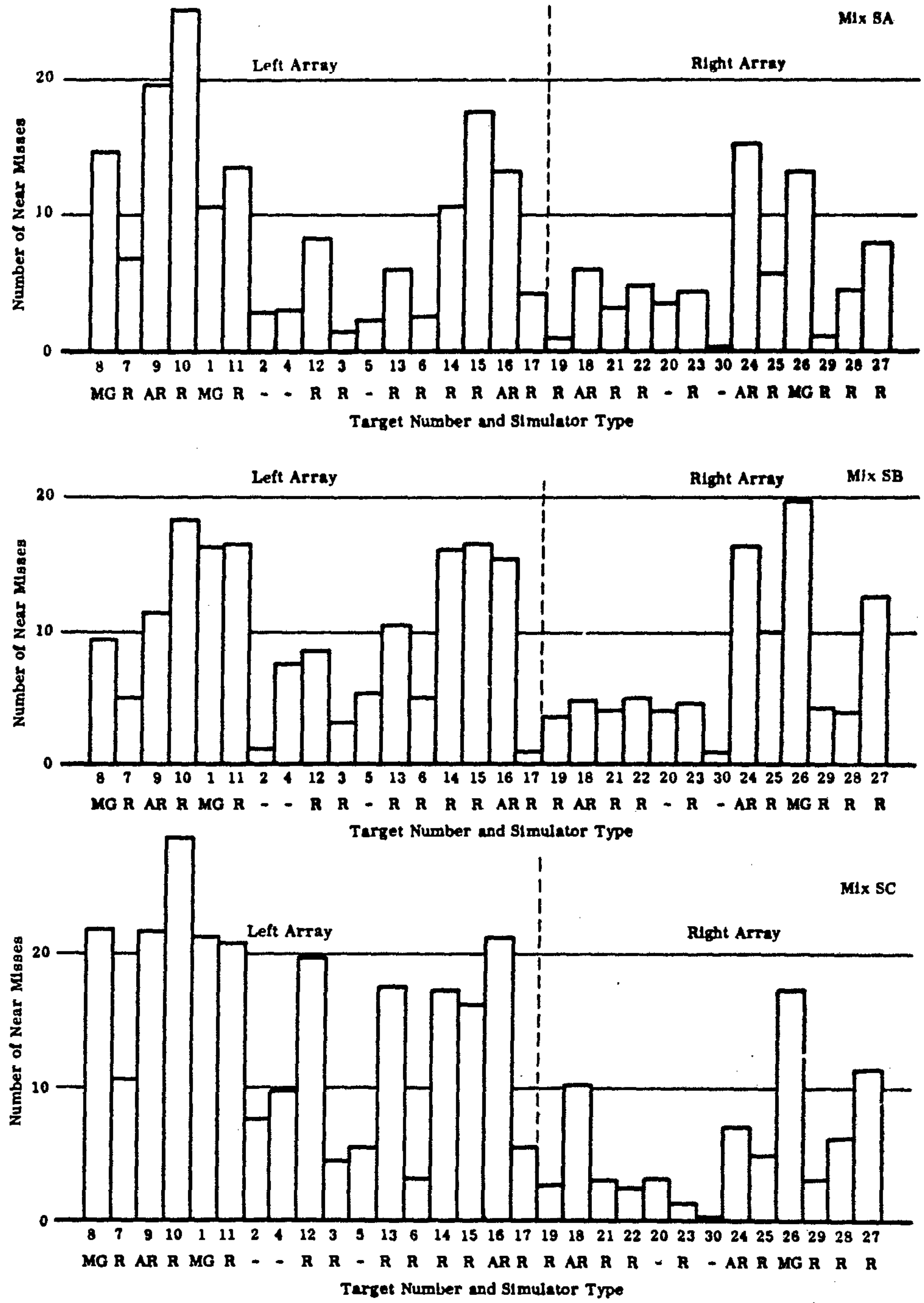


Figure 6-8 (Continued)

NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 2

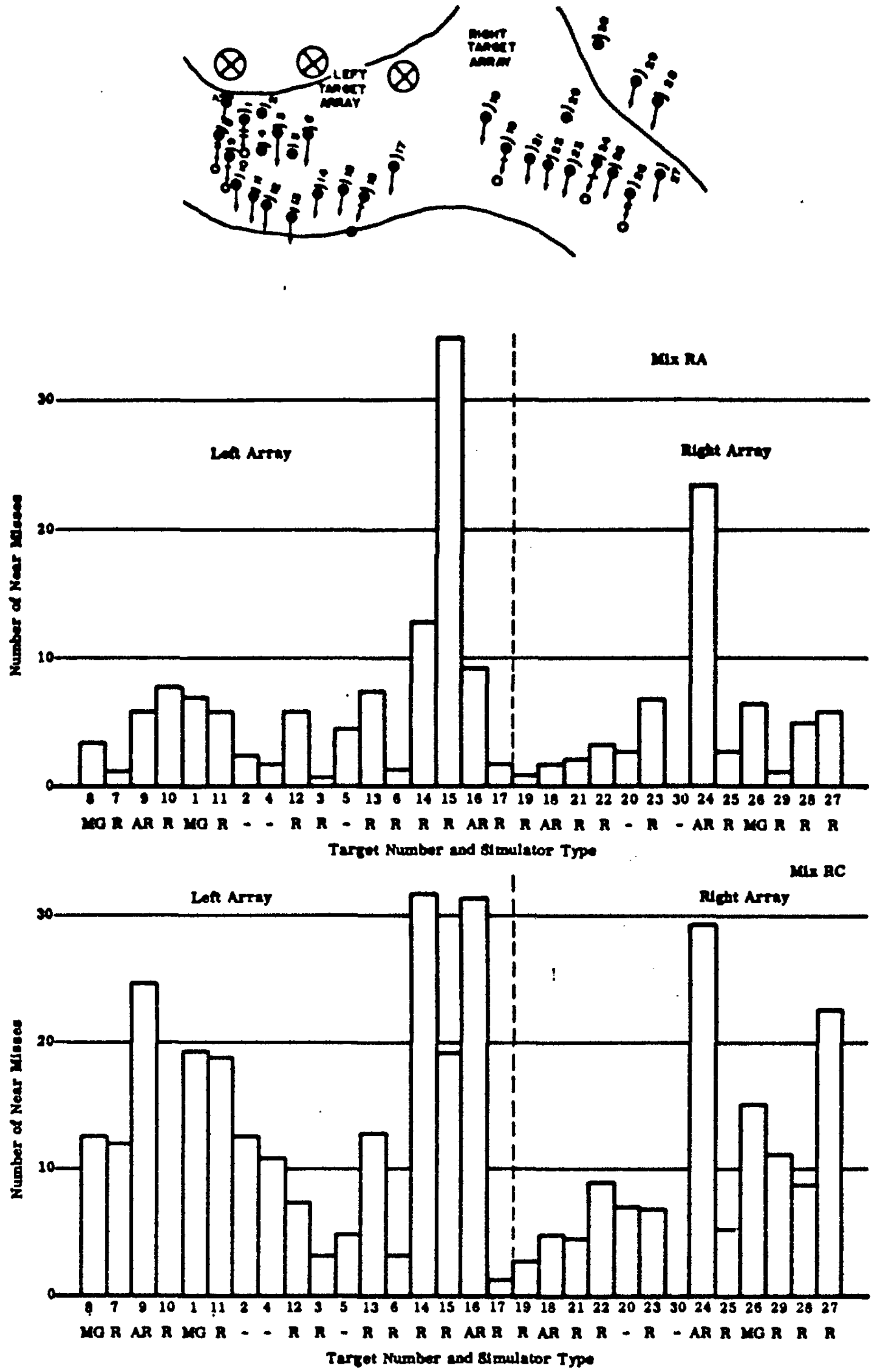


Figure 6-8 (Concluded)

NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 2

3. Situation 4: Rifle Squad in Approach to Contact

The approach to contact situation evaluated rifle squad weapon mixes in standing quickfire. This situation, in which the firers were time stressed, was designed to evaluate the pointing characteristics of small arms. It consisted of 40 targets programmed to appear in 12 events (or groups) of one to ten targets each. The 12 target groups were deployed at various points along a valley 430 meters long. The range from targets to the firers was 19 to 180 meters. Programmed target exposure times ran from 2 seconds to 10 seconds for some of the longer range targets (beyond 100 meters). Total programmed cumulative exposure time for all 40 targets was 2.996 minutes. The time required for each squad to complete the approach to contact course was 25 to 30 minutes.

Results are presented in subtables and graphically for cumulative exposure times, sustainability, number of targets hit, and number of total hits, across all events in Figure 6-9. Cumulative hits and percent of ammunition remaining as a function of time by range and event are presented in Figure 6-10. In addition, three sets of tables are presented, listing the rank order and associated standard scores for the following measures.

Table a -- Rank order of weapon mixes and associated standard scores for sum of target effects across all 12 events. This weights the event by range and number of targets unequally.

Table b -- Rank order of weapon mixes and associated standard scores with all events weighted equally. In effect, this table represents the average of the standard scores computed for each event, where Table a represents the standard scores computed from the sum of raw scores across all 40 targets (12 events).

Table c -- Rank order of weapon mixes and associated standard scores for the ambush situation (ten enemy targets at a range of 21 to 34 meters).

Table a. SUM OF RAW SCORES ACROSS ALL TARGETS
(Events Weighted Unequally)

Target Effects Only			Overall Effectiveness*		
Rank	Mix	Standard Score	Rank	Mix	Standard Score
1	SC	61.4	1	CA	62.5
2	CA	59.3	2	UA	56.7
3	SB	52.8	3	RA	54.4
4	UA	51.7	4	SC	53.7
5	RA	50.6	5	CB	53.4
6	UB	49.6	6	SB	52.6
7	CB	45.2	7	UB	51.7
8	UD	44.2	8	SA	46.9
9	SA	44.2	9	UC	35.1
10	UC	40.9	10	UD	33.0

Table b. AVERAGE OF 12 EVENT STANDARD SCORES
(Events Weighted Equally)

Target Effects Only			Overall Effectiveness*		
Rank	Mix	Standard Score	Rank	Mix	Standard Score
1	CA	62.9	1	CA	64.5
2	SC	57.0	2	UA	57.5
3	UA	54.4	3	UB	53.9
4	UB	53.4	4	SB	51.6
5	SB	51.3	5	RA	51.6
6	SA	46.7	6	SC	51.5
7	RA	46.4	7	CB	50.8
8	UD	44.2	8	SA	48.5
9	CB	42.4	9	UD	35.2
10	UC	41.5	10	UC	34.7

* Sustainability weighted 1/3; Target effects 2/3

Table c. AMBUSH EVENT (10 TARGETS - 21 to 34 METERS)

Target Effects Only			Overall Effectiveness*		
Rank	Mix	Standard Score	Rank	Mix	Standard Score
1	SC	61.8	1	SC	59.6
2	UA	53.9	2	RA	56.0
3	SB	52.4	3	UA	55.7
4	SA	51.4	4	CA	55.6
5	UB	51.2	5	SA	52.7
6	CB	50.3	6	SB	52.1
7	CA	48.9	7	CB	52.0
8	RA	48.5	8	UB	48.6
9	UD	45.4	9	UD	43.5
10	UC	37.4	10	UC	25.0

* Sustainability weighted 1/3; Target effects 2/3

Key:

UA - 9 M14 Rifles

UD - 9 M14E2 Rifles

UB - 7 M14 Rifles and 2 M14E2 AR

UC - 5 M14 Rifles and 2 M60 MG

SA - 9 Stoner Rifles

SB - 7 Stoner Rifles and 2 Stoner AR

SC - 7 Stoner Rifles and 2 Stoner MG

CA - 9 Colt Rifles

CB - 7 Colt Rifles and 2 Colt AR

RA - 9 AK47 Rifles

Mix RC results for Situation 4 are presented below.

CET	Near Misses	Percent Ammo Remaining	Targets Hit	Total Hits
2.17	--	52.00	26.66	38.60

EFFECTIVENESS MEASURES

Cumulative Exposure Times

A

Mix	$\bar{X}$ CET	SD	Standard Score z'
SC	1.96	.1	61.4
CA	1.97	.2	59.3
SB	2.03	.1	52.8
UA	2.04	.1	51.7
RA	2.05	.2	50.6
UB	2.06	.1	49.6
CB	2.10	.1	45.2
UD	2.11	.1	44.2
SA	2.11	.1	44.2
UC	2.14	.2	40.9
$\bar{X}$	2.06		
SD	.03		

Number of Near Misses

B

Mix	$\bar{X}$ Near Misses	SD	Standard Score z'
$\bar{X}$			
SD			

Sustainability (% Ammo Remaining)

C

Mix	$\bar{X}$ % Remaining	SD	Standard Score z'
CB	80.8	5.6	69.6
CA	80.2	4.8	68.8
UA	78.7	4.8	66.6
RA	75.8	2.8	62.1
UB	71.7	6.2	55.9
SA	69.3	5.7	52.2
SB	69.2	9.9	52.1
SC	60.2	7.4	38.3
UC	50.5	22.8	23.6
UD	42.0	9.0	10.6
$\bar{X}$	67.8		
SD	13.11		

COLLATERAL

Number of Targets Hit

D

Mix	$\bar{X}$ Targets Hit	SD	Standard Score z'
SC	30.8	2.3	57.0
UB	30.7	2.1	56.5
SB	30.5	1.1	55.4
CA	30.4	2.3	54.9
UA	30.0	2.4	52.8
RA	29.8	4.3	51.7
SA	29.2	.9	48.6
UC	27.9	4.7	41.6
UD	27.8	2.8	41.0
CB	27.7	2.7	40.5
$\bar{X}$	29.48		
SD	3.75		

Target Effects

F

Mix	Standard Score Target Effects
SC	61.4
CA	59.3
SB	52.8
UA	51.7
RA	50.6
UB	49.6
CB	45.2
UD	44.2
SA	44.2
UC	40.9

Overall Effectiveness

G

Mix	Overall Fire Effectiveness
CA	62.5
UA	56.7
RA	54.4
SC	53.7
CB	53.4
SB	52.6
UB	51.7
SA	46.9
UC	35.1
UD	33.0

Cumulative Exposure Times

H

	SC	CA	SB	UA	RA	UB	CB	UD	SA	UC
SC		≥.40	.10	.13	.14	.09	.03	.02	.02	.05
CA			.28	.26	.26	.22	.11	.09	.09	.11
SB				≥.40	.38	.33	.12	.06	.04	.14
UA					≥.40	≥.40	.22	.18	.16	.19
RA						≥.40	.30	.26	.25	.26
UB							.27	.22	.20	.22
CB								≥.40	≥.40	.37
UD									≥.40	.39
SA										.39

Nu

I

Sustainability (% Ammo Remaining)

J

	CB	CA	UA	RA	UB	SA	SB	SC	UC	UD
CB		≥.40	.25	.05	.01	.004	.02	.001	.01	.001
CA			.30	.05	.02	.004	.02	.001	.01	.001
UA				.14	.03	.01	.03	.001	.01	.001
RA					.10	.02	.09	.001	.02	.001
UB						.26	.31	.01	.03	.001
SA							≥.40	.02	.04	.001
SB								.05	.05	.001
SC									.17	.003
UC										.21

No. of Targets Hit

K

	SC	UB	SB	CA	UA	RA	SA	UC	UD	CB
SC		≥.40	.37	.37	.28	.32	.08	.11	.04	.03
UB			≥.40	.40	.30	.34	.08	.12	.04	.04
SB				≥.40	.33	.37	.03	.12	.03	.03
CA					≥.40	≥.40	.14	.14	.06	.05
UA						≥.40	.24	.19	.09	.08
RA							.37	.26	.18	.18
SA								.27	.14	.12
UC									≥.40	≥.40
UD										≥.40

T

L

	SC	SB	UA	S
SC		.22	.21	.
SB			≥.40	.
UA				.
SA				
CA				
UB				
RA				
CB				
UC				

Note: Standard Scores computed from raw scores using scores to three decimal places.

UA - 9 M14 Rifles
UB - 7 M14 Rifles/2 M14E2 AR
UC - 5 M14 Rifles/2 M60 MG
UD - 9 M14E2 Rifles
CA - 9 Colt Rifles

CB - 7 Colt Rifles/2 Colt AR
SA - 9 Stoner Rifles
SB - 7 Stoner Rifles/2 Stoner AR
SC - 7 Stoner Rifles/2 Stoner MG
RA - 9 AK47 Rifles

$\bar{X}$
SD
CET
z'

COLLATERAL PERFORMANCE MEASURES

D Number of Targets Hit

Mix	$\bar{X}$ Targets Hit	SD	Standard Score z'
SC	30.8	2.3	57.0
UB	30.7	2.1	56.5
SB	30.5	1.1	55.4
CA	30.4	2.3	54.9
UA	30.0	2.4	52.8
RA	29.8	4.3	51.7
SA	29.2	.9	48.5
UC	27.9	4.7	41.6
UD	27.8	2.8	41.0
CB	27.7	2.7	40.5
$\bar{X}$	29.48		
SD	3.75		

E Total Hits on Targets

Mix	$\bar{X}$ Hits	SD	Standard Score z'
SC	53.8	9.1	83.5
SB	50.0	7.3	67.7
UA	49.6	8.7	66.0
SA	47.4	8.3	56.8
CA	47.3	6.2	56.4
UB	44.5	5.9	44.7
RA	44.5	6.0	44.7
CB	42.4	8.9	36.0
UC	39.5	7.6	23.9
UD	38.6	7.6	20.2
$\bar{X}$	45.76		
SD	4.80		

I Number of Near Misses

L Total Hits on Targets

	SC	SB	UA	SA	CA	UB	RA	CB	UC	UD
SC		.22	.21	.12	.10	.03	.05	.03	.01	.01
SB			>.40	.29	.26	.09	.11	.08	.02	.02
UA				.34	.31	.14	.16	.09	.04	.02
SA					>.40	.25	.27	.17	.06	.04
CA						.22	.24	.15	.04	.03
UB							>40	.32	.12	.08
RA								.33	.13	.10
CB									.28	.22
UC										>.40

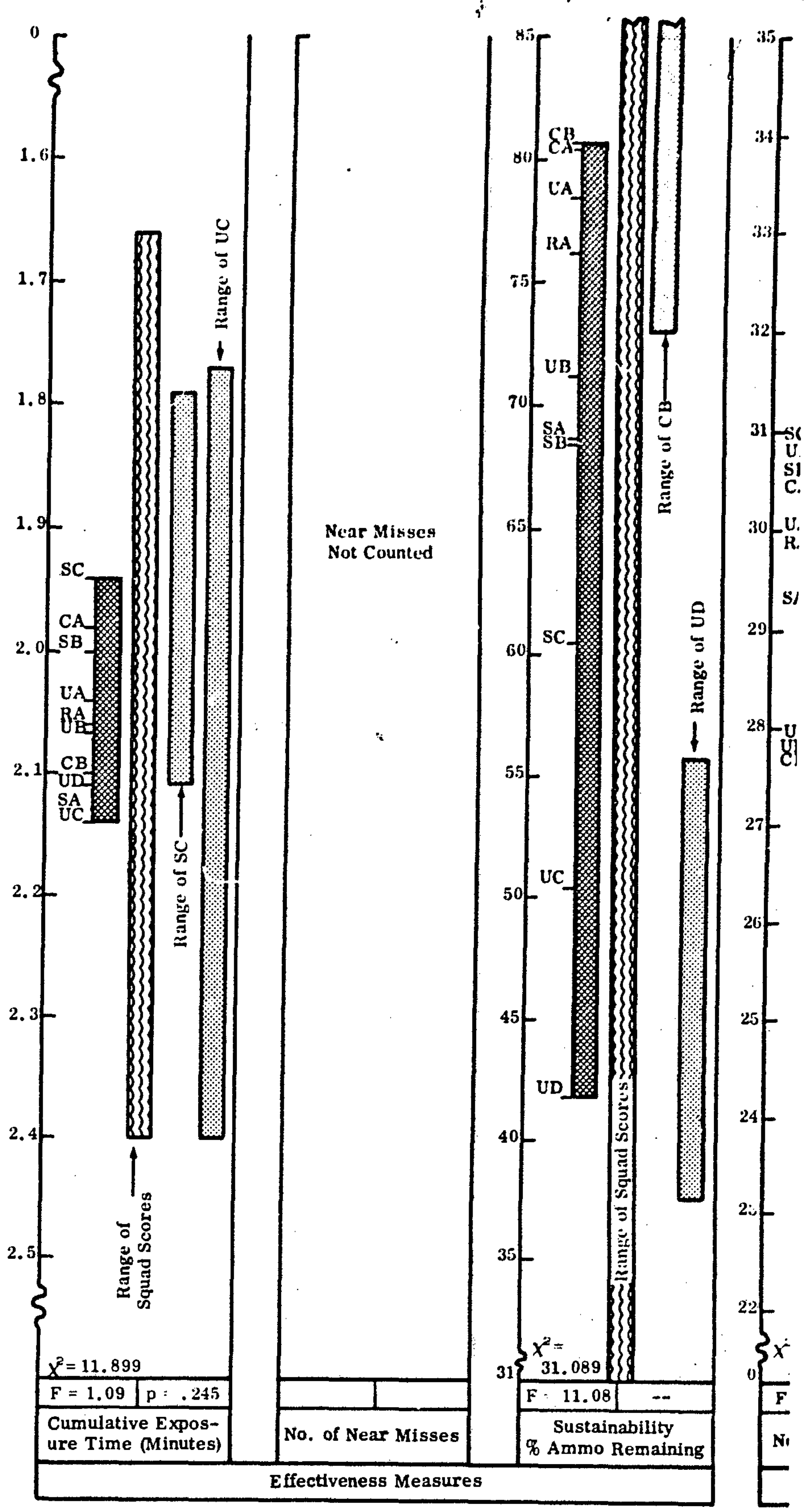


Figure 6-9 SUMMARY OF RESULTS--S

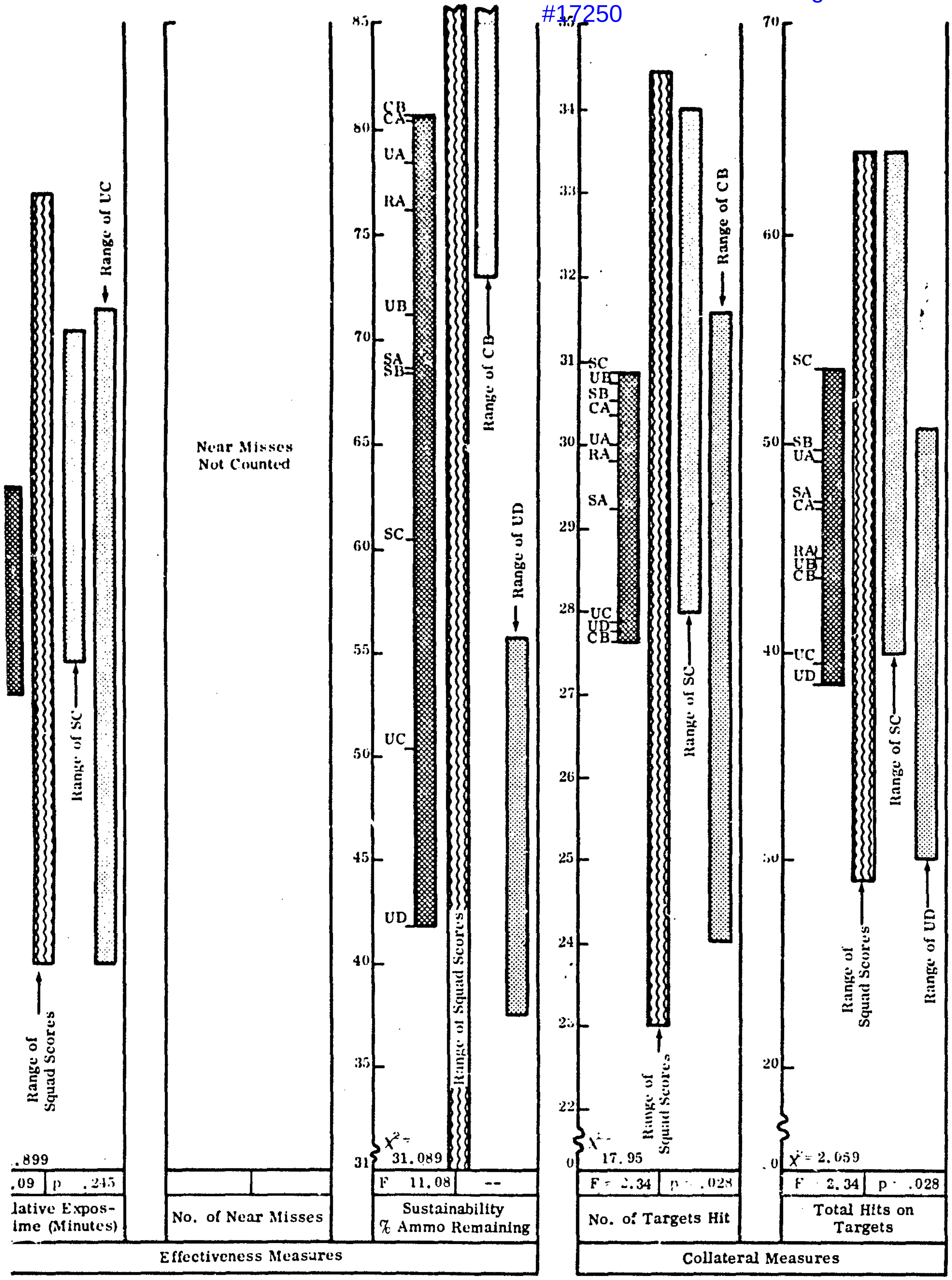
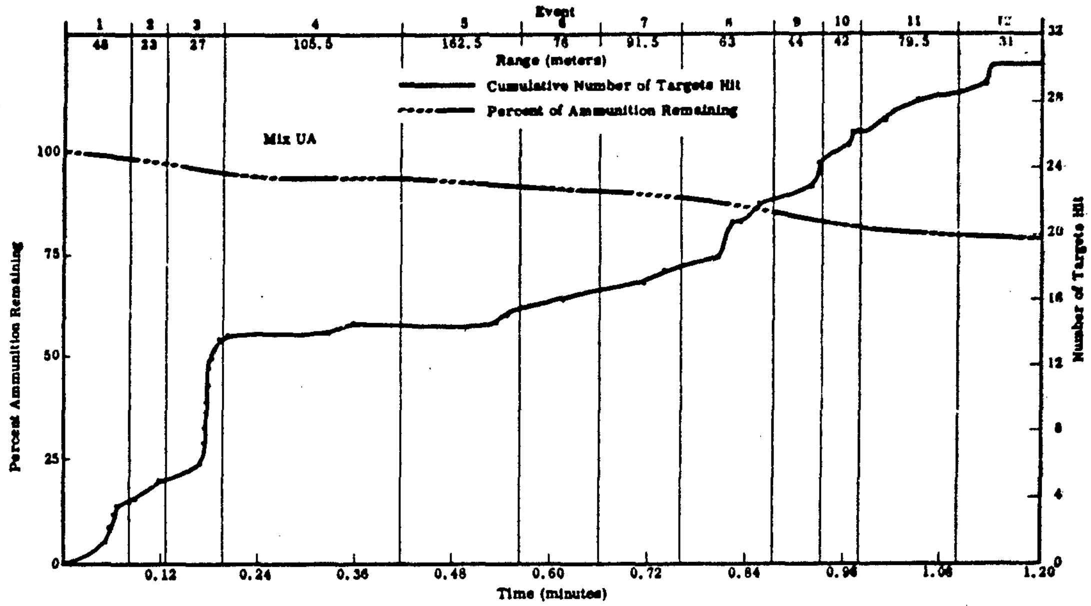


Figure 6-9 SUMMARY OF RESULTS--SITUATION 4



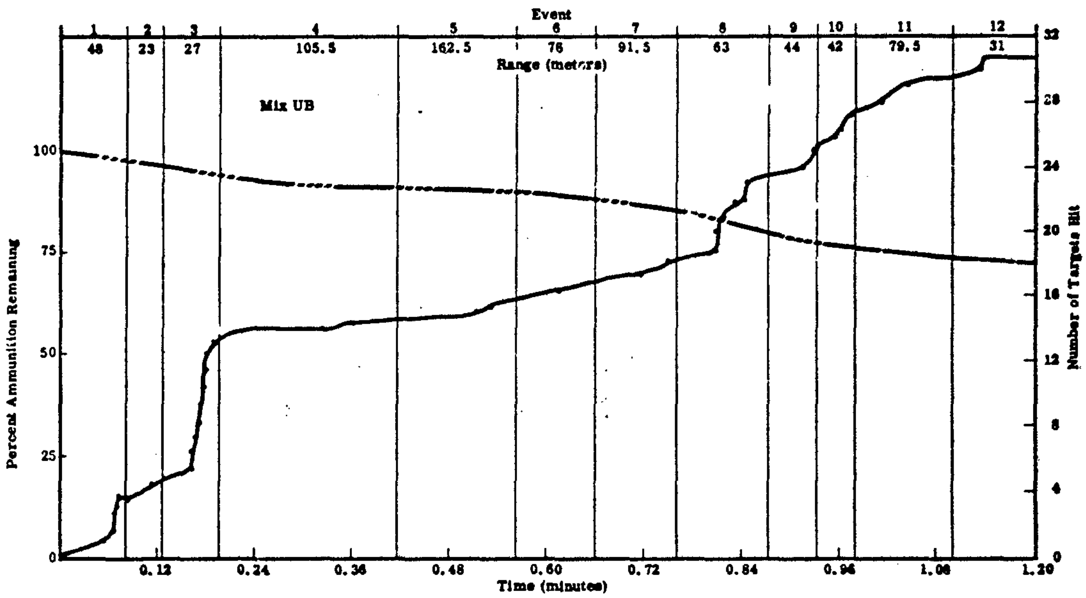
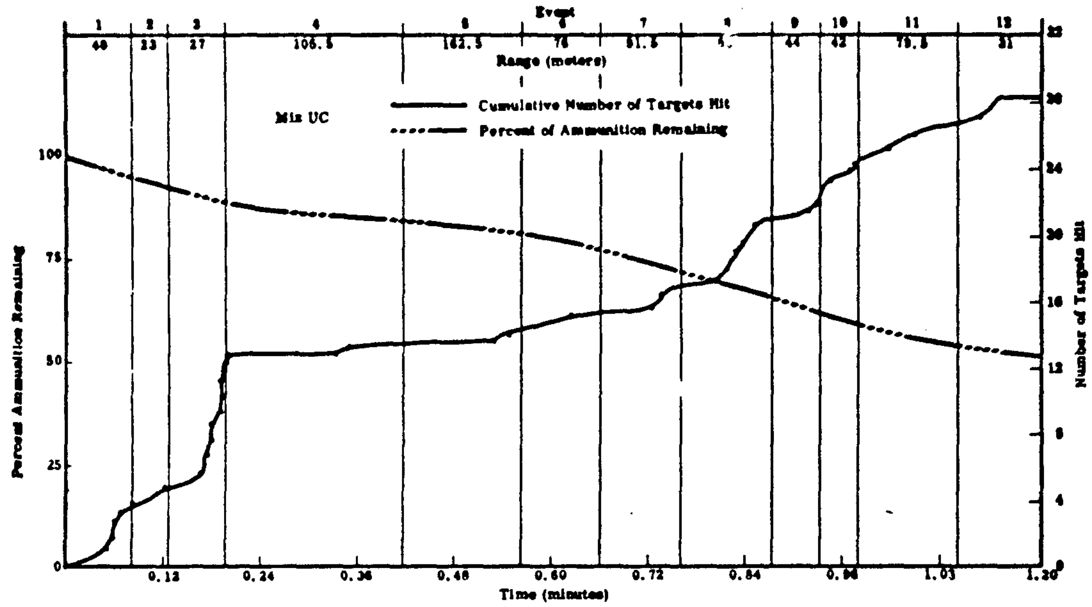


Figure 6-10 CUMULATIVE NUMBER OF TARGETS HIT AND PERCENT OF AMMUNITION REMAINING--SITUATION 4



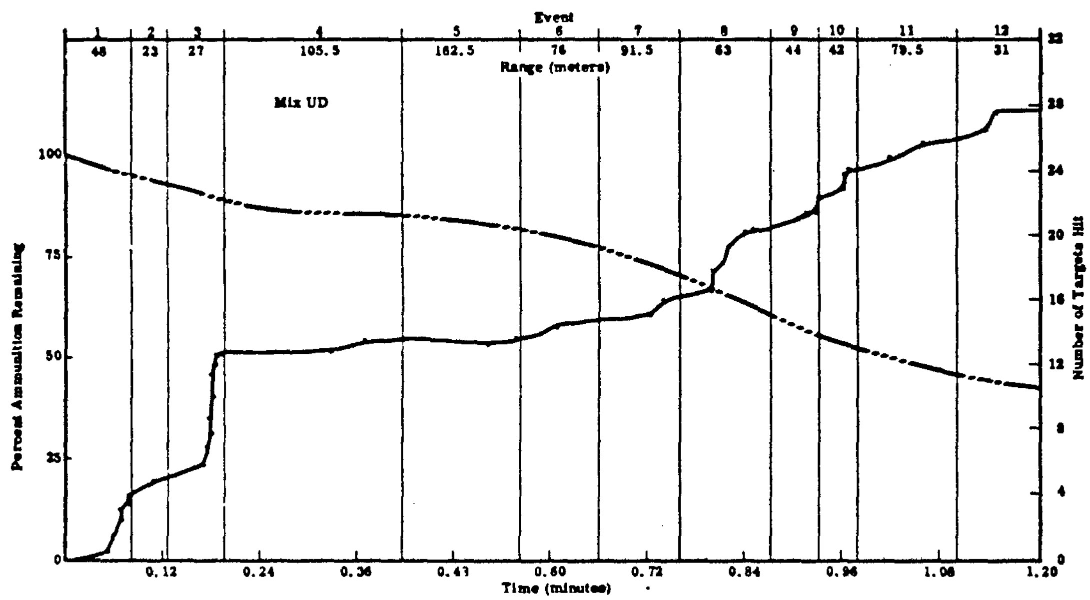
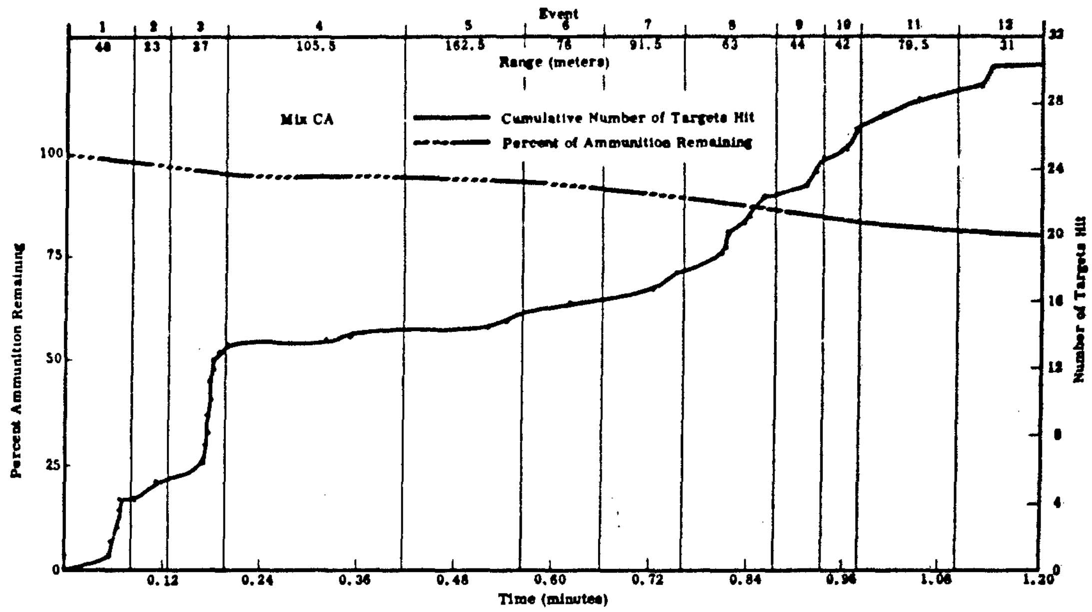


Figure 6-10 (Continued) CUMULATIVE NUMBER OF TARGETS HIT AND PERCENT OF AMMUNITION REMAINING--SITUATION 4



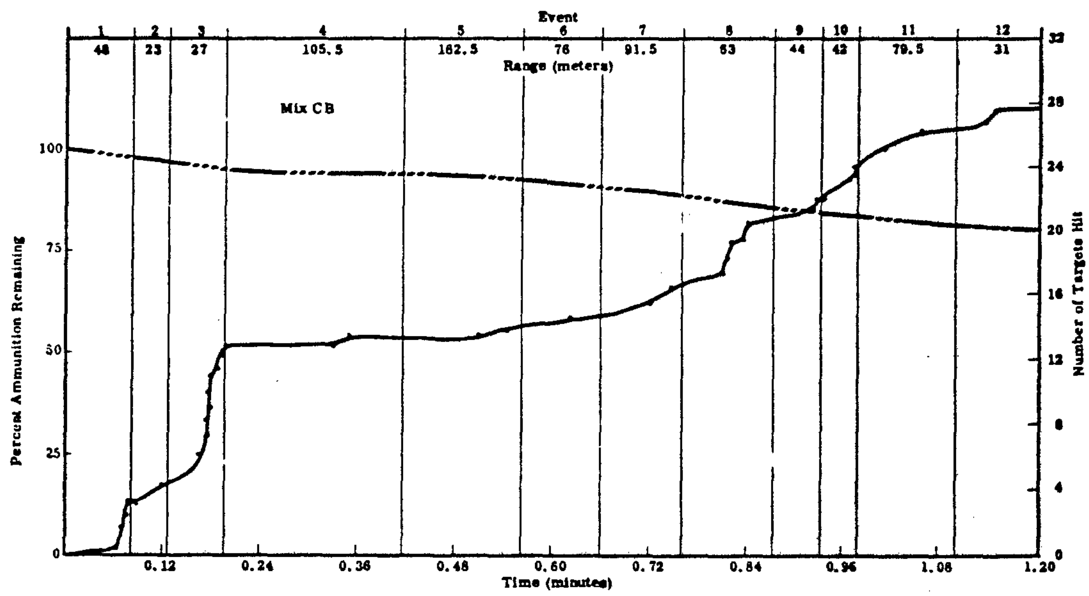


Figure 6-10 (Continued) CUMULATIVE NUMBER OF TARGETS HIT AND PERCENT OF AMMUNITION REMAINING--SITUATION 4

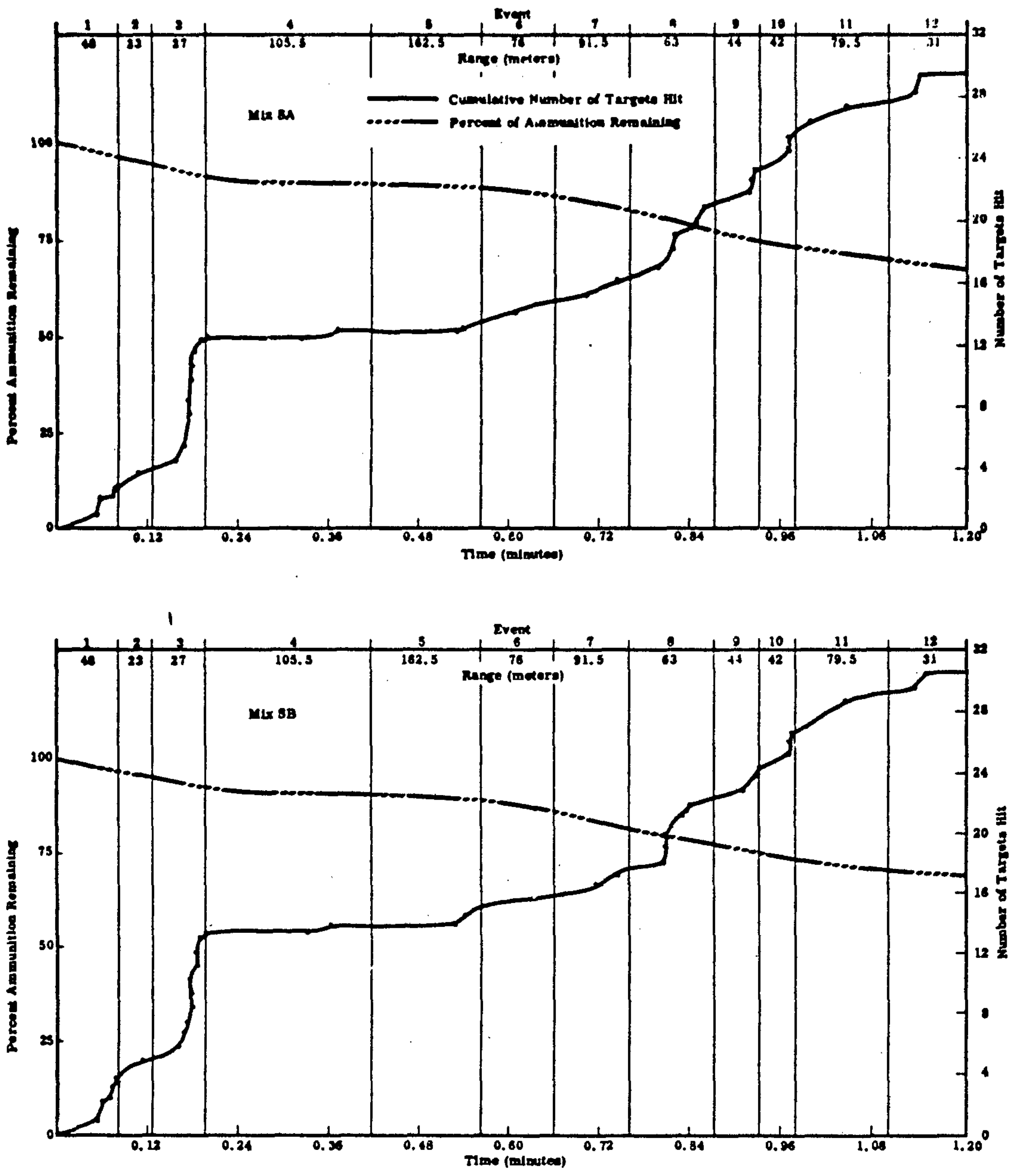
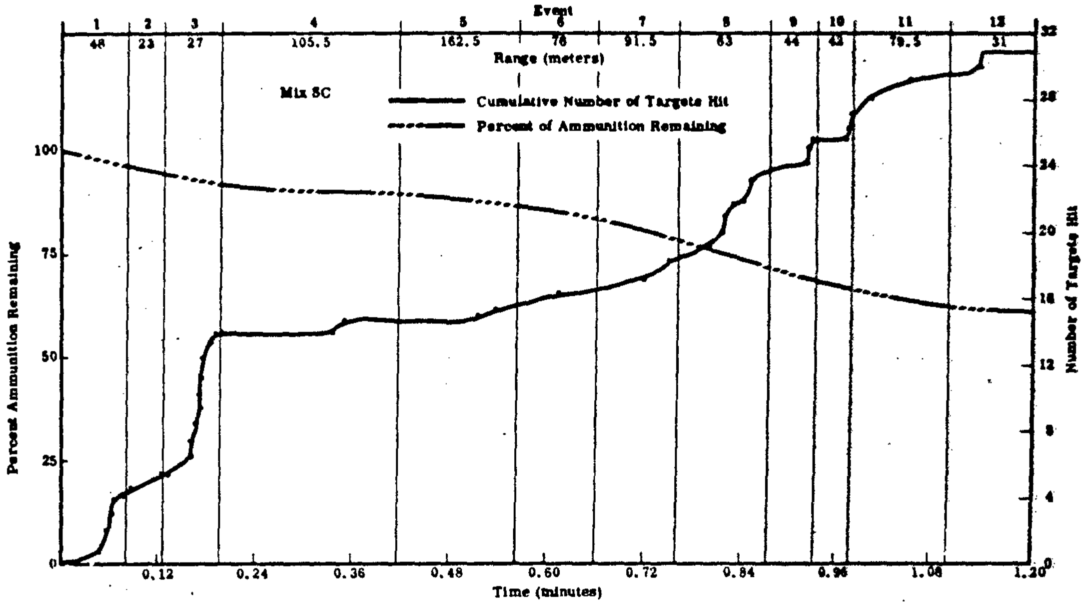


Figure 6-10 (Continued) CUMULATIVE NUMBER OF TARGETS HIT AND PERCENT OF AMMUNITION REMAINING--SITUATION 4



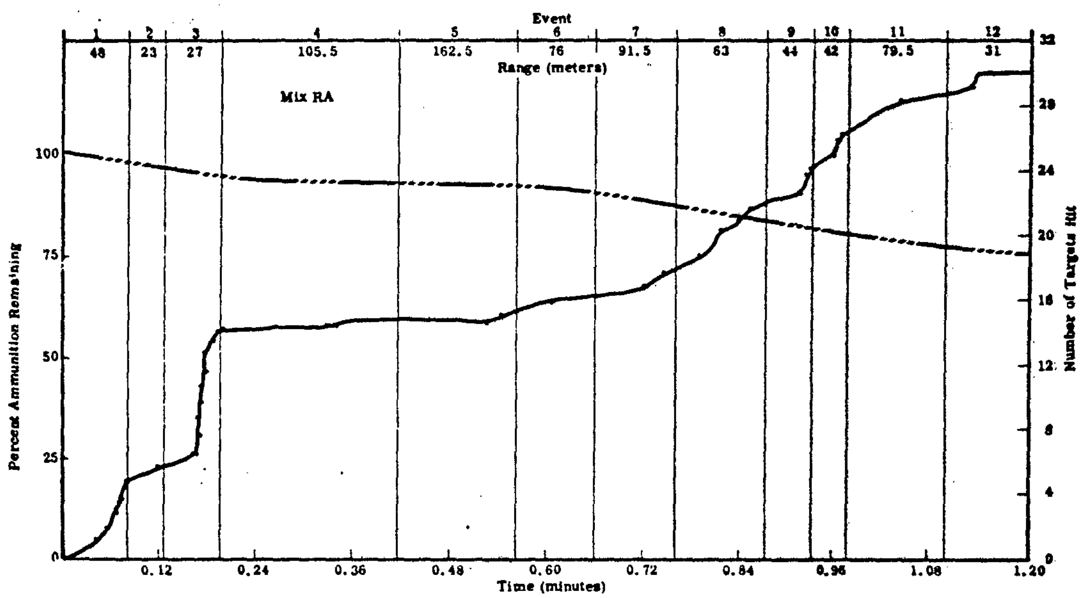


Figure 6-10 (Concluded) CUMULATIVE NUMBER OF TARGETS HIT AND PERCENT OF AMMUNITION REMAINING--SITUATION 4

4. Situation 5: Rifle Squad as a Base of Fire Supporting the Advance

Rifle squad weapon mixes fired from unprepared firing positions on two arrays of enemy targets. The duration of fire was 4 minutes, with the first 2 minutes devoted to an array of 14 enemy targets occupying an area 60 meters wide and 42 meters deep. The range of targets from the firers was 379 to 445 meters. The second 2 minutes of fire were delivered on an array of 13 targets occupying an area 45 meters wide and 62 meters deep, at ranges from the firers of 477 to 560 meters. The technique of distributed fire was used throughout the sector, with point fire used when targets were seen or weapon simulators gave specific cues to a target's location.

Arrays X and Y are presented separately following the overall results for the two arrays combined.

Results for Situation 5 are tabulated and presented graphically in Figures 6-11, 6-12, and 6-13. Figure 6-14 shows plots of cumulative average first hits as a function of time. For Mix RC, only cumulative number of hits is presented. Figure 6-15 shows the distribution of near misses by target.

The rank order of the ten mixes (other than Mix RC) with associated standard scores are given below.

Target Effects Only			Overall Effectiveness*		
Rank	Mix	Standard Score	Rank	Mix	Standard Score
1	SA	82.6	1	SA	74.5
2	SB	66.9	2	CB	67.9
3	SC	63.6	3	SB	63.8
4	CB	63.4	4	SC	57.5
5	UA	48.7	5	CA	50.1
6	UD	46.7	6	UA	47.5
7	UC	41.8	7	UD	41.5
8	CA	31.6	8	UC	36.44
9	UB	27.6	9	RA	30.77
10	RA	27.3	10	UB	30.1

* Sustainability weighted 1/3; Target effects 2/3

Key:

UA - 9 M14 Rifles

UD - 9 M14E2 Rifles

UB - 7 M14 Rifles and 2 M14E2 AR

UC - 5 M14 Rifles and 2 M60 MG

SA - 9 Stoner Rifles

RC - 7 AK47 Rifles and 2 RPD MG

SB - 7 Stoner Rifles and 2 Stoner AR

SC - 7 Stoner Rifles and 2 Stoner MG

CA - 9 Colt Rifles

CB - 7 Colt Rifles and 2 Colt AR

RA - 9 AK47 Rifles

Mix RC results for Situation 5 are presented below.

CET	Near Misses	Percent Ammo Remaining	Targets Hit	Total Hits
41.41	167.80	51.60	5.72	6.12

EFFECTIVENESS MEASURES

COLLATERAL PERFORMANCE

A Cumulative Exposure Times

Mix	X̄ CET	SD	Standard Score z'
SA	38.6	2.5	74.2
CB	38.6	3.3	74.0
SC	39.5	2.9	63.1
SB	39.7	4.3	61.2
UA	40.2	4.2	54.3
UD	40.3	2.4	53.2
UC	40.7	2.4	48.6
UB	42.5	2.2	27.2
CA	42.6	3.2	25.5
RA	43.2	2.3	18.5
X̄	40.60		
σ	1.65		

B Number of Near Misses

Mix	X̄ Near Misses	SD	Standard Score z'
SA	207.3	43.4	90.9
SB	177.8	67.7	72.6
SC	164.2	63.0	64.1
CB	145.8	31.7	52.7
UA	130.3	51.6	43.1
UD	125.5	40.3	40.1
CA	121.5	51.5	37.6
RA	119.0	43.8	36.0
UC	117.1	29.7	34.9
UB	106.2	34.4	28.0
X̄	141.48		
σ	32.17		

C Sustainability (% Ammo Remaining)

Mix	X̄ % Remaining	SD	Standard Score z'	Sustainability Time (Min)
CA	84.8	3.7	87.1	26.3
CB	79.0	4.9	77.1	19.0
SA	68.0	9.6	58.3	12.5
SB	67.6	8.1	57.6	12.3
SC	60.4	12.6	45.3	10.1
UA	60.3	5.4	45.1	10.1
RA	55.9	9.6	37.6	9.1
UB	54.4	4.3	35.1	8.8
UD	52.1	2.7	31.2	8.4
UC	48.8	10.3	25.6	7.8
X̄	63.12			
σ	11.72			

D Number of Targets Hit

Mix	X̄ Targets Hit	SD	Standard Score z'
SA	8.9	1.7	79.1
CB	8.3	3.2	71.7
SC	7.9	2.9	67.2
SB	7.7	2.8	64.0
UD	6.5	2.5	50.0
UA	6.4	3.1	47.9
UC	5.6	2.2	38.8
CA	5.1	4.1	31.9
UB	5.0	2.5	31.0
RA	4.0	2.3	18.6
X̄	6.54		
σ	1.62		

E Tota

Mix	
SA	1
SB	
CB	
SC	
UD	
UA	
UC	
CA	
UB	
RA	
X̄	
σ	

F Target Effects

Mix	Standard Score Target Effects
SA	82.5
SB	66.9
SC	63.6
CB	63.3
UA	48.7
UD	46.7
UC	41.7
CA	31.5
UB	27.6
RA	27.3

G Overall Effectiveness

Mix	Overall Fire Effectiveness
SA	74.5
CB	67.9
SB	63.8
SC	57.5
CA	50.1
UA	47.5
UD	41.5
UC	36.4
RA	30.7
UB	30.1

H Cumulative Exposure Time

	SA	CB	SC	SB	UA	UD	UC	UB	CA	RA
SA		>.40	.39	.31	.22	.13	.09	.01	.02	.008
CB			.31	.32	.23	.16	.12	.02	.03	.02
SC				>.40	.37	.30	.22	.04	.05	.02
SB					>.40	.37	.31	.09	.10	.07
UA						>.40	>.40	.14	.15	.10
UD							>.40	.07	.10	.04
UC								.11	.14	.06
UB									>.40	.31
CA										.37

I Number of Near Mis

	SA	SB	SC	CB	UA	UD	C
SA		.19	.10	.01	.01	.004	.0
SB			.36	.16	.10	.07	.0
SC				.27	.17	.12	.1
CB					.27	.18	.1
UA						>40	.3
UD							>.4
CA							
RA							
UC							

J Sustainability (% Ammo Remaining)

	CA	CB	SA	SB	SC	UA	RA	UB	UD	UC
CA		.02	.002	.000	.001	.000	.001	.000	.000	.000
CB			.02	.009	.004	.000	.001	.000	.000	.000
SA				>.40	.13	.05	.03	.004	.002	.004
SB					.13	.05	.03	.004	.000	.004
SC						>.40	.26	.15	.08	.06
UA							.18	.03	.005	.02
RA								.37	.19	.14
UB									.15	.13
UD										.24

K No. of Targets Hit

	SA	CB	SC	SB	UD	UA	UC	CA	UB	RA
SA		.35	.25	.19	.04	.06	.01	.03	.005	.003
CB			>.40	.36	.16	.16	.07	.09	.04	.02
SC				>.40	.19	.19	.08	.10	.05	.02
SB					.24	.23	.10	.12	.06	.02
UD						>.40	.26	.24	.15	.06
UA							.33	.28	.21	.10
UC								.39	.33	.13
CA									>.40	.31
UB										.26

L Total Hits on Targ

	SA	SB	CB	SC	UD	UA	
SA		.24	.15	.15	.02	.02	.0
SB			>.40	>.40	.15	.13	.0
CB				>.40	.16	.14	.0
SC					.17	.15	.0
UD						>.40	.2
UA							.3
UC							
CA							
UB							

Note: Standard Scores computed from raw scores using scores to three decimal places.

UA - 9 M14 Rifles
UB - 7 M14 Rifles/2 M14E2 AR
UC - 5 M14 Rifles/2 M60 MG
UD - 9 M14E2 Rifles
CA - 9 Colt Rifles

CB - 7 Colt Rifles/2 Colt AR
SA - 9 Stoner Rifles
SB - 7 Stoner Rifles/2 Stoner AR
SC - 7 Stoner Rifles/2 Stoner MG
RA - 9 AK47 Rifles

X̄ - Mean (Average
SD - Standard Devia
CET - Cumulative Ex
z' - Standard Score

COLLATERAL PERFORMANCE MEASURES

Number of Targets Hit

Mix	$\bar{X}$ Targets Hit	SD	Standard Score z'
SA	8.9	1.7	79.1
CB	8.3	3.2	71.7
SC	7.9	2.9	67.2
SB	7.7	2.8	64.0
UD	6.5	2.5	50.0
UA	6.4	3.1	47.9
UC	5.6	2.2	38.8
CA	5.1	4.1	31.9
UB	5.0	2.5	31.0
RA	4.0	2.3	18.6
$\bar{X}$	6.54		
σ	1.62		

Total Hits on Targets

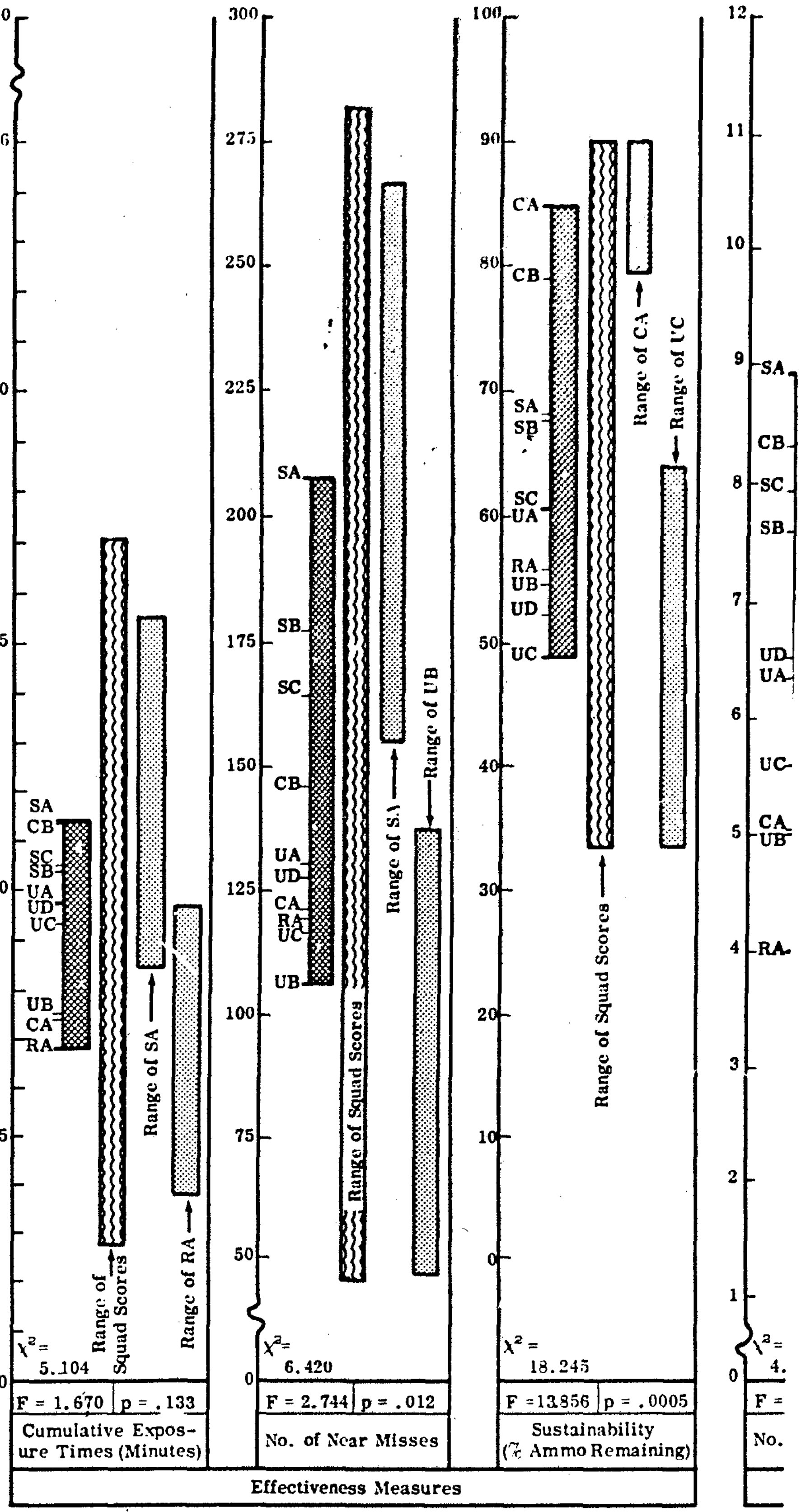
Mix	$\bar{X}$ Hits	SD	Standard Score z'
SA	10.2	2.4	83.2
SB	8.8	3.9	69.2
CB	8.5	3.2	65.6
SC	8.4	3.3	65.2
UD	6.7	2.7	47.9
UA	6.4	3.1	44.6
UC	5.6	2.2	37.2
CA	5.2	4.3	33.2
UB	5.0	2.5	30.9
RA	4.3	2.3	22.9
$\bar{X}$	6.91		
σ	1.98		

Number of Near Misses

	SA	SB	SC	CB	UA	UD	CA	RA	UC	UB
SA		.19	.10	.01	.01	.004	.006	.005	.002	.001
SB			.36	.16	.10	.07	.07	.07	.04	.02
SC				.27	.17	.12	.12	.11	.07	.04
CB					.27	.18	.18	.14	.07	.03
UA						>.40	.39	.35	.30	.18
UD							>.40	>.40	.35	.20
CA								>.40	>.40	.28
RA									>.40	.30
UC										.28

Total Hits on Targets

	SA	SB	CB	SC	UD	UA	UC	CA	UB	RA
SA		.24	.15	.15	.02	.02	.004	.02	.03	.02
SB			>.40	>.40	.15	.13	.06	.08	.04	.02
CB				>.40	.16	.14	.05	.09	.03	.02
SC					.17	.15	.06	.09	.04	.02
UD						>.40	.24	.25	.14	.07
UA							.33	.31	.21	.12
UC								>.40	.33	.16
CA									>.40	.32
UB										.30



dt AR

Stoner AR
Stoner MG

$\bar{X}$ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposure Time
z' - Standard Score (X = 50, SD = 20)

Figure 6-11 SUMMARY OF RESULTS--S

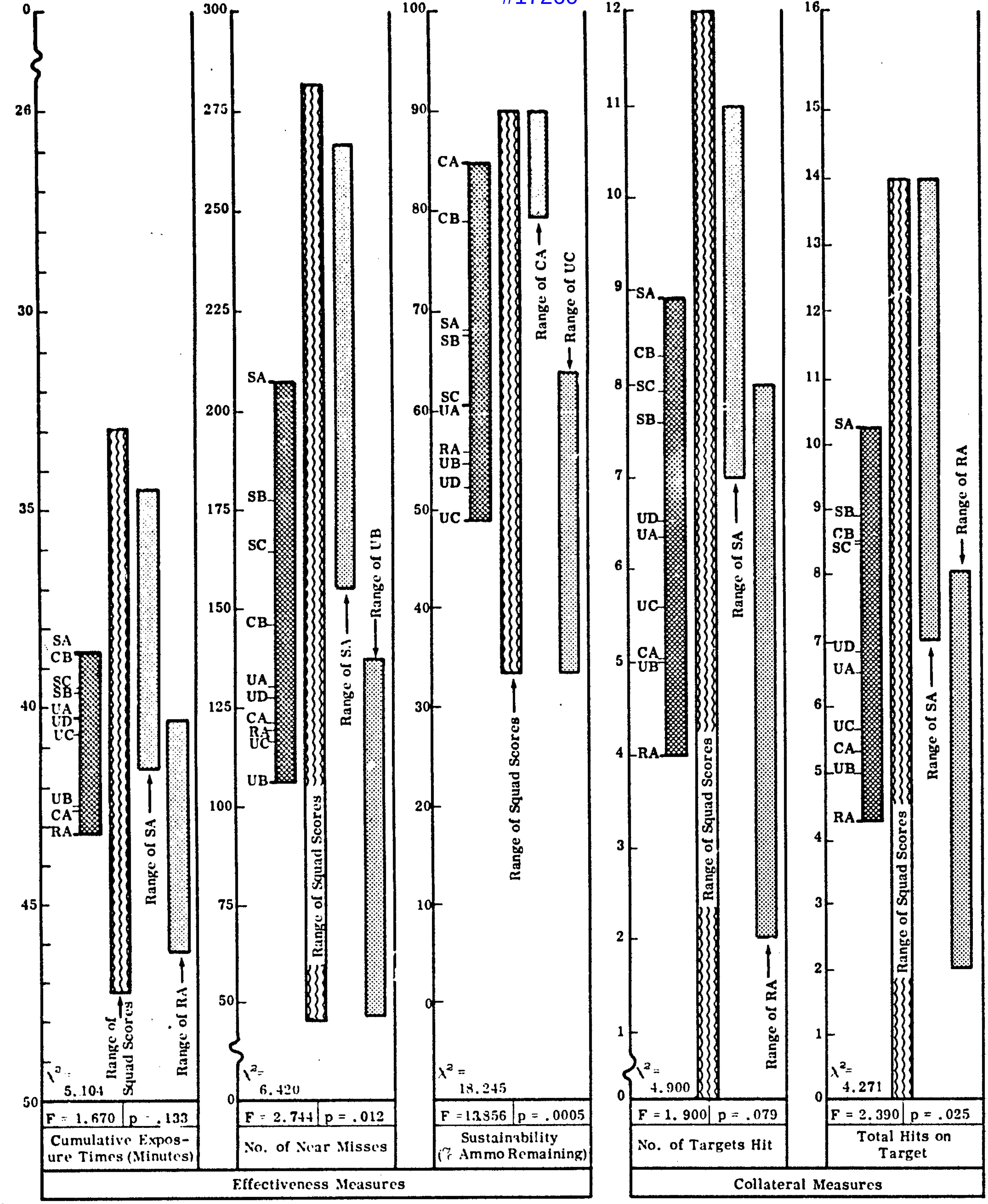


Figure 6-11 SUMMARY OF RESULTS--SITUATION 5

BLANK PAGE

EFFECTIVENESS MEASURES

A — Cumulative Exposure Times

Mix	X̄ CET	SD	Standard Score z'
CB	18.6	1.9	76.9
SA	18.6	1.7	72.1
SB	19.2	1.9	65.6
UA	19.4	2.0	59.8
UD	19.8	2.0	52.2
SC	19.9	2.5	50.5
UC	20.2	2.4	44.3
UB	20.7	1.4	34.6
CA	20.8	1.8	31.8
RA	21.8	1.3	12.7
X̄	19.93		
σ	.993		

B — Number of Near Misses

Mix	X̄ Near Misses	SD	Standard Score z'
SA	125.7	48.5	82.4
SB	120.3	48.8	77.2
CB	109.0	25.2	66.3
SC	100.5	43.0	58.1
UA	89.9	38.9	47.9
CA	83.3	35.1	41.5
UD	80.0	29.1	38.3
RA	72.2	27.6	30.8
UC	70.3	26.4	29.0
UB	70.0	22.8	28.7
X̄	92.13		
σ	20.73		

C — Sustainability (% Ammo Remaining)

Mix	X̄ % Remaining	SD	Standard Score z'
CA	85.9	3.8	87.4
CB	80.6	5.8	77.0
SA	71.1	5.1	59.6
SB	70.6	7.0	57.5
SC	65.3	12.0	47.2
UA	63.7	7.5	44.1
RA	59.0	7.4	35.0
UD	57.8	2.7	30.8
UB	57.5	4.5	32.1
UC	55.7	6.2	28.6
X̄	66.71		
σ	10.28		

COLLATERAL PERFORMA

D — Number of Targets Hit

Mix	X̄ Targets Hit	SD	Standard Score z'
CB	5.3	2.1	79.0
SB	5.0	0.9	73.1
SA	4.6	1.0	64.7
SC	4.4	1.8	62.0
UA	4.1	2.1	54.9
UD	3.6	1.9	46.3
CA	3.2	2.2	38.4
UB	3.0	1.5	33.9
UC	2.8	2.0	30.0
RA	2.2	1.6	18.2
X̄	3.82		
σ	1.016		

F — Target Effects

Mix	Standard Score Target Effects
SA	77.3
CB	71.6
SB	71.4
SC	54.3
UA	53.9
UD	45.3
UC	36.7
CA	36.7
UB	31.7
RA	21.7

G — Overall Effectiveness

Mix	Overall Fire Effectiveness
CB	73.4
SA	71.0
SB	66.8
CA	53.6
SC	51.9
UA	50.6
UD	41.0
UC	34.0
UB	31.8
RA	26.2

H — Cumulative Exposure Time

	CB	SA	SB	UA	UD	SC	UC	UB	CA	RA
CB		>.40	.31	.28	.26	.11	.11	.03	.03	.006
SA			.38	.33	.19	.14	.14	.03	.04	.003
SB				>.40	.29	.23	.21	.07	.08	.02
UA					>.40	.37	.31	.18	.17	.06
UD						>.40	.39	.20	.19	.05
SC							>.40	.18	.18	.03
UC								.34	.31	.11
UB									>.40	.10
CA										.17

I — Number of Near

	SA	SB	CB	SC	UA	CA
SA		>.40	.24	.18	.10	.06
SB			.29	.21	.11	.07
CB				.34	.17	.05
SC					.33	.2
UA						.38
CA						
UD						
RA						
UC						

J — Sustainability (% Ammo Remaining)

	CA	CB	SA	SB	SC	UA	RA	UD	UB	UC
CA		.05	.000	.000	.002	.000	.001	.000	.000	.000
CB			.008	.01	.01	.001	.001	.000	.000	.000
SA				>.40	.15	.04	.006	.000	.000	.000
SB					.19	.07	.02	.002	.003	.003
SC						>.40	.17	.08	.09	.06
UA							.16	.05	.06	.04
RA								.36	.35	.23
UD									>.40	.24
UB										.29

K — No. of Targets Hit

	CB	SB	SA	SC	UA	UD	CA	UB	UC	RA
CB		.38	.23	.23	.16	.09	.06	.03	.03	.02
SB			.23	.26	.17	.08	.05	.01	.02	.004
SA				>.40	.30	.16	.10	.03	.04	.01
SC					.38	.24	.16	.09	.09	.03
UA						.36	.26	.17	.15	.07
UD							.37	.27	.24	.11
CA								>.40	.37	.20
UB									>.40	.21
UC										.30

L — Total Hits on T

	SB	CB	SA	SC	UA	UD
SB		>.40	.32	.24	.09	.08
CB			.37	.29	.14	.11
SA				.39	.19	.15
SC					.28	.2
UA						>.40
UD						
CA						
UB						
UC						

Note: Standard Scores computed from raw scores using scores to three decimal places.

UA - 9 M14 Rifles
UB - 7 M14 Rifles/2 M14E2 AR
UC - 5 M14 Rifles/2 M60 MG
UD - 9 M14E2 Rifles
CA - 9 Colt Rifles

CB - 7 Colt Rifles/2 Colt AR
SA - 9 Stoner Rifles
SB - 7 Stoner Rifles/2 Stoner AR
SC - 7 Stoner Rifles/2 Stoner MG
RA - 9 AK47 Rifles

X̄ - Mean (Aver
SD - Standard De
CET - Cumulative
z' - Standard Sc

COLLATERAL PERFORMANCE MEASURES

Number of Targets Hit

Mix	$\bar{X}$ Targets Hit	SD	Standard Score z'
CB	5.3	2.1	79.0
SB	5.0	0.9	73.1
SA	4.6	1.0	64.7
SC	4.4	1.8	62.0
UA	4.1	2.1	54.9
UD	3.6	1.9	46.3
CA	3.2	2.2	38.4
UB	3.0	1.5	33.9
UC	2.8	2.0	30.0
RA	2.2	1.6	18.2
$\bar{X}$	3.82		
σ	1.016		

Total Hits on Targets

Mix	$\bar{X}$ Hits	SD	Standard Score z'
SB	5.5	1.4	75.9
CB	5.5	2.2	75.4
SA	5.1	1.7	68.6
SC	4.8	2.0	63.5
UA	4.1	2.1	48.9
UD	3.8	2.3	47.1
CA	3.2	2.5	37.4
UB	3.0	1.5	33.5
UC	2.8	2.0	30.1
RA	2.2	1.6	20.0
$\bar{X}$	3.99		
σ	1.18		

Number of Near Misses

	SA	SB	CB	SC	UA	CA	UD	RA	UC	UB
A		>.40	.24	.18	.10	.06	.04	.03	.02	.02
B			.29	.21	.11	.07	.04	.03	.02	.02
B				.34	.17	.09	.05	.02	.02	.01
C					.33	.23	.18	.12	.09	.08
A						.38	.32	.21	.17	.15
A							>.40	.29	.24	.23
D								.33	.28	.26
A									>.40	>.40
C										>.40

Total Hits on Targets

	SB	CB	SA	SC	UA	UD	CA	UB	UC	RA
3		>.40	.32	.24	.09	.08	.04	.009	.01	.004
B			.37	.29	.14	.11	.07	.02	.03	.01
\				.39	.19	.15	.09	.03	.03	.01
:					.28	.23	.14	.06	.06	.02
\						>.40	.27	.17	.15	.07
)							.35	.25	.22	.11
\								>.40	.38	.23
3									>.40	.21
:										.30

AR
ier AR
ier MG

$\bar{X}$ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposure Time
z' - Standard Score ($\bar{X}$ = 50, SD = 20)

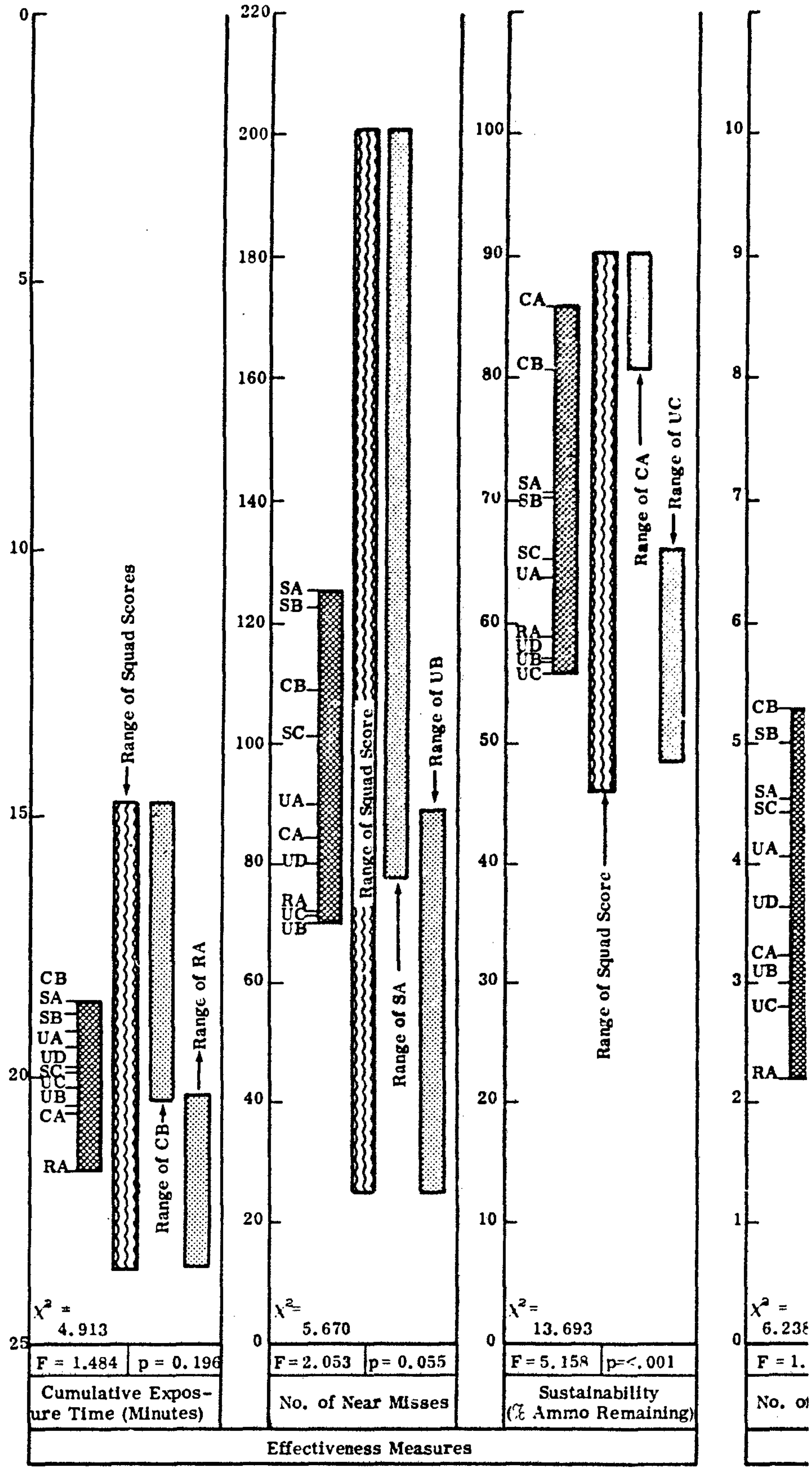


Figure 6-12 SUMMARY OF RESULTS--SITUATI

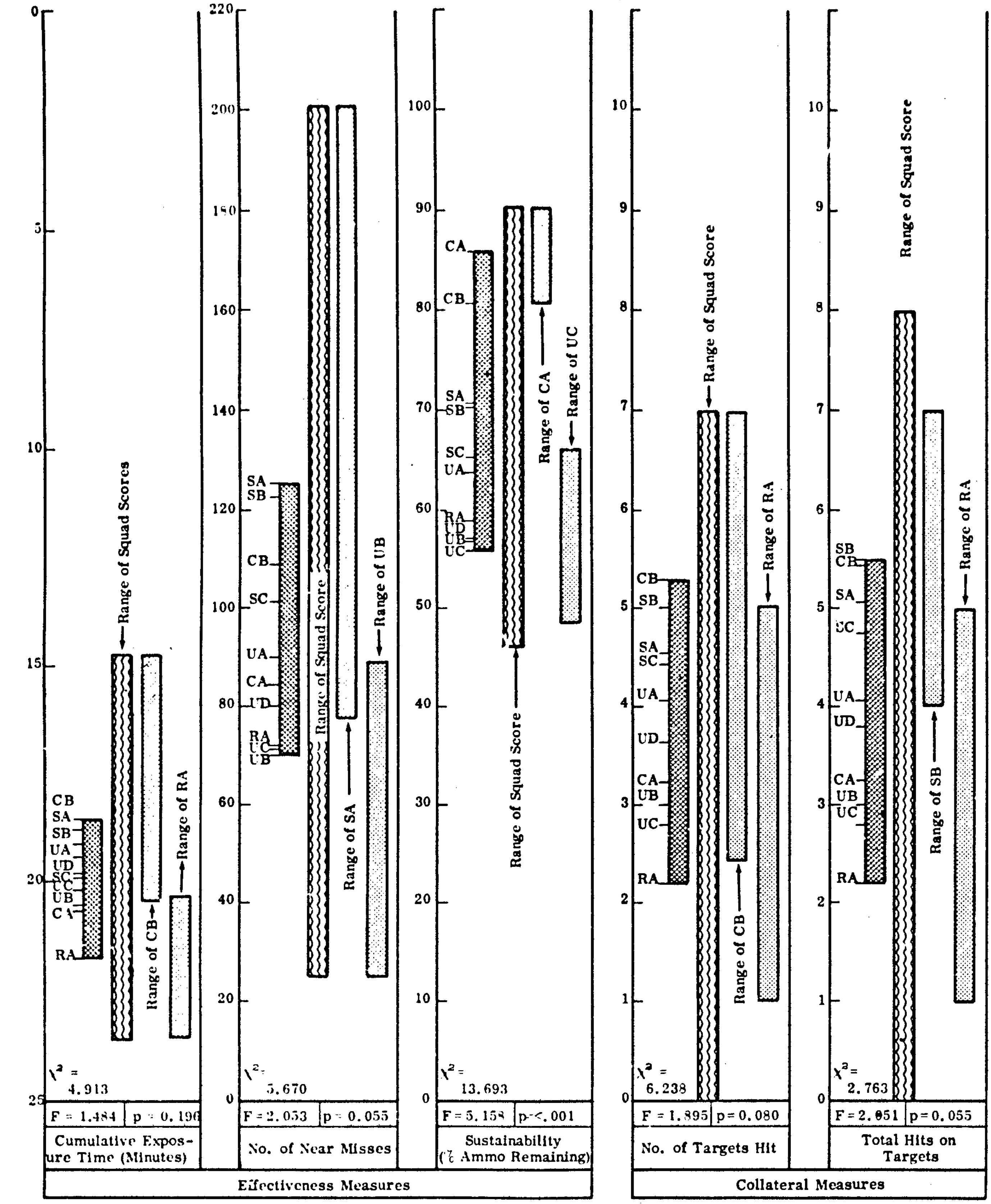


Figure 6-12 SUMMARY OF RESULTS--SITUATION 5 (ARRAY X)

BLANK PAGE

EFFECTIVENESS MEASURES

COLLATERAL PE

A Cumulative Exposure Times

Mix	X̄ CET	SD	Standard Score z'
SC	19.7	1.7	75.1
SA	19.8	2.1	72.5
CB	20.0	1.8	65.8
UA	20.4	2.0	57.0
UC	20.5	2.2	53.4
SB	20.5	2.9	53.1
UD	20.5	2.9	53.1
RA	21.4	1.5	30.6
UB	21.8	1.3	20.3
CA	21.8	1.8	20.3
X̄	20.64		
σ	0.77		

B Number of Near Misses

Mix	X̄ Near Misses	SD	Standard Score z'
SA	81.7	11.2	94.7
SC	63.7	23.0	69.8
SB	57.5	27.8	61.3
UC	46.8	21.1	46.5
RA	46.8	20.9	46.4
UD	45.5	23.8	44.6
UA	40.5	16.1	37.7
CA	38.2	20.7	34.5
CB	36.8	18.4	32.6
UB	36.2	17.2	31.7
X̄	49.36		
σ	14.44		

C Sustainability (% Ammo Remaining)

Mix	X̄ % Remaining	SD	Standard Score z'	Sustainability Time (Min)
CA	83.7	4.0	86.5	24.5
CB	77.5	4.3	77.1	17.9
SA	65.0	13.9	58.1	11.4
SB	64.6	9.3	57.5	11.3
UA	56.9	6.4	45.8	9.3
SC	55.5	13.8	43.8	9.0
RA	52.7	12.9	39.5	8.5
UB	52.1	5.3	38.5	8.4
UD	46.4	5.2	30.0	7.5
UC	42.0	14.9	23.2	6.9
X̄	59.63			
σ	13.19			

D Number of Targets Hit

Mix	X̄ Targets Hit	SD	Standard Score z'
SA	4.3	1.4	91.3
SC	3.5	1.2	69.8
CB	3.0	1.8	56.9
UD	2.9	1.0	54.3
UC	2.8	1.7	52.5
SB	2.7	2.0	48.4
UA	2.3	1.5	38.8
UB	2.0	1.4	31.0
CA	2.0	2.0	31.0
RA	1.8	0.8	25.9
X̄	2.73		
σ	0.77		

F Target Effects

Mix	Standard Score Target Effects
SA	83.6
SC	72.5
SB	57.2
UC	50.0
CB	49.2
UD	48.9
UA	47.4
RA	38.5
CA	27.4
UB	26.0

G Overall Effectiveness

Mix	Overall Fire Effectiveness
SA	75.1
SC	62.9
CB	58.5
SB	57.3
CA	47.1
UA	46.8
UD	42.6
UC	41.0
RA	38.8
UB	30.2

H Cumulative Exposure Time

	SC	SA	CB	UA	UC	SB	UD	RA	UB	CA
SC		>.40	.34	.27	.22	.25	.13	.05	.02	.03
SA			>.40	.33	.28	.31	.22	.09	.04	.05
CB				.39	.35	.37	.28	.11	.04	.06
UA					>.40	>.40	>.40	.22	.12	.14
UC						>.40	>.40	.29	.13	.15
SB							>.40	.28	.17	.19
UD								.13	.04	.08
RA									.32	.25
UB										>.40

I Numbe

	SA	SC	SB	UC
SA		.06	.04	.004
SC			.34	.11
SB				.24
UC				
RA				
UD				
UA				
CA				
CB				

J Sustainability (% Ammo Remaining)

	CA	CB	SA	SB	UA	SC	RA	UB	UD	UC
CA		.02	.005	.000	.000	.000	.001	.000	.000	.000
CB			.03	.007	.000	.003	.001	.000	.000	.000
SA				>.40	.11	.03	.09	.03	.007	.01
SB					.07	.11	.06	.01	.002	.006
UA						>.40	.25	.10	.006	.03
SC							.37	.29	.08	.07
RA								>.40	.15	.12
UB									.05	.08
UD										.25

K No. of Targets Hit

	SA	SC	CB	UD	UC	SB	UA	UB	CA	RA
SA		.15	.09	.04	.07	.06	.02	.01	.02	.004
SC			.29	.19	.23	.20	.09	.04	.08	.02
CB				>.40	>.40	.38	.25	.16	.19	.11
UD					>.40	>.40	.22	.12	.17	.04
UC						>.40	.29	.19	.23	.13
SB							.37	.26	.29	.19
UA								.37	.39	.27
UB									>.40	>.40
CA										>.40

L Total

	SA	SC	SB	CB
SA		.08	.10	.04
SC			>.40	.25
SB				>.40
CB				
UD				
UC				
UA				
RA				
UB				

Note: Standard Scores computed from raw scores using scores to three decimal places.

UA - 9 M14 Rifles
UB - 7 M14 Rifles/2 M14E2 AR
UC - 5 M14 Rifles/2 M60 MG
UD - 9 M14E2 Rifles
CA - 9 Colt Rifles

CB - 7 Colt Rifles/2 Colt AR
SA - 9 Stoner Rifles
SB - 7 Stoner Rifles/2 Stoner AR
SC - 7 Stoner Rifles/2 Stoner MG
RA - 9 AK47 Rifles

X̄ - M
SD - St
CET - C
z' - St

COLLATERAL PERFORMANCE MEASURES

Number of Targets Hit

D

Mix	$\overline{X}$ Targets Hit	SD	Standard Score Z'
SA	4.3	1.4	91.3
SC	3.5	1.2	69.8
CB	3.0	1.8	56.9
UD	2.9	1.0	54.3
UC	2.8	1.7	52.5
SB	2.7	2.0	48.4
UA	2.3	1.5	38.8
UB	2.0	1.4	31.0
CA	2.0	2.0	31.0
RA	1.8	0.8	25.9
$\overline{X}$	2.73		
σ	0.77		

Total Hits on Targets

E

Mix	$\overline{X}$ Hits	SD	Standard Score Z'
SA	5.2	1.9	95.7
SC	3.7	1.4	65.2
SB	3.3	2.7	58.3
CB	3.0	1.8	51.6
UD	2.9	1.0	49.6
UC	2.8	1.7	48.2
UA	2.3	1.5	37.4
RA	2.0	0.7	31.3
UB	2.0	1.4	31.3
CA	2.0	2.0	31.3
$\overline{X}$	2.92		
σ	0.98		

Number of Near Misses

I

CA		SA	SC	SB	UC	RA	UD	UA	CA	CB	UB
.03	SA		.06	.04	.004	.004	.004	.001	.001	.000	.001
.05	SC			.34	.11	.12	.11	.04	.04	.02	.02
.06	SB				.24	.25	.22	.11	.10	.08	.07
.14	UC					>.40	>.40	.29	.24	.20	.18
.15	RA						>.40	.29	.26	.21	.19
.19	UD							.34	.29	.25	.23
.08	UA								>.40	.36	.33
.25	CA									>.40	>.40
.40	CB										>.40

Total Hits on Targets

L

RA		SA	SC	SB	CB	UD	UC	UA	RA	UB	CA
004	SA		.08	.10	.04	.02	.03	.01	.004	.005	.01
02	SC			>.40	.25	.15	.19	.07	.02	.03	.06
11	SB				>.40	.36	.36	.22	.15	.15	.18
04	CB					>.40	>.40	.25	.14	.16	.19
13	UD						>.40	.22	.07	.12	.17
19	UC							.29	.17	.19	.23
27	UA								.35	.37	.39
40	RA									>.40	>.40
40	UB										>.40

2 Colt AR
s
s/2 Stoner AR
s/2 Stoner MG

$\overline{X}$ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposure Time
z' - Standard Score ($\overline{X}$ = 50, SD = 20)

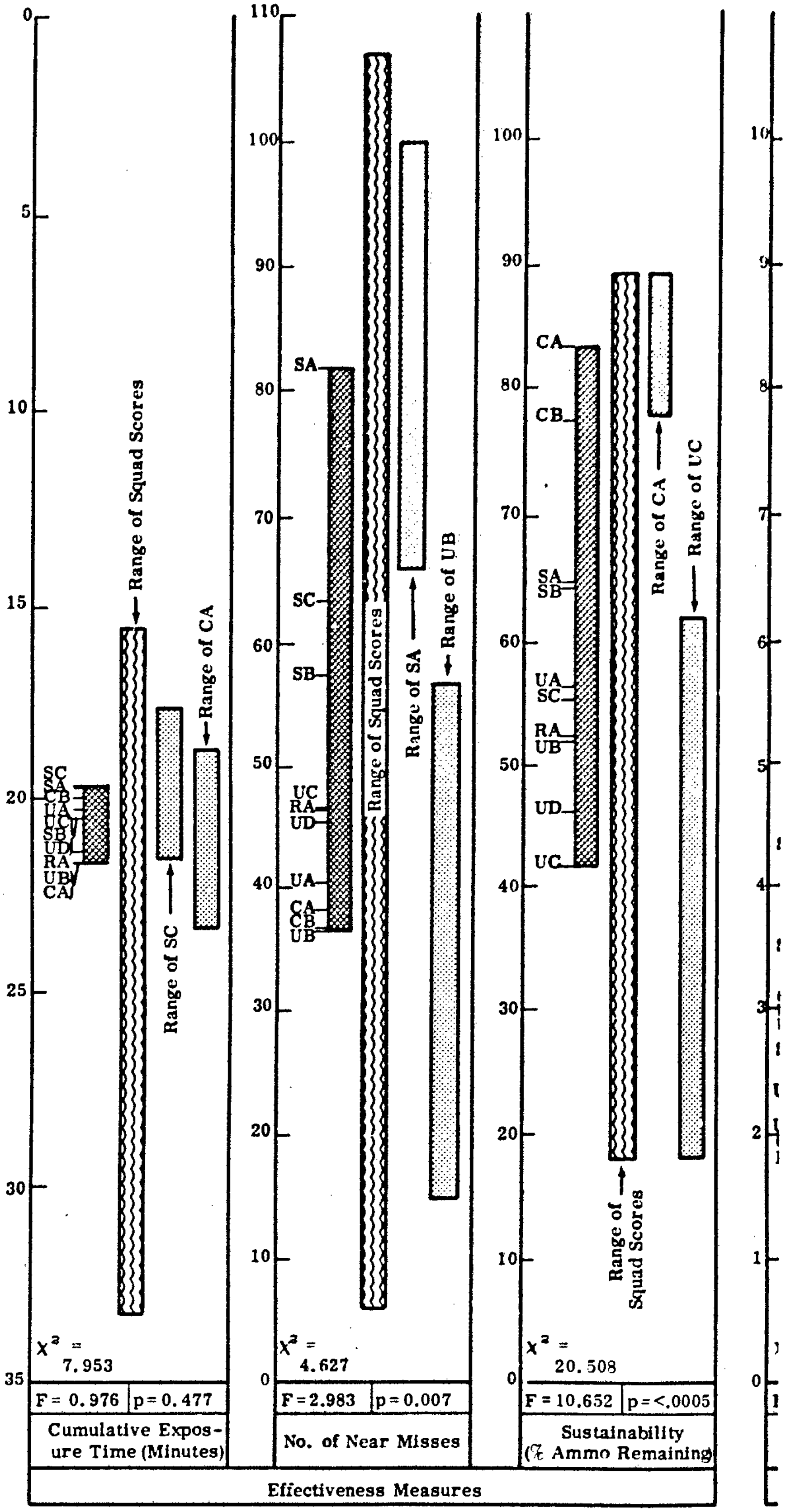


Figure 6-13 SUMMARY OF RESULTS--SITI

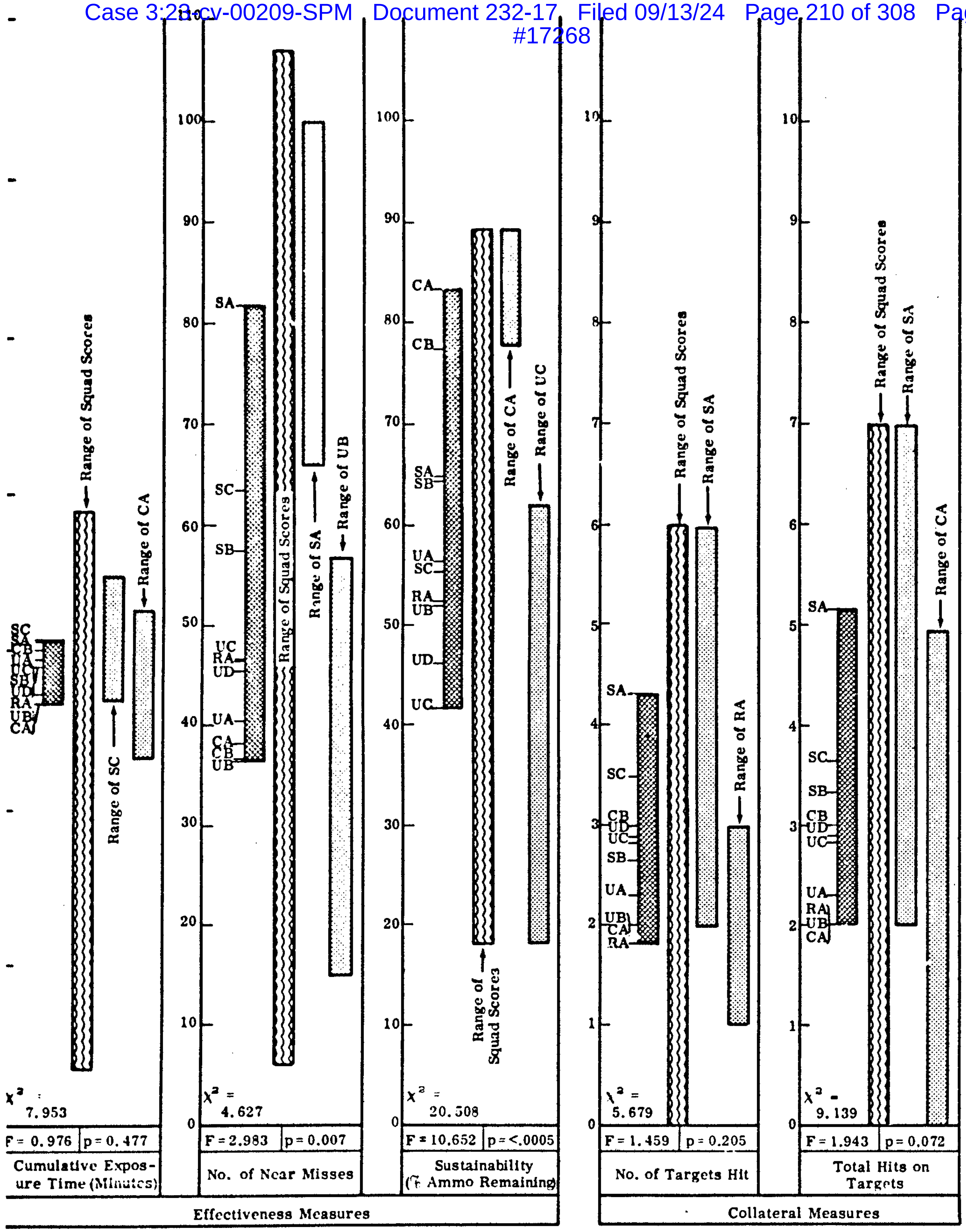


Figure 6-13 SUMMARY OF RESULTS--SITUATION 5 (ARRAY Y)

BLANK PAGE

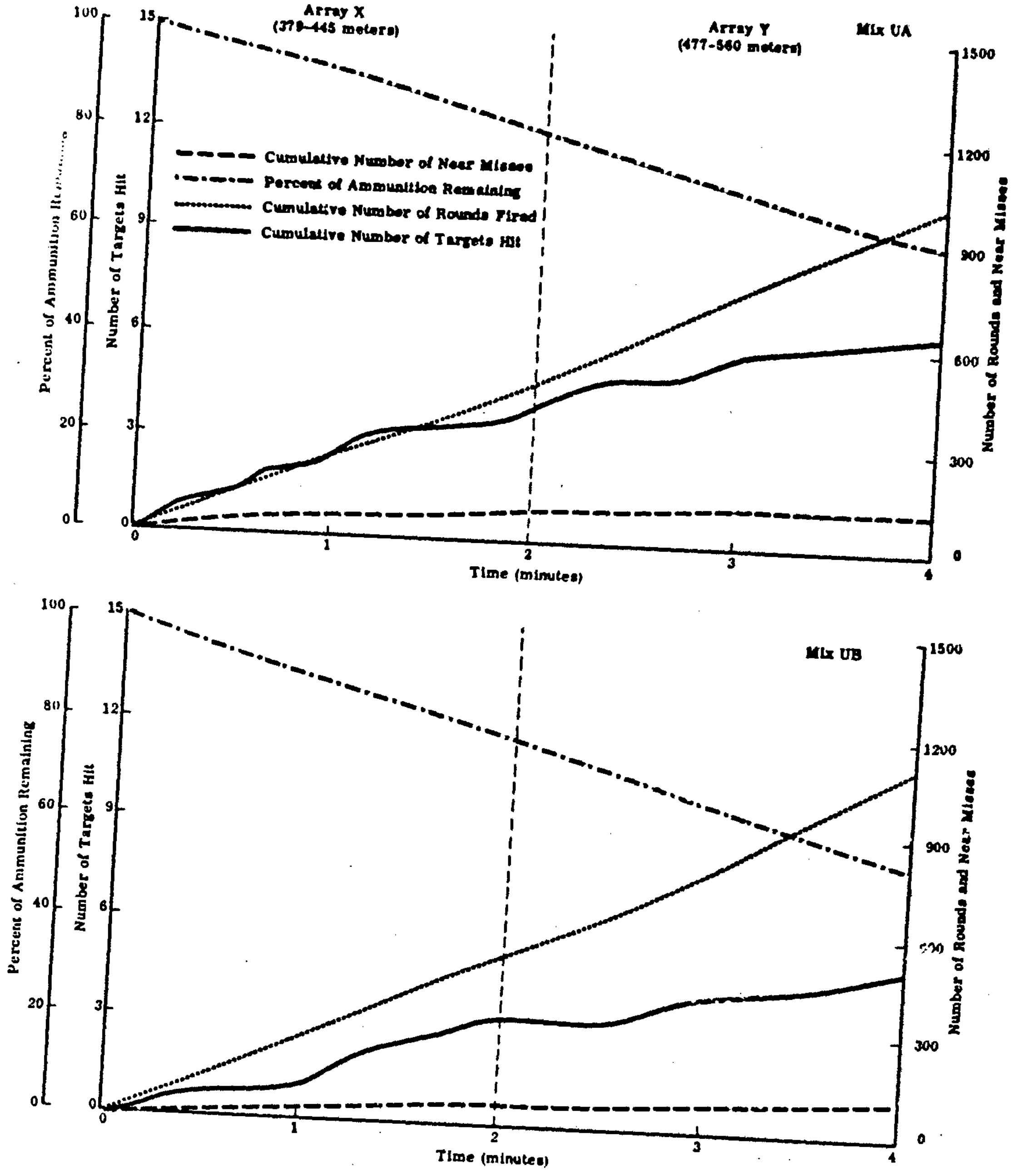
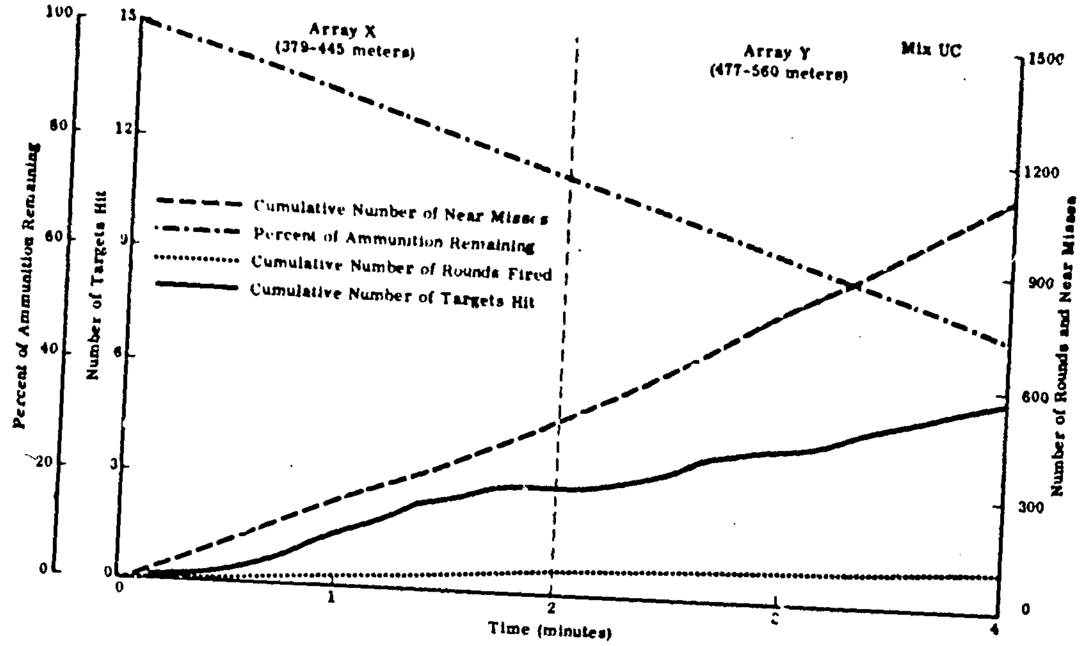


Figure 6-14 CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 5



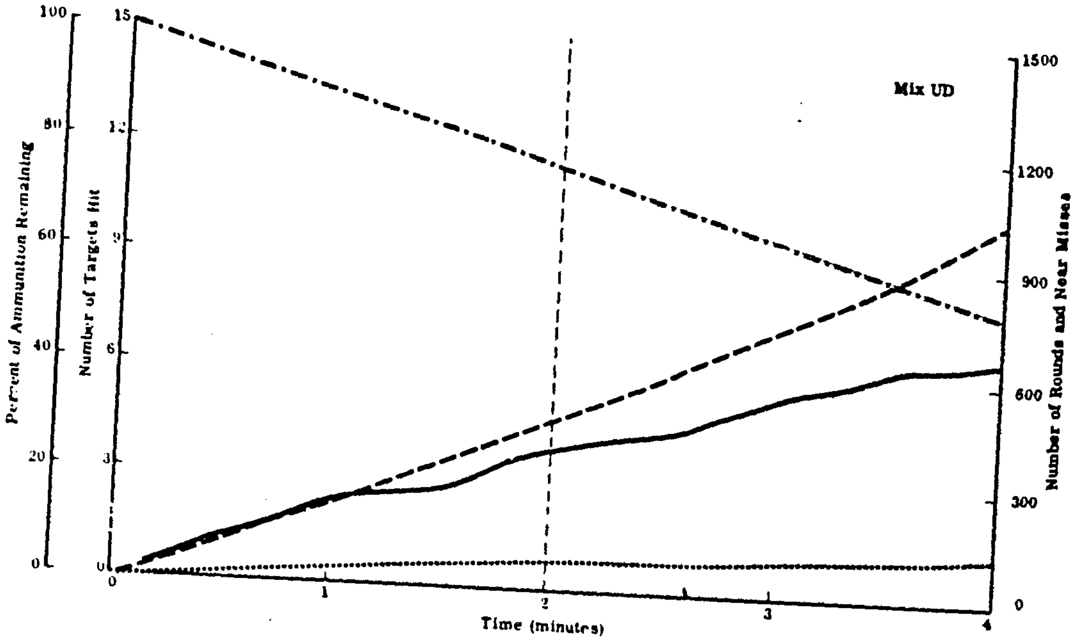


Figure 6-14 (Continued)

CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 5

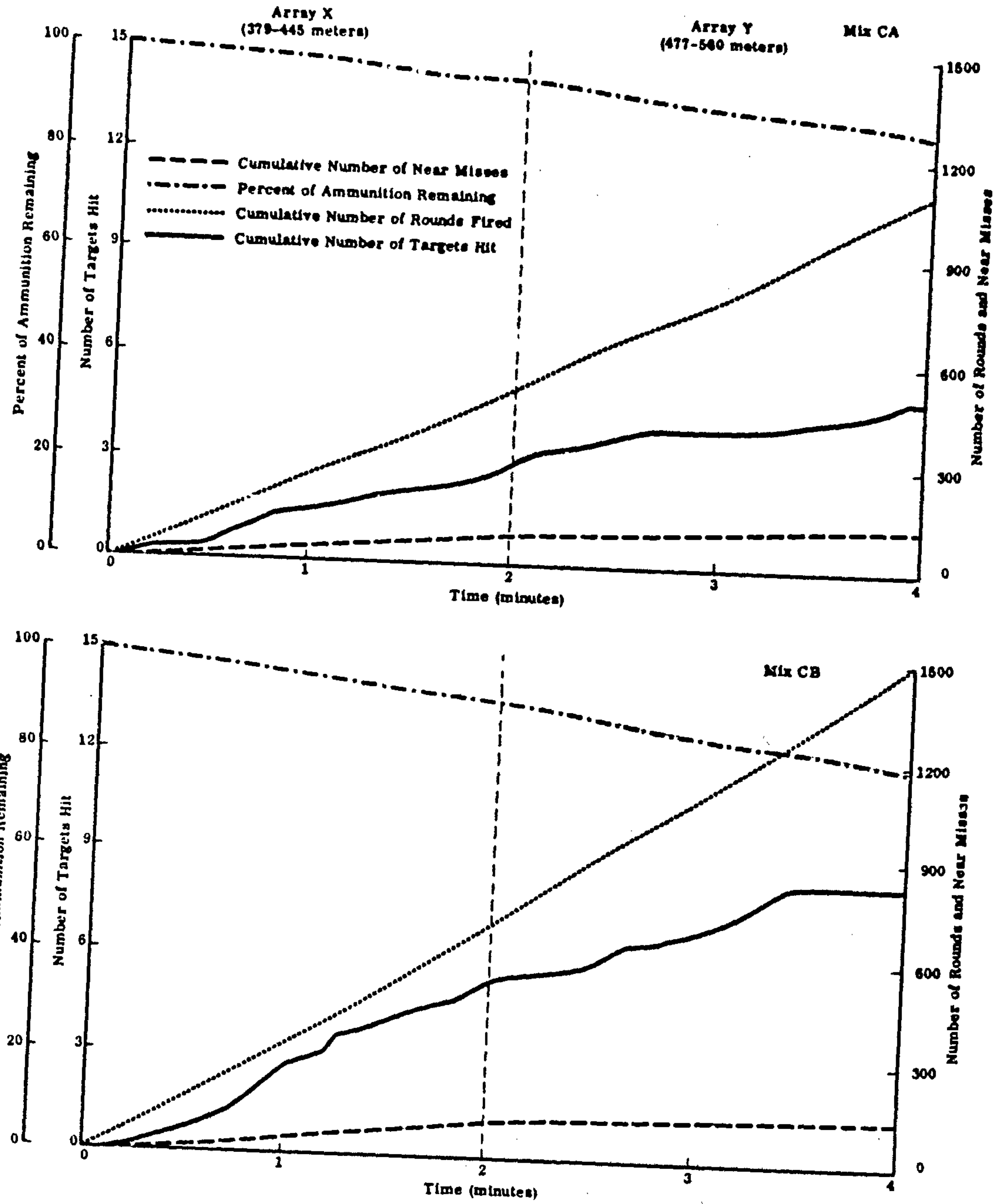
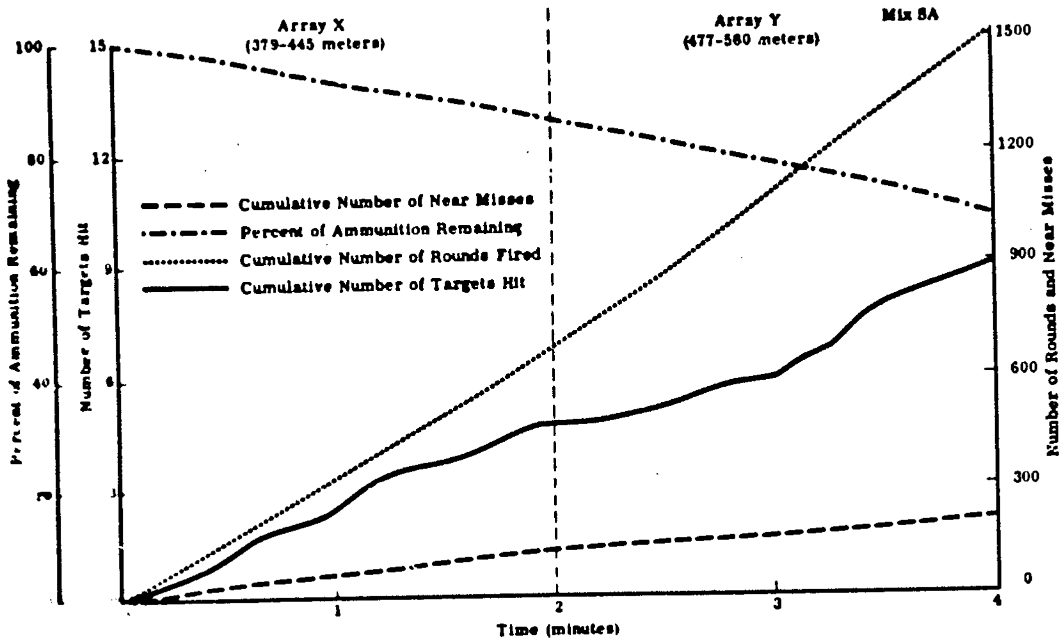


Figure 6-14 (Continued)

CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 5



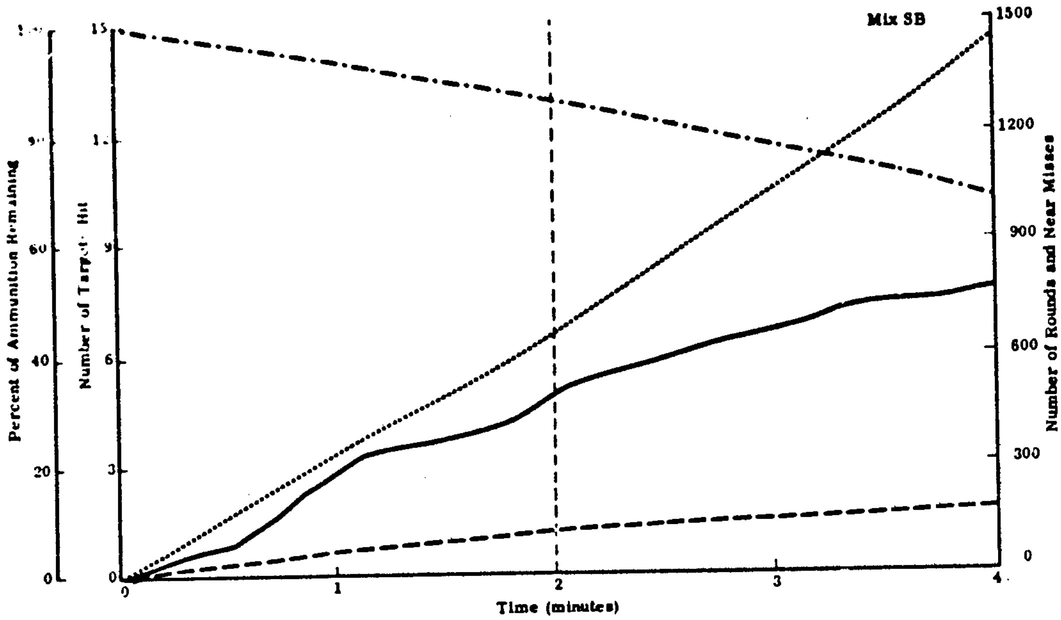


Figure 6-14 (Continued)

CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 5

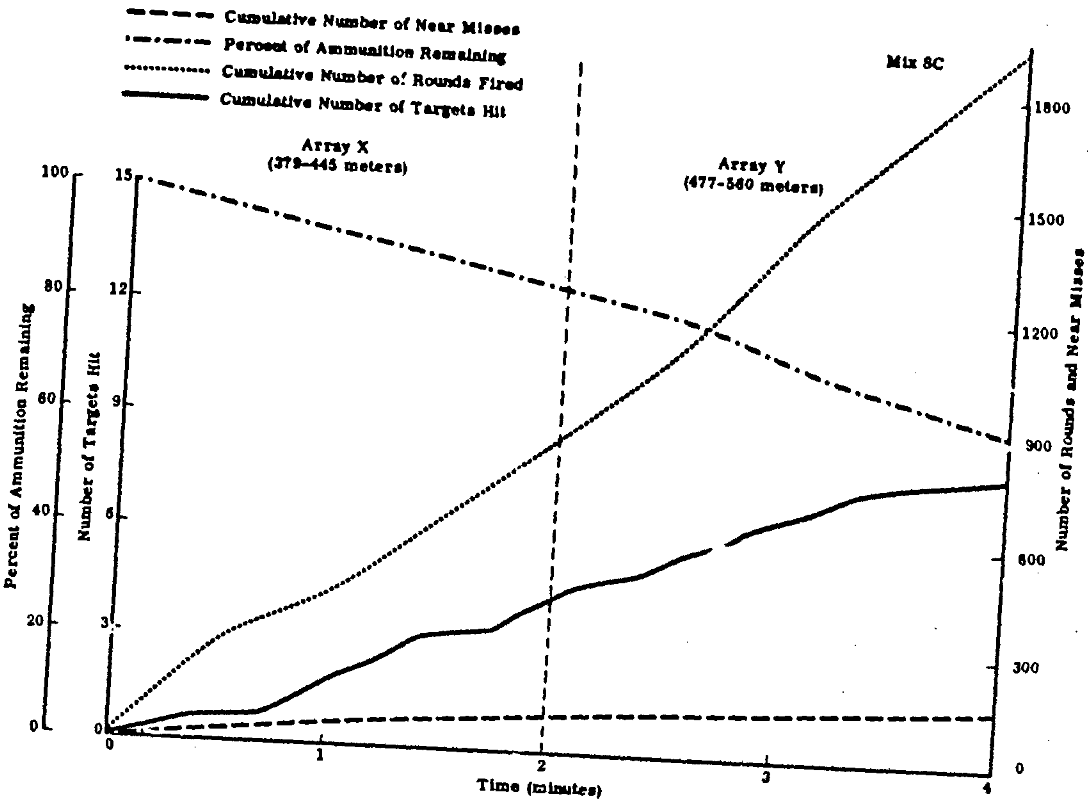
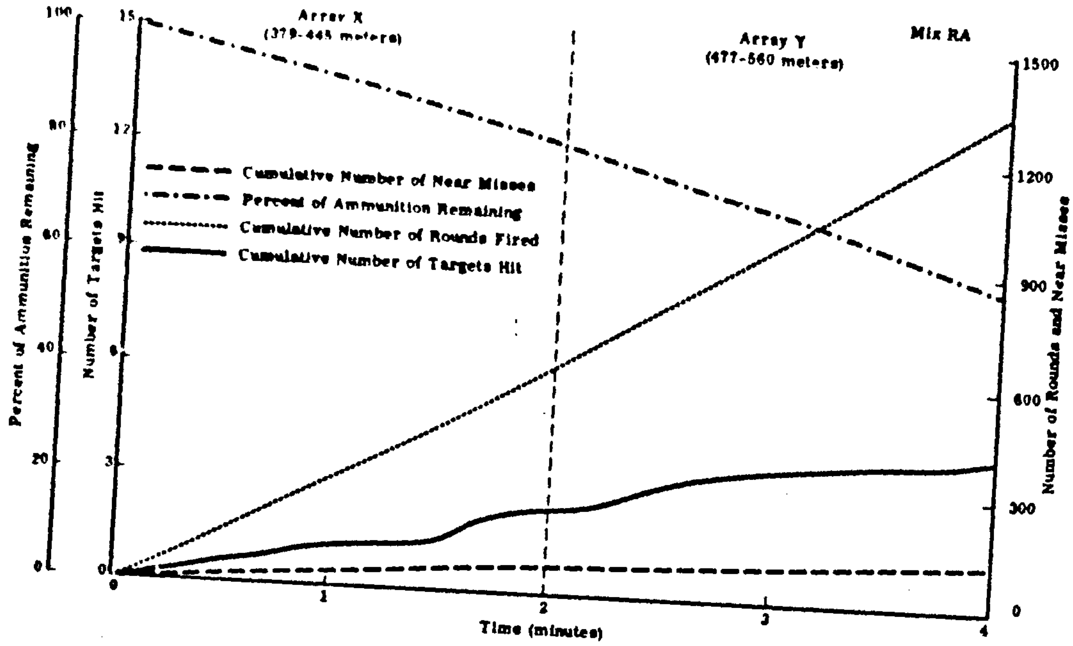


Figure 6-14 (Continued)

CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 5



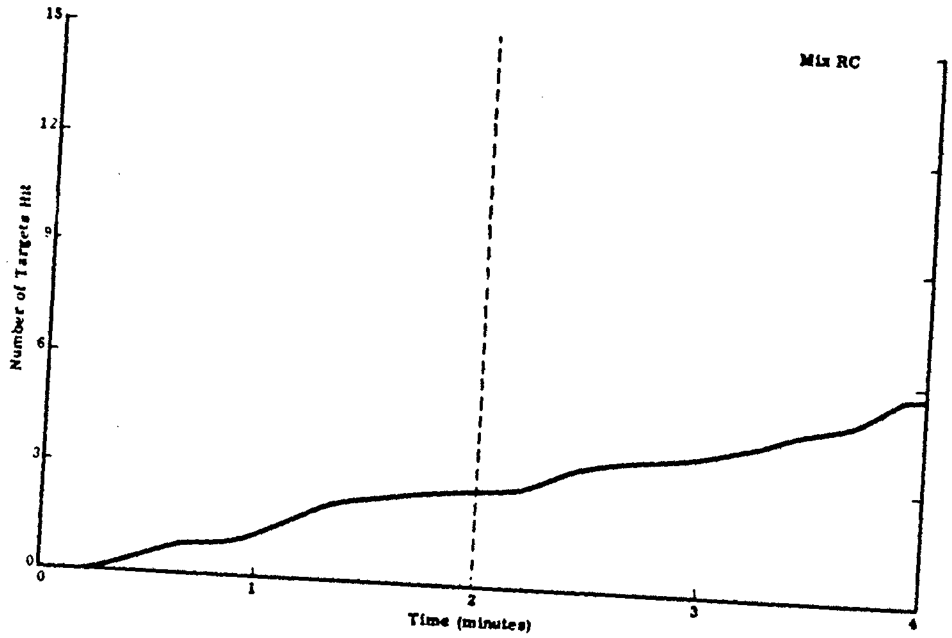


Figure 6-14 (Concluded)

CUMULATIVE NUMBER OF ROUNDS FIRED, TARGETS HIT, NEAR MISSES, AND PERCENT OF AMMUNITION REMAINING--SITUATION 5

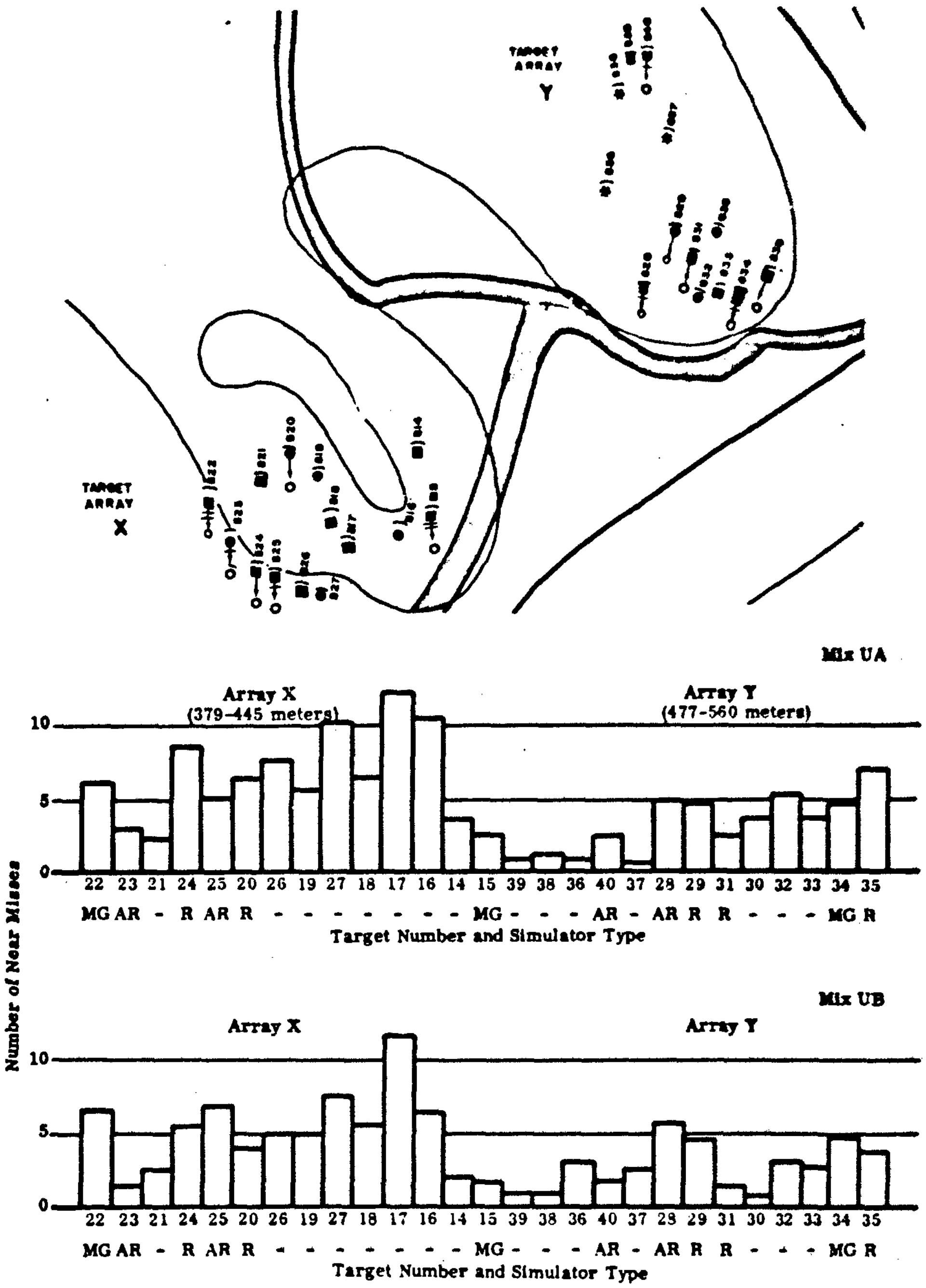


Figure 6-15 NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 5

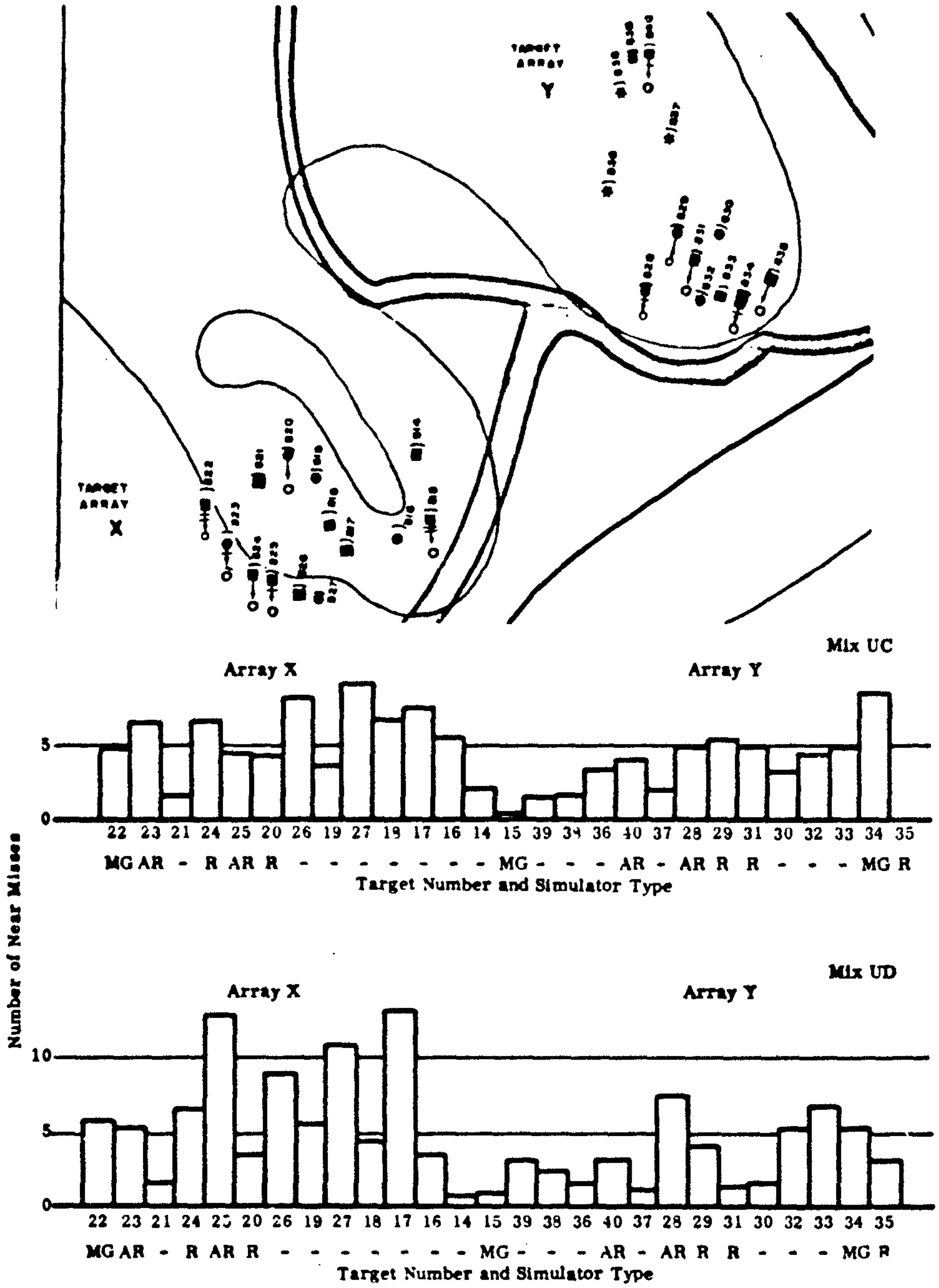


Figure 6-15 (Continued) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 5

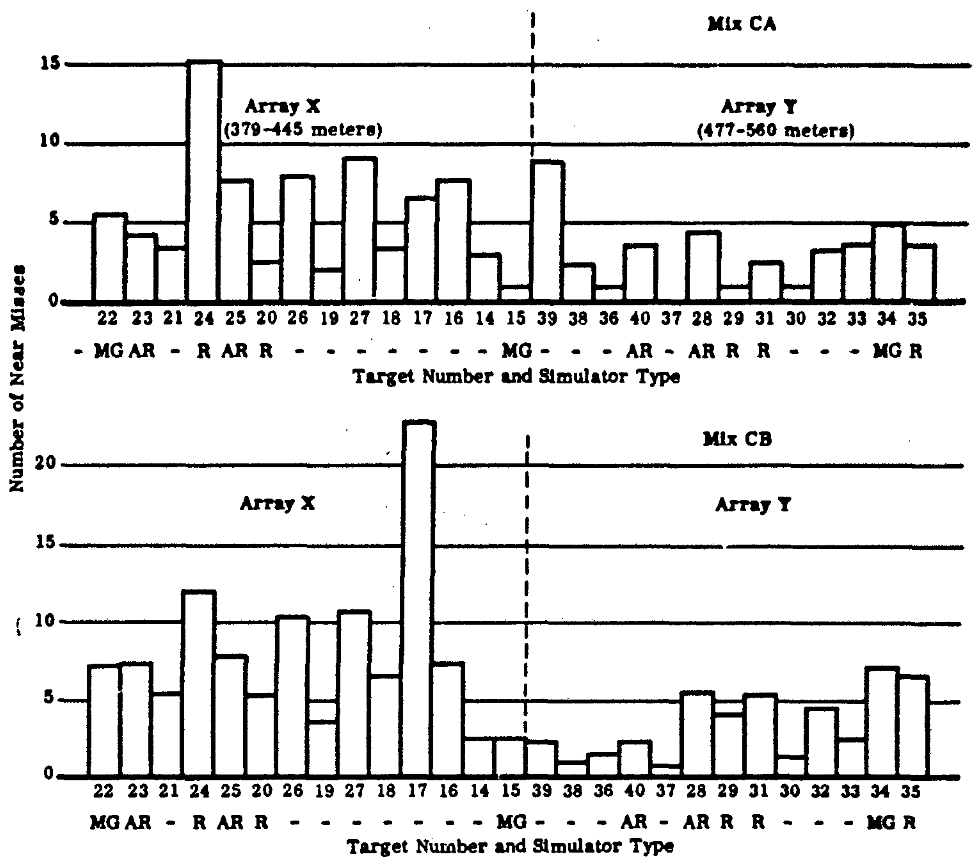


Figure 6-15 (Continued) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 5

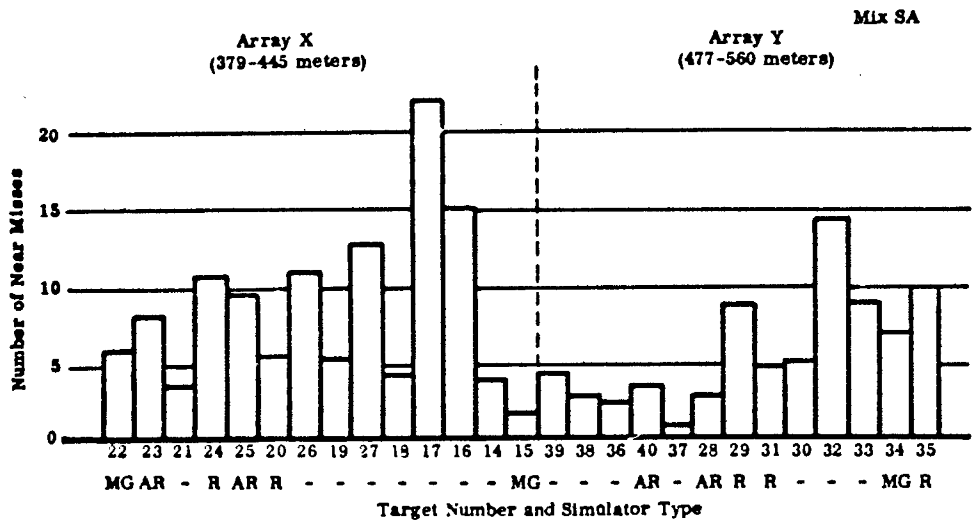


Figure 6-15 (Continued) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 5

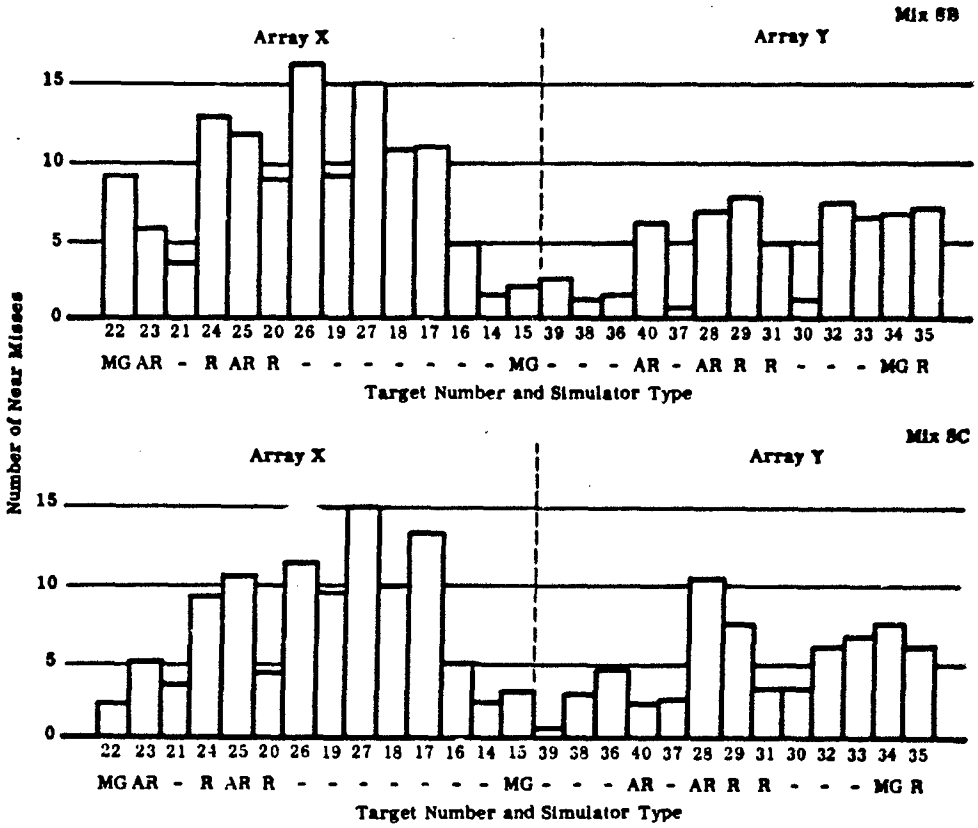


Figure 6-15 (Continued) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 5

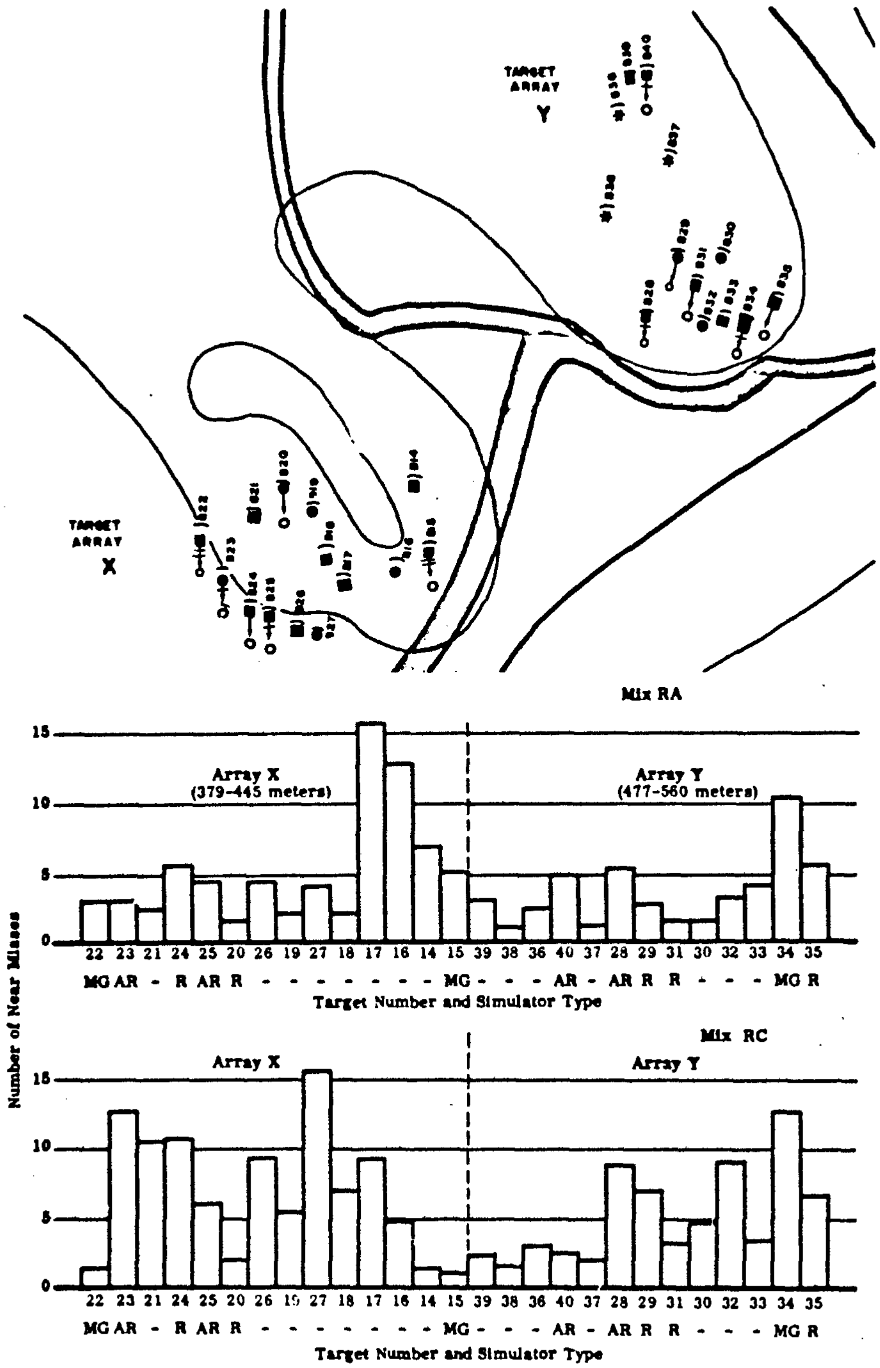


Figure 6-15 (Concluded) NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 5

5. Situation 7: Rifle Squad in Defense Against Attack

Rifle squad weapon mixes fired from hastily prepared foxholes at enemy targets appearing at ranges from 345 meters to 45 meters. Targets appeared in sequence, with long range targets appearing first. The attack ended with ten targets in an assault formation 45 meters from the firing positions. The duration of the situation was 8.19 minutes.

Two series of runs were made in this situation: Series 1, in which M14 rifles, were fired in the semiautomatic mode, while Stoner, Colt, M14E2, and AK47 weapons fired in the automatic mode; and Series 2, in which half of each mix fired automatic and the other half fired semiautomatic. Series 2 determined the best mode of fire (semiautomatic or automatic) for the various rifles and provided an index of the percentage increase or decrease in effectiveness furnished by automatic and semiautomatic fire in this situation (primarily aimed fire as a function of time at visible targets). Weapon mixes were then compared on the basis of their best mode of fire as determined by these Series 2 results. If Series 2 results showed a decrease in effectiveness resulting from a mode of fire different from that used in Series 1, the Series 1 score was left untouched. However, if Series 2 firings showed that a given percentage increase in effectiveness could be expected by using a mode of fire different from that used in Series 1, that mix's Series 1 score was increased (for comparative purposes) by an amount equivalent to the percent of increase indicated by Series 2 results. Results of Series 2 firings indicated that within the squad context in terms of both target effects and overall effectiveness (visible quick exposure targets from 45 to 345 meters), semiautomatic fire was superior to automatic fire for all rifles.

Results for the ten mixes (other than Mix RC) are presented in Figure 6-16. Figure 6-17 presents plots of cumulative exposure time (CET), targets hit, rounds fired, total hits, and percent of ammunition remaining as a function of range for the Colt, Stoner, AK47, and the all-M14E2 squad mixes in automatic fire, and for the other US 7.62mm mixes in semiautomatic fire. Although Figure 6-16 illustrates the expected performance of mixes in their best mode of fire, the plots in Figure 6-17 represent only firings in Series 1; therefore, Figure 6-17 is presented for purposes of illustration and does not necessarily represent performances with the weapons in their best mode of fire.

The rank order of weapon mixes (other than Mix RC) with associated standard scores are given below.

Target Effects Only			Overall Effectiveness*		
Rank	Mix	Standard Score	Rank	Mix	Standard Score
1	CB	86.4	1	CB	84.6
2	SC	65.3	2	SC	61.5
3	SB	63.8	3	SB	60.2
4	CA	59.5	4	CA	59.5
5	UA	55.7	5	SA	57.6
6	SA	48.0	6	UA	55.2
7	RA	37.4	7	RA	37.6
8	UB	33.1	8	UB	33.8
9	UC	31.8	9	UB	31.1
10	UD	19.1	10	UD	19.0

* Sustainability weighted 1/3/ Target effects 2/3

Key:

UA - 9 M14 Rifles

UD - 9 M14E2 Rifles

UB - 7 M14 Rifles and 2 M14E2 AR

UC - 5 M14 Rifles and 2 M60 MG

SA - 9 Stoner Rifles

SB - 7 Stoner Rifles and 2 Stoner AR

SC - 7 Stoner Rifles and 2 Stoner MG

CA - 9 Colt Rifles

CB - 7 Colt Rifles and 2 Colt AR

RA - 9 AK47 Rifles

Mix RC results for Situation 7 are presented below.

CET	Near Misses	Percent Ammo Remaining	Targets Hit	Total Hits
6.74	--	61.44	46.60	72.00

EFFECTIVENESS MEASURES

Cumulative Exposure Times

A

Mix	X̄ CET	SD	Standard Score z'
CB	4.1	0.9	86.1
SC	5.0	0.7	64.8
SB	5.0	1.4	63.8
CA	5.2	1.2	59.2
UA	5.4	0.4	55.4
SA	5.6	0.6	50.3
RA	6.1	0.9	37.2
UB	6.3	0.7	32.9
UC	6.3	0.7	31.7
UD	6.8	1.5	18.7
X̄	5.57		
σ	.79		

Number of Near Misses

B

Mix	X̄ Near Misses	SD	Standard Score z'
X̄			
σ			

Sustainability (% Ammo Remaining)

C

Mix	X̄ % Remaining	SD	Standard Score z'	Sustainability Time (Min)
CB	94.8	1.0	80.9	158.1
SA	91.4	2.2	76.8	95.6
CA	77.1	5.8	59.6	35.9
UA	72.5	6.7	54.0	29.9
SC	72.4	8.2	53.9	29.8
SB	71.7	7.4	53.1	29.1
UC	59.1	12.5	37.9	20.1
RA	59.1	5.2	37.9	20.1
UB	50.1	12.9	27.1	16.5
UD	43.1	7.5	18.7	14.5
X̄	69.12			
σ	16.64			

COLLATERAL PERFORMANCE MEASURES

Number of Targets Hit

D

Mix	X̄ Targets Hit	SD	Standard Score z'
SB	56.0	0.0	77.4
SC	56.0	0.0	77.4
CB	54.4	4.1	69.5
RA	52.8	4.0	61.3
CA	50.2	3.7	48.4
UA	48.5	3.4	37.6
UB	48.1	3.7	37.8
UC	47.5	3.6	34.6
SA	47.0	1.8	32.4
UD	44.9	4.1	21.8
X̄	50.54		
σ	4.00		

Total Hits on Targets

E

Mix	X̄ Hits	SD	Standard Score z'
CB	90.5	17.0	84.0
CA	84.5	11.5	69.1
SB	82.5	23.0	64.3
SC	82.2	10.1	63.4
RA	76.7	11.5	49.9
UC	74.2	12.2	13.9
UB	73.4	8.4	41.8
UD	70.2	5.8	33.8
UA	69.2	6.7	31.4
SA	64.1	8.1	18.7
X̄	76.74		
σ	8.10		

Target Effects

F

Mix	Standard Score Target Effects
CB	86.1
SC	64.8
SB	63.8
CA	59.2
UA	55.4
SA	50.3
RA	37.2
UB	32.9
UC	31.7
UD	18.7

Overall Effectiveness

G

Mix	Overall Fire Effectiveness
CB	84.4
SC	61.2
SB	60.2
CA	59.3
SA	59.1
UA	54.9
RA	37.4
UC	33.8
UB	31.0
UD	18.7

Cumulative Exposure Time

H

	CB	SC	SB	CA	UA	SA	RA	UB	UC	UD
CB		.05	.11	.06	.006	.004	.004	.000	.000	.003
SC			>.40	.35	.15	.08	.02	.006	.005	.02
SB				>.40	.30	.21	.09	.04	.04	.03
CA					>.40	.27	.11	.05	.04	.04
UA						.25	.05	.01	.01	.02
SA							.13	.04	.03	.05
RA								.36	.33	.19
UB									>.40	.22
UC										.24

Number of Near Misses

I

Sustainability (% Ammo Remaining)

J

	CB	SA	CA	UA	SC	SB	UC	RA	UB	UD
		.004	.000	.000	.000	.000	.000	.001	.000	.000
			.001	.000	.001	.001	.000	.001	.000	.000
				.12	.14	.10	.008	.001	.000	.000
					>.40	>.40	.03	.004	.003	.000
						>.40	.03	.008	.004	.000
							.04	.006	.004	.000
								>.40	.13	.02
									.09	.003
										.14

No. of Targets Hit

K

	SB	SC	CB	RA	CA	UA	UB	UC	SA	UD
SB		•	•	•	•	•	•	•	•	•
SC			•	•	•	•	•	•	•	•
CB				.26	.05	.01	.01	.006	.002	.002
RA					.15	.04	.04	.02	.006	.006
CA						.21	.17	.11	.04	.02
UA							>.40	.32	.19	.07
UB								.38	.27	.09
UC									>.40	.14
SA										.14

Total Hits on Targets

L

	CB	CA	SB	SC	RA	UC	UB	UD	UA	SA
CB		.24	.26	.16	.08	.04	.13	.01	.01	.004
CA			>.40	.36	.15	.09	.05	.02	.02	.004
SB				>.40	.31	.23	.19	.12	.11	.05
SC					.21	.13	.07	.02	.02	.004
RA						.37	.30	.13	.13	.03
UC							>.40	.24	.22	.06
UB								.23	.21	.04
UD									>.40	.08
UA										.16

Note: Standard Scores computed from raw scores using scores to three decimal places.

Variance and standard deviation if mixes SC and SB is zero and no distribution exists therefore probability values cannot be computed.

UA - 9 M14 Rifles
UB - 7 M14 Rifles/2 M14E2 AR
UC - 5 M14 Rifles/2 M60 MG
UD - 9 M14E2 Rifles
CA - 9 Colt Rifles

CB - 7 Colt Rifles/2 Colt AR
SA - 9 Stoner Rifles
SB - 7 Stoner Rifles/2 Stoner AR
SC - 7 Stoner Rifles/2 Stoner MG
RA - 9 AK47 Rifles

X̄ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposure Time
z' - Standard Score (X = 50, SD = 20)

COLLATERAL PERFORMANCE MEASURES

C

Mix	[illegible]	SD	[illegible]	[illegible]
CB	94.8	1.0	80.9	154.1
SA	91.4	4.2	76.8	95.8
CA	77.1	5.8	59.6	35.9
UA	72.5	6.7	54.0	29.9
SC	72.4	8.2	53.9	28.9
SB	71.7	7.4	53.1	29.1
UC	59.1	13.5	37.9	20.1
RA	59.1	5.2	37.9	20.1
UB	50.1	12.9	27.1	16.5
UD	43.1	7.5	19.7	14.5
$\bar{X}$	69.12			
σ	16.64			

Number of Targets Hit

D

Mix	$\bar{X}$ Targets Hit	SD	Standard Score z'
SB	56.0	0.0	77.4
SC	56.0	0.0	77.4
CB	54.4	4.1	69.5
RA	52.8	4.0	61.3
CA	50.2	3.7	48.4
UA	48.5	3.4	37.6
UB	48.1	3.7	37.8
UC	47.5	3.6	34.6
SA	47.0	1.8	32.4
UD	44.9	4.1	21.8
$\bar{X}$	50.54		
σ	4.00		

Total Hits on Targets

E

Mix	$\bar{X}$ Hits	SD	Standard Score z'
CB	90.5	17.0	84.0
CA	84.5	11.5	69.1
SB	82.5	23.0	64.3
SC	82.2	10.1	63.4
RA	76.7	11.5	49.9
UC	74.2	12.2	43.9
UB	73.4	8.4	41.8
UD	70.2	5.8	33.8
UA	69.2	8.7	31.4
SA	64.1	5.1	18.7
$\bar{X}$	76.74		
σ	8.10		

Cumulative Exposure Time

B	SC	SB	CA	UA	SA	RA	UB	UC	UD
	.05	.11	.06	.006	.004	.004	.000	.000	.003
		>.40	.35	.15	.08	.02	.008	.007	.02
			>.40	.30	.21	.09	.04	.04	.03
				>.40	.27	.11	.05	.04	.04
					.25	.05	.01	.01	.02
						.13	.04	.03	.05
							.36	.33	.19
								>.40	.22
									>.24

Number of Near Misses

I

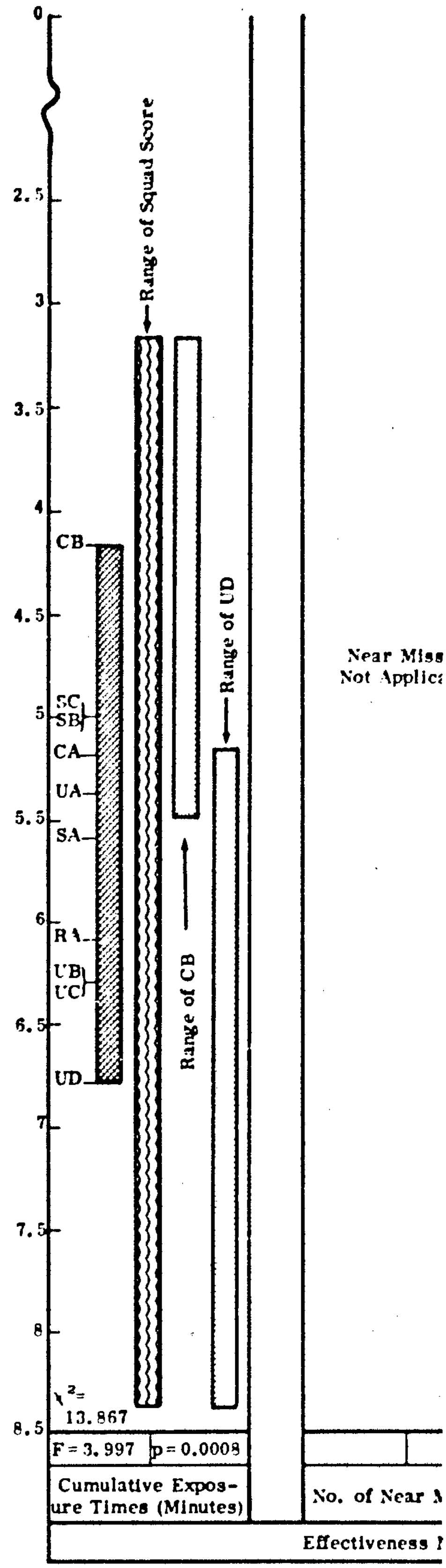
No. of Targets Hit

J	SC	CB	RA	CA	UA	UB	UC	SA	UD	
	•	•	•	•	•	•	•	•	•	CB
		•	•	•	•	•	•	•	•	CA
		`	.26	.05	.01	.01	.006	.002	.002	SB
				.15	.04	.04	.02	.006	.006	SC
					.21	.17	.11	.04	.02	RA
						>.40	.32	.19	.07	UC
							.38	.27	.09	UB
								>.40	.14	UD
									.14	UA

Total Hits on Targets

L

	CB	CA	SB	SC	RA	UC	UB	UD	UA	SA
CB		.24	.26	.16	.08	.04	.13	.01	.01	.004
CA			>.40	.36	.15	.09	.05	.02	.02	.004
SB				>.40	.31	.23	.19	.12	.11	.05
SC					.21	.13	.07	.02	.02	.004
RA						.37	.30	.13	.13	.03
UC							>.40	.24	.22	.06
UB								.23	.21	.04
UD									>.40	.08
UA										.16



M14 Rifles
M14 Rifles/2 M14E2 AR
M14 Rifles/2 M60 MG
M14E2 Rifles
Colt Rifles

CB - 7 Colt Rifles/2 Colt AR
SA - 9 Stoner Rifles
SB - 7 Stoner Rifles/2 Stoner AR
SC - 7 Stoner Rifles/2 Stoner MG
RA - 9 AK47 Rifles

$\bar{X}$ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposure Time
z' - Standard Score ($\bar{X}$ = 50, SD = 20)

Figure 6-

2

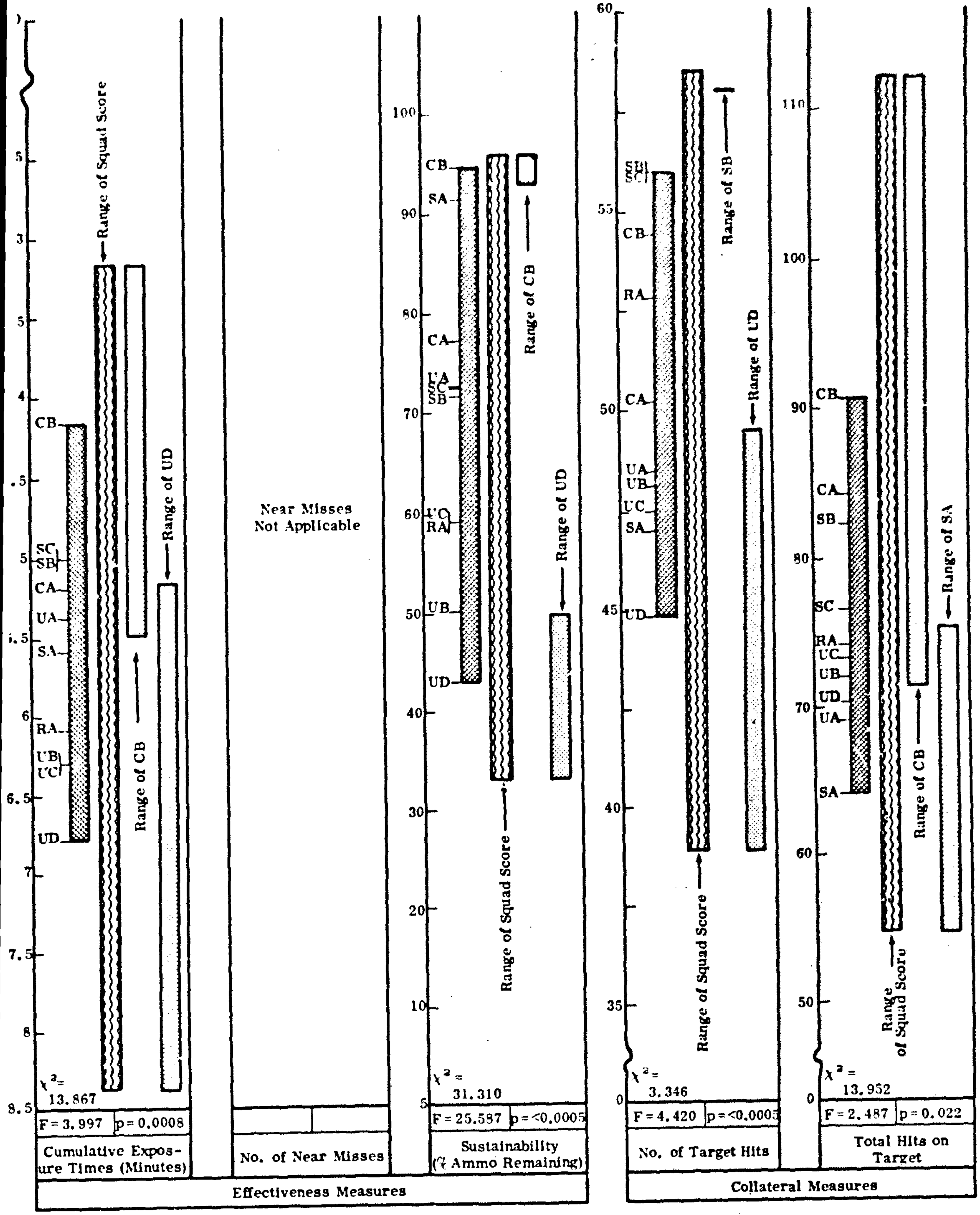


Figure 6-16 SUMMARY OF RESULTS--SITUATION 7

BLANK PAGE

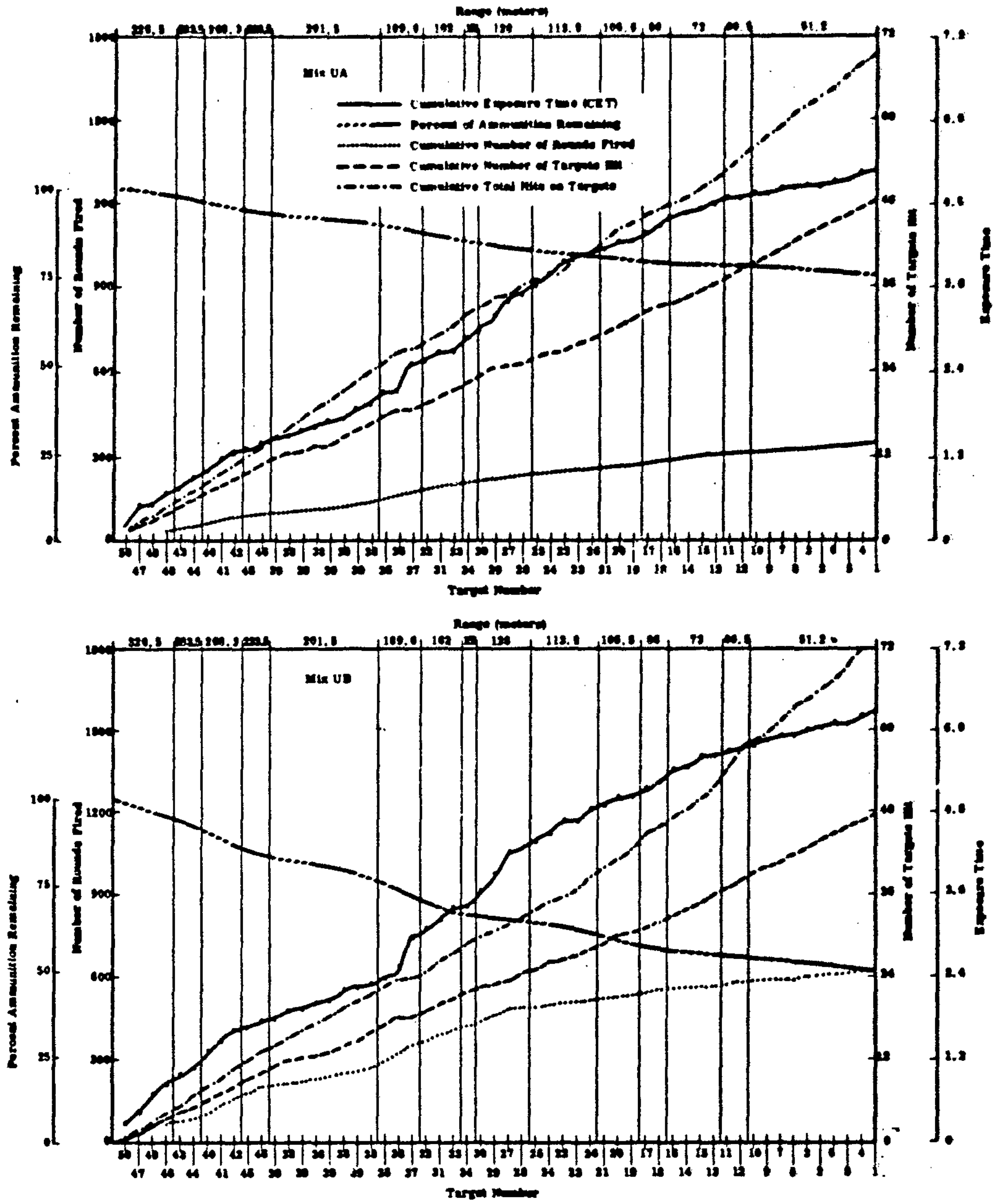
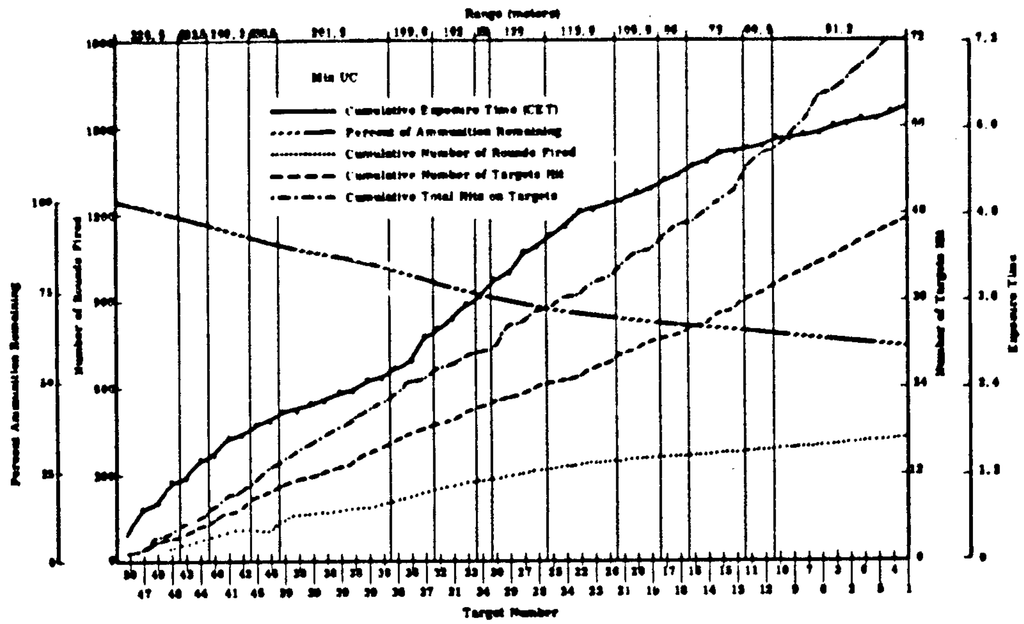


Figure 6-17

CUMULATIVE EXPOSURE TIME, TARGETS HIT, ROUNDS FIRED, TOTAL HITS, AND PERCENT OF AMMUNITION REMAINING--SITUATION 7



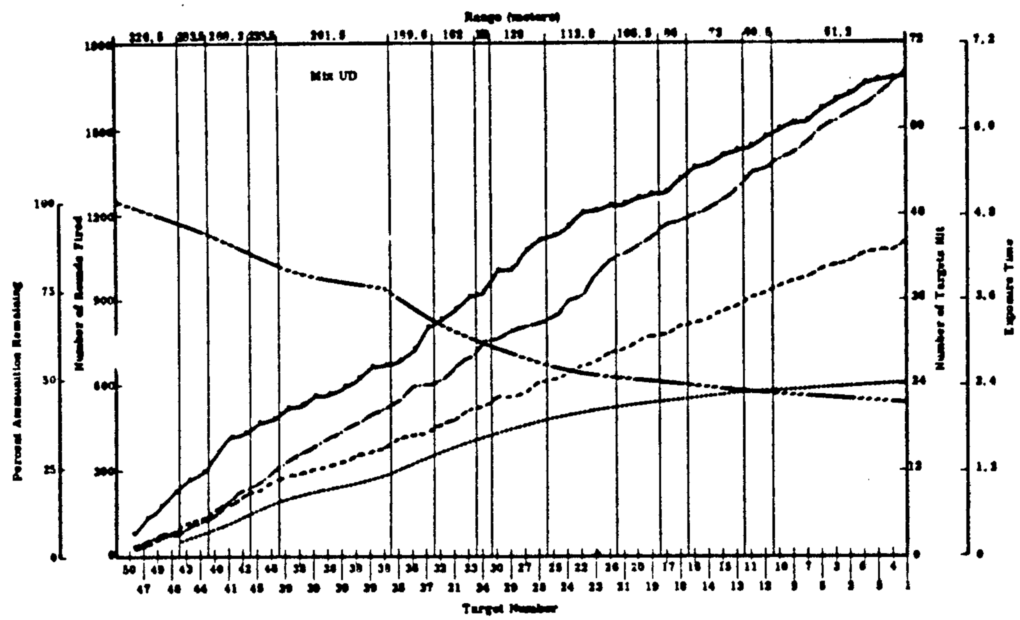
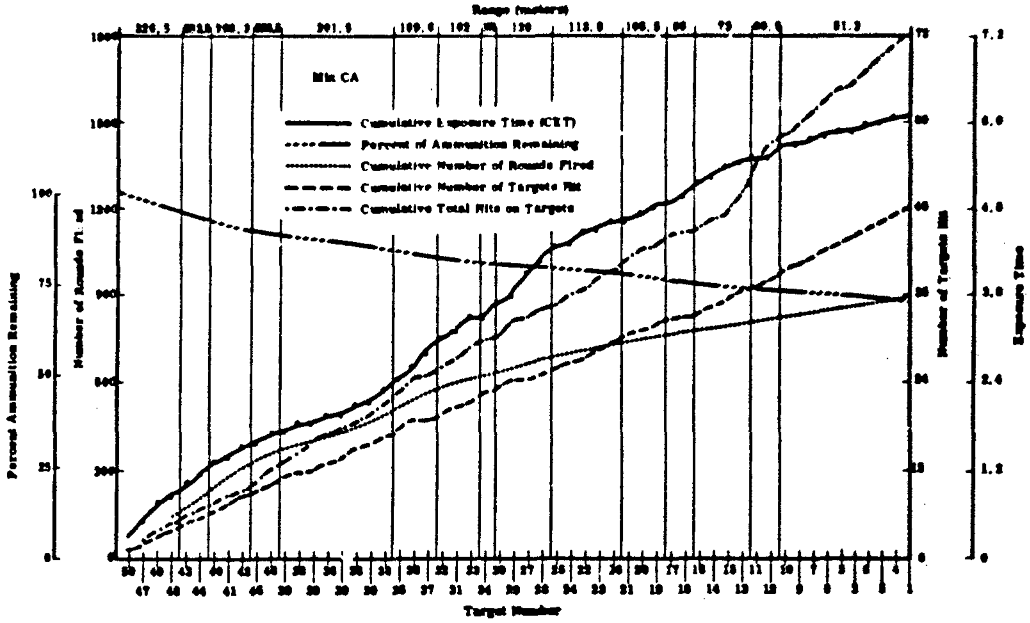


Figure 6-17 (Continued)

CUMULATIVE EXPOSURE TIME, TARGETS HIT, ROUNDS FIRED, TOTAL HITS, AND PERCENT OF AMMUNITION REMAINING--SITUATION 7



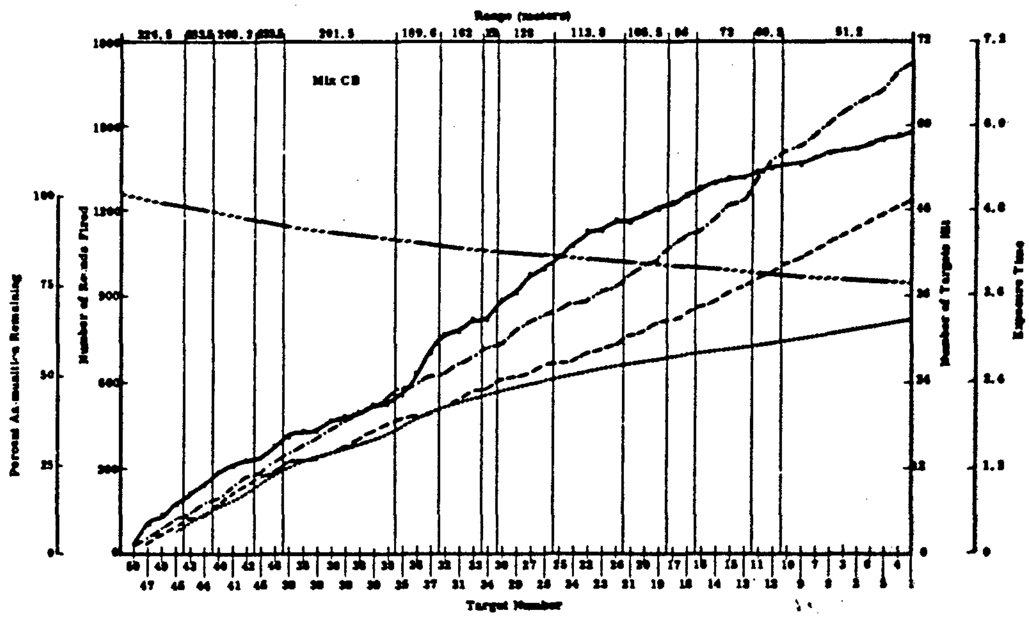


Figure 6-17 (Continued)

CUMULATIVE EXPOSURE TIME, TARGETS HIT, ROUNDS FIRED, TOTAL HITS, AND PERCENT OF AMMUNITION REMAINING--SITUATION 7

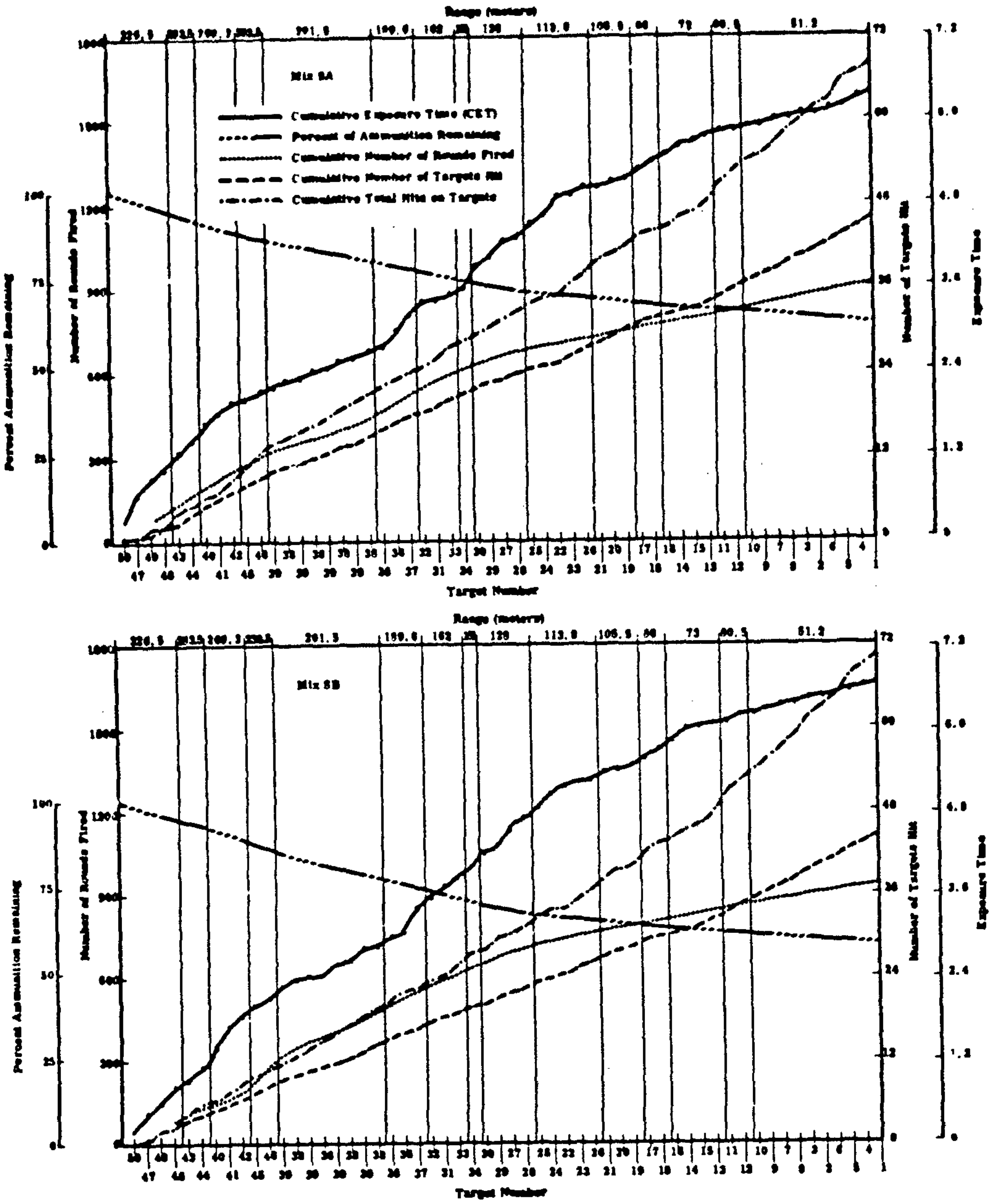
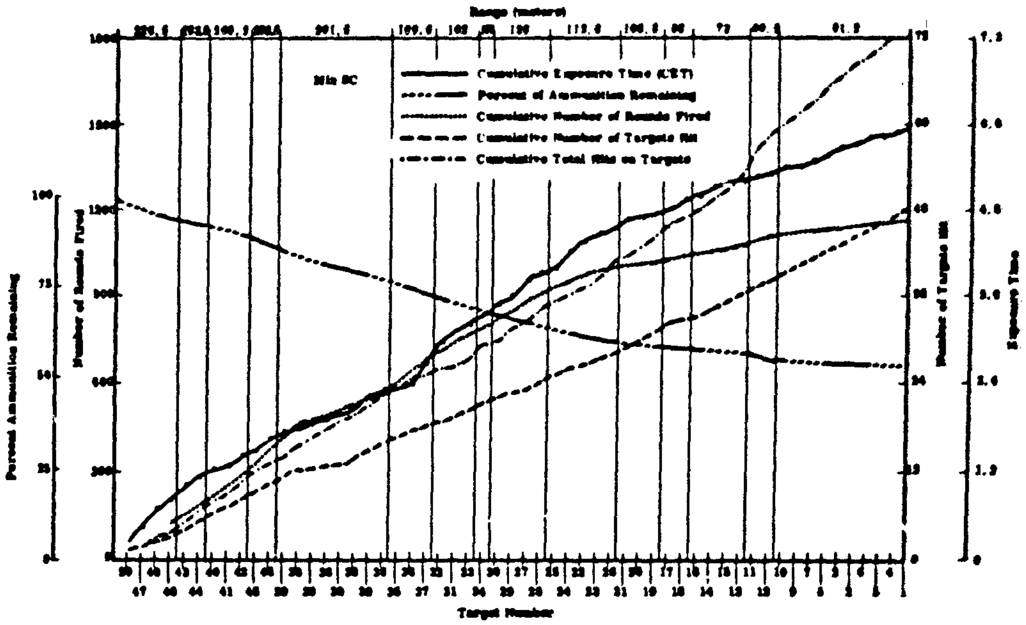


Figure 6-17 (Continued)

CUMULATIVE EXPOSURE TIME, TARGETS HIT, ROUNDS FIRED, TOTAL HITS, AND PERCENT OF AMMUNITION REMAINING--SITUATION 7



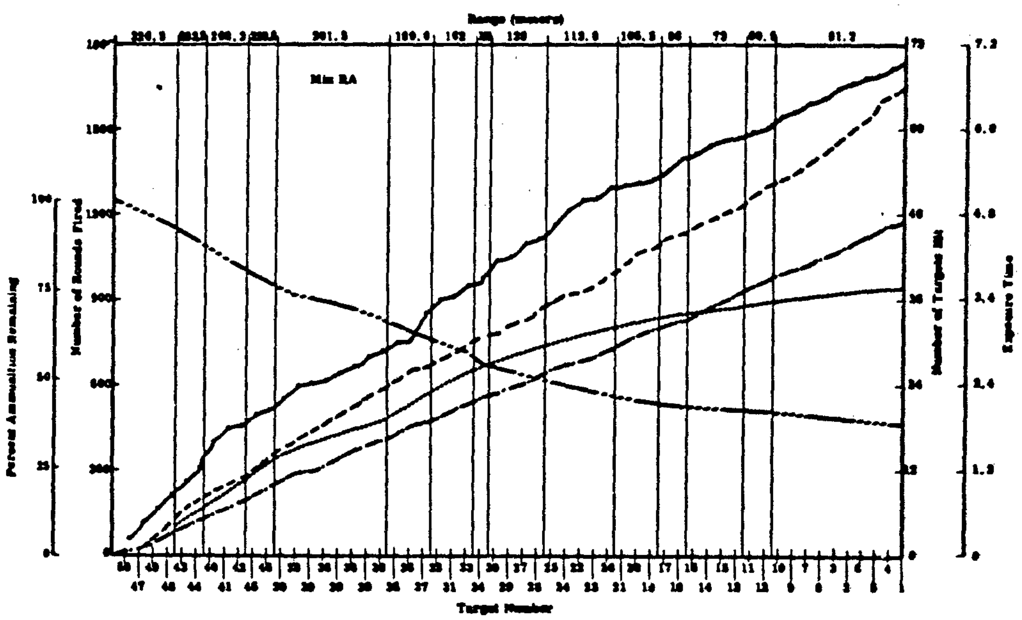


Figure 6-17 (Concluded)

CUMULATIVE EXPOSURE TIME, TARGETS HIT, ROUNDS FIRED, TOTAL HITS, AND PERCENT OF AMMUNITION REMAINING--SITUATION 7

6. Situation 8: Rifle Squad in Night Defense Against Attack

Rifle squad weapon mixes fired from hastily prepared foxholes at enemy targets raised for fixed exposure times in sequence beginning at a range of 235 meters from the firers and ending with a ten-man final assault at 45 meters. The cycle was then repeated with targets coming up in a different sequence the second cycle. This represented a regrouping for a second attack and provided a broader data base. In this situation the enemy targets were not visible to the firers because of darkness, and cues were simulator flash and sound. The duration of the situation was 4.8 minutes for both cycles combined.

As in Situation 7, a second series (not to be confused with the second cycle discussed above) was fired to determine the better mode of fire (semiautomatic or automatic) for the different rifles. Because of the variability of scores, however, it was not possible to conclude that one mode was better than the other for any weapon in this night situation. For example, although the M14 rifles that were fired at night in the automatic mode increased their target effects approximately 17.4 percent, they were still not superior to the low impulse weapons and expended 26.4 percent more ammunition to achieve the gain. It was therefore judged that the proper mode of fire for the M14 at night under circumstances similar to those of Situation 8 is semiautomatic. In like manner, there was no reason for concluding that the other rifles had not fired in their best mode in Series 1; therefore, Series 2 scores were not integrated with Series 1 socres.

Results for the ten mixes (other than Mix RC) are presented in Figure 6-18. Figure 6-19 illustrates CET as a function of target range for Cycles 1 and 2. On each cycle the range is decreasing as the attack progresses toward the weapon positions.

Results for the ten mixes (other than Mix RC) are presented in the following tables and graphs. The rank order of ten mixes with associated standard scores is presented below.

Target Effects Only			Overall Effectiveness*		
Rank	Mix	Standard Score	Rank	Mix	Standard Score
1	SB	74.6	1	CB	70.9
2	SC	71.9	2	SB	69.5
3	CB	66.9	3	SC	65.2
4	SA	65.8	4	SA	64.1
5	CA	48.9	5	CA	58.4
6	UB	46.2	6	UC	45.6
7	UC	43.5	7	UB	43.1
8	UA	43.5	8	UA	42.5
9	RA	23.5	9	RA	21.5
10	UD	15.4	10	UD	19.5

* Sustainability weighted 1/3; Target effects 2/3

Key:

UA - 9 M14 Rifles

UD - 9 M14E2 Rifles

UB - 7 M14 Rifles and 2 M14E2 AR

UC - 5 M14 Rifles and 2 M60 MG

SA - 9 Stoner Rifles

RC - 7 AK47 Rifles and 2 RPD MG

SB - 7 Stoner Rifles and 2 Stoner AR

SC - 7 Stoner Rifles and 2 Stoner MG

CA - 9 Colt Rifles

CB - 7 Colt Rifles and 2 Colt AR

RA - 9 AK47 Rifles

Mix RC results for Situation 8 are presented below.

CET	Near Misses	Percent Ammo Remaining	Targets Hit	Total Hits
6.73	--	20.00	19.40	28.80

EFFECTIVENESS MEASURES

A

Cumulative Exposure Times

Mix	$\bar{X}$ CET	SD	Standard Score z'
SB	6.03	.5	74.6
SC	6.10	.6	71.9
CB	6.23	.4	66.9
SA	6.26	.2	65.8
CA	6.70	.5	48.9
UB	6.77	.4	46.2
UC	6.84	.6	43.5
UA	6.84	.3	43.5
RA	7.36	.6	23.5
UD	7.57	.5	15.4
$\bar{X}$	6.67		
SD	.52		

B

Number of Near Misses

Mix	$\bar{X}$ Near Misses	SD	Standard Score z'
$\bar{X}$			
SD			

C

Sustainability (% Ammo Remaining)

Mix	$\bar{X}$ % Remaining	SD	Standard Score z'	Sustainability Time (Min)
CB	69.4	4.2	78.8	15.6
CA	68.6	4.9	77.4	15.2
SA	58.3	2.4	60.6	11.4
SB	57.4	9.5	59.2	11.2
SC	52.9	3.9	51.8	10.1
UC	51.6	10.5	49.7	9.9
UA	46.0	4.6	40.5	8.8
UB	43.7	3.4	36.8	8.5
UD	38.1	3.1	27.6	7.7
RA	21.9	6.5	17.5	7.0
$\bar{X}$	51.8			
SD	12.25			

COLLATERAL PERFORMANCE MEASU

D

Number of Targets Hit

Mix	$\bar{X}$ Targets Hit	SD	Standard Score z'
CB	25.5	4.3	76.0
SB	24.7	5.3	71.4
SA	23.8	3.6	66.3
SC	23.6	5.0	65.2
UB	21.3	3.0	52.1
CA	20.7	3.2	48.6
UA	19.8	2.9	43.5
UC	18.3	3.9	35.0
RA	16.4	5.0	24.1
UD	15.3	5.0	17.9
$\bar{X}$	20.94		
SD	3.51		

E

Total Hits on

Mix	$\bar{X}$ Hits	[illegible]
SC	38.0	[illegible]
CB	37.8	[illegible]
SB	35.7	[illegible]
SA	35.4	[illegible]
CA	31.3	[illegible]
UB	28.3	[illegible]
UA	22.8	[illegible]
UC	22.2	[illegible]
RA	19.6	[illegible]
UD	19.2	[illegible]
$\bar{X}$	29.03	
SD	7.59	

F

Target Effects

Mix	Standard Score Target Effects
SB	74.6
SC	71.9
CB	66.9
SA	65.8
CA	48.9
UB	46.2
UC	43.5
UA	43.5
RA	23.5
UD	15.4

G

Overall Effectiveness

Mix	Overall Fire Effectiveness
CB	70.9
SB	69.5
SC	65.2
SA	64.1
CA	58.4
UC	45.6
UB	43.1
UA	42.5
RA	21.5
UD	19.5

H

Cumulative Exposure Time

	SB	SC	CB	SA	CA	UB	UC	UA	RA	UD
SB		>.40	.29	.27	.05	.03	.03	.02	.007	.002
SC			.33	.28	.04	.02	.03	.01	.005	.001
CB				>.40	.05	.02	.03	.01	.003	.001
SA					.05	.02	.03	.005	.004	.001
CA						.39	.32	.28	.04	.008
UB							>.40	.38	.04	.01
UC								≥.40	.09	.02
UA									.05	.01
RA										.28

I

Number of Near Misses

J

Sustainability (% Ammo Remaining)

	CB	CA	SA	SB	SC	UC	UA	UB	UD	RA
CB		.37	.001	.01	.001	.003	.001	.001	.001	.001
CA			.002	.02	.001	.004	.001	.001	.001	.001
SA				>.40	.02	.10	.001	.001	.001	.001
SB					.17	.17	.02	.004	.001	.001
SC						≥.40	.02	.002	.001	.001
UC							.13	.06	.008	.004
UA								.18	.004	.002
UB									.009	.003
UD										.03

K

No. of Targets Hit

	CB	SB	SA	SC	UB	CA	UA	UC	RA	UD
CB		.39	.25	.26	.04	.03	.02	.009	.005	.003
SB			.38	.37	.11	.08	.04	.02	.02	.006
SA				≥.40	.13	.08	.04	.03	.02	.008
SC					.19	.14	.08	.04	.03	.02
UB						.36	.20	.09	.04	.02
CA							.32	.14	.06	.03
UA								.24	.10	.04
UC									.25	.14
RA										.37

L

Total Hits on Targets

	SC	CB	SB	SA	CA	UB	UA	UC
SC		≥.40	.33	.34	.14	.04	.005	.008
CB			.37	.35	.15	.02	.001	.001
SB				.38	.35	.05	.004	.005
SA					.19	.02	.001	.003
CA						.20	.02	.02
UB							.003	.01
UA								.38
UC								
RA								

Note: Standard Scores computed from raw scores using scores to three decimal places.

UA - 9 M14 Rifles
UB - 7 M14 Rifles/2 M14E2 AR
UC - 5 M14 Rifles/2 M60 MG
UD - 9 M14E2 Rifles
CA - 9 Colt Rifles

CB - 7 Colt Rifles/2 Colt AR
SA - 9 Stoner Rifles
SB - 7 Stoner Rifles/2 Stoner AR
SC - 7 Stoner Rifles/2 Stoner MG
RA - 9 AK47 Rifles

$\bar{X}$ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposure T
z' - Standard Score ($\bar{X}$ = 50,

— COLLATERAL PERFORMANCE MEASURES

Number of Targets Hit

	$\bar{X}$ Targets Hit	SD	Standard Score z'
B	25.5	4.3	76.0
B	24.7	5.3	71.4
\	23.8	3.6	66.3
C	23.6	5.0	65.2
B	21.3	3.0	52.1
A	20.7	3.2	48.6
A	19.8	2.9	43.5
C	18.3	3.9	35.0
A	16.4	5.0	24.1
D	15.3	5.0	17.9
	20.94		
D	3.51		

Total Hits on Targets

Mis	$\bar{X}$ Hits	SD	Standard Score z'
SC	38.0	11.4	73.6
CB	37.8	12.0	73.1
SB	35.7	9.2	67.6
SA	35.4	6.5	66.8
CA	31.3	7.8	56.0
UB	28.3	4.8	48.1
UA	22.8	1.9	33.6
UC	22.2	4.8	32.0
RA	19.6	7.0	25.2
UD	19.2	4.8	24.1
$\bar{X}$	29.03		
SD	7.59		

Number of Near Misses

Total Hits on Targets

	SC	CB	SB	SA	CA	UB	UA	UC	RA	UD
C		>.40	.36	.34	.14	.04	.005	.008	.01	.004
B			.37	.35	.15	.02	.001	.001	.30	.005
B				.38	.35	.05	.004	.005	.006	.003
\					.19	.02	.001	.003	.004	.001
\						.20	.02	.02	.02	.005
B							.003	.01	.01	.002
\								.38	.15	.06
C									.2[illegible]	
\										>[illegible]

\R

ier AR

ier MG

$\bar{X}$ - Mean (Average)
SD - Standard Deviation
CET - Cumulative Exposure Time
z' - Standard Score (X = 50, SD = 20)

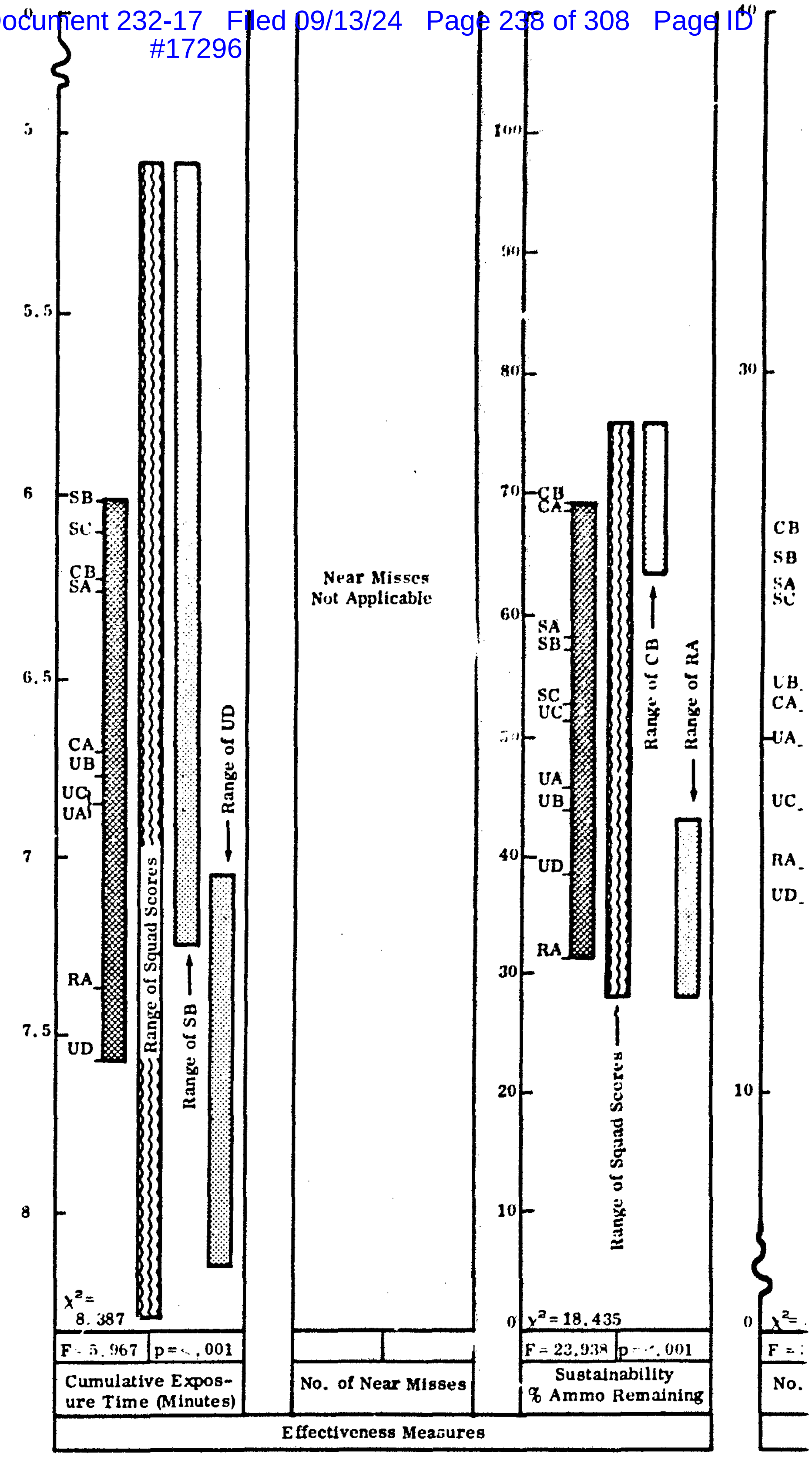


Figure 6-18 SUMMARY OF RESULTS--SI

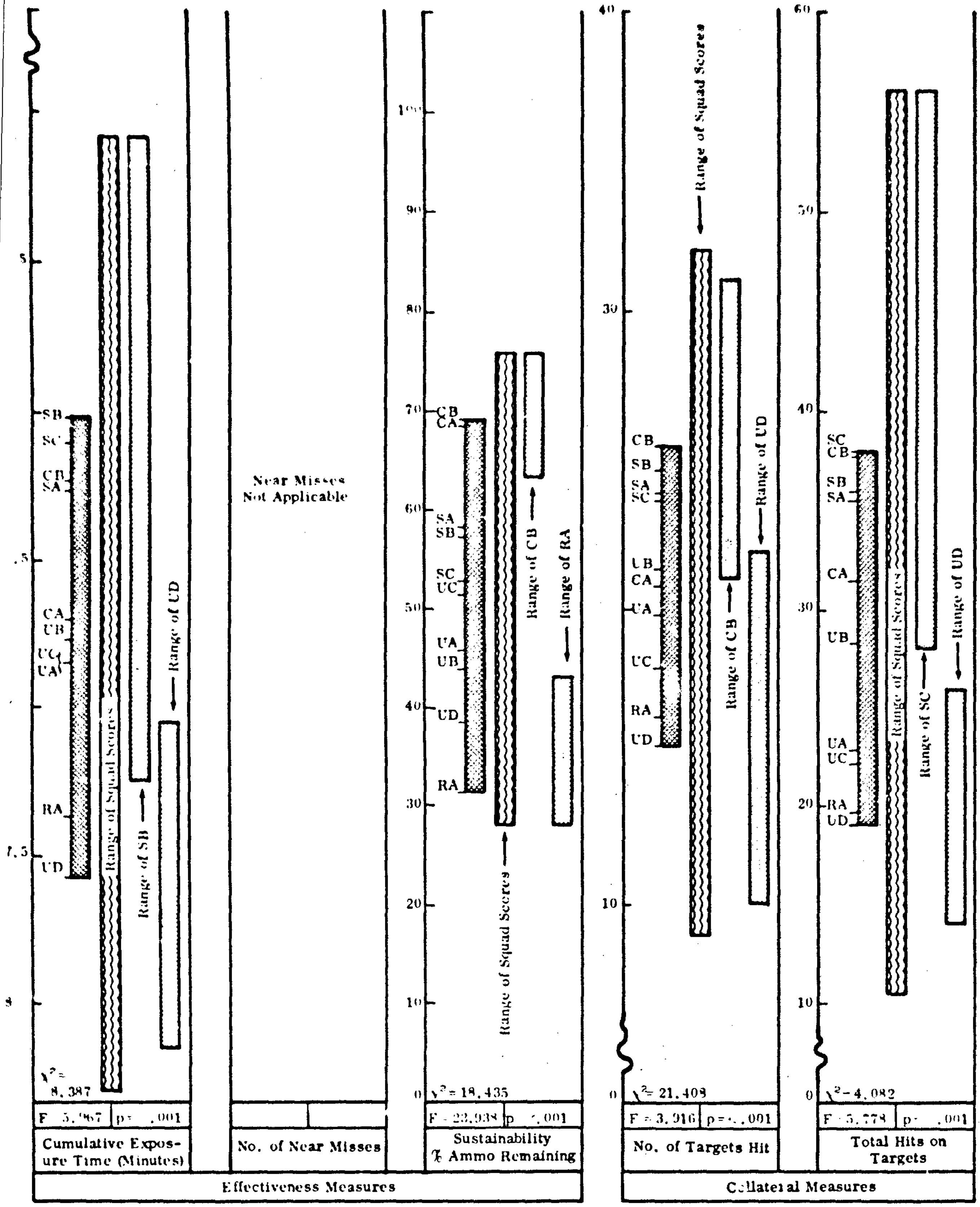


Figure 6-18 SUMMARY OF RESULTS--SITUATION 8

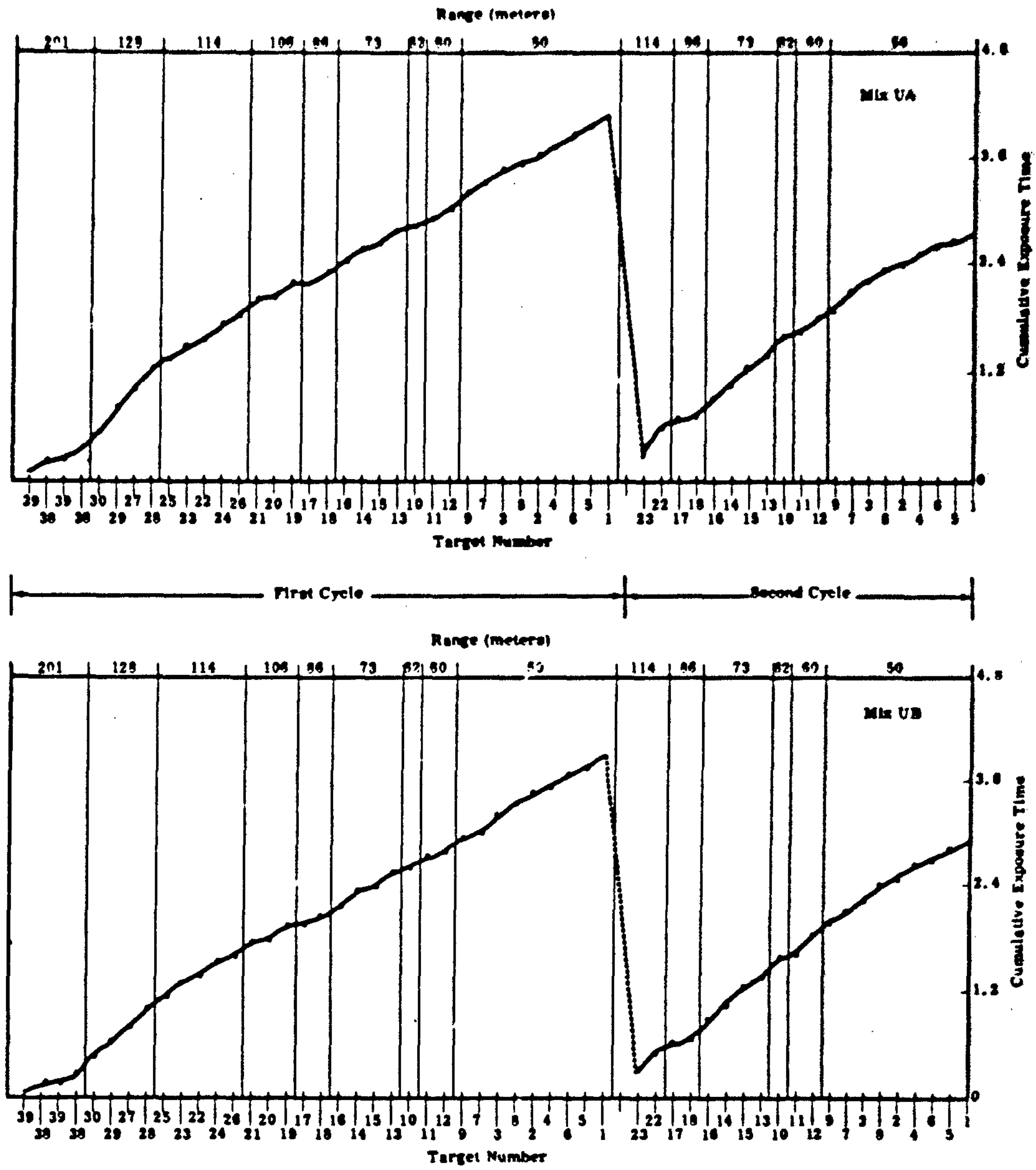


Figure 6-19

CUMULATIVE EXPOSURE TIME--SITUATION 8

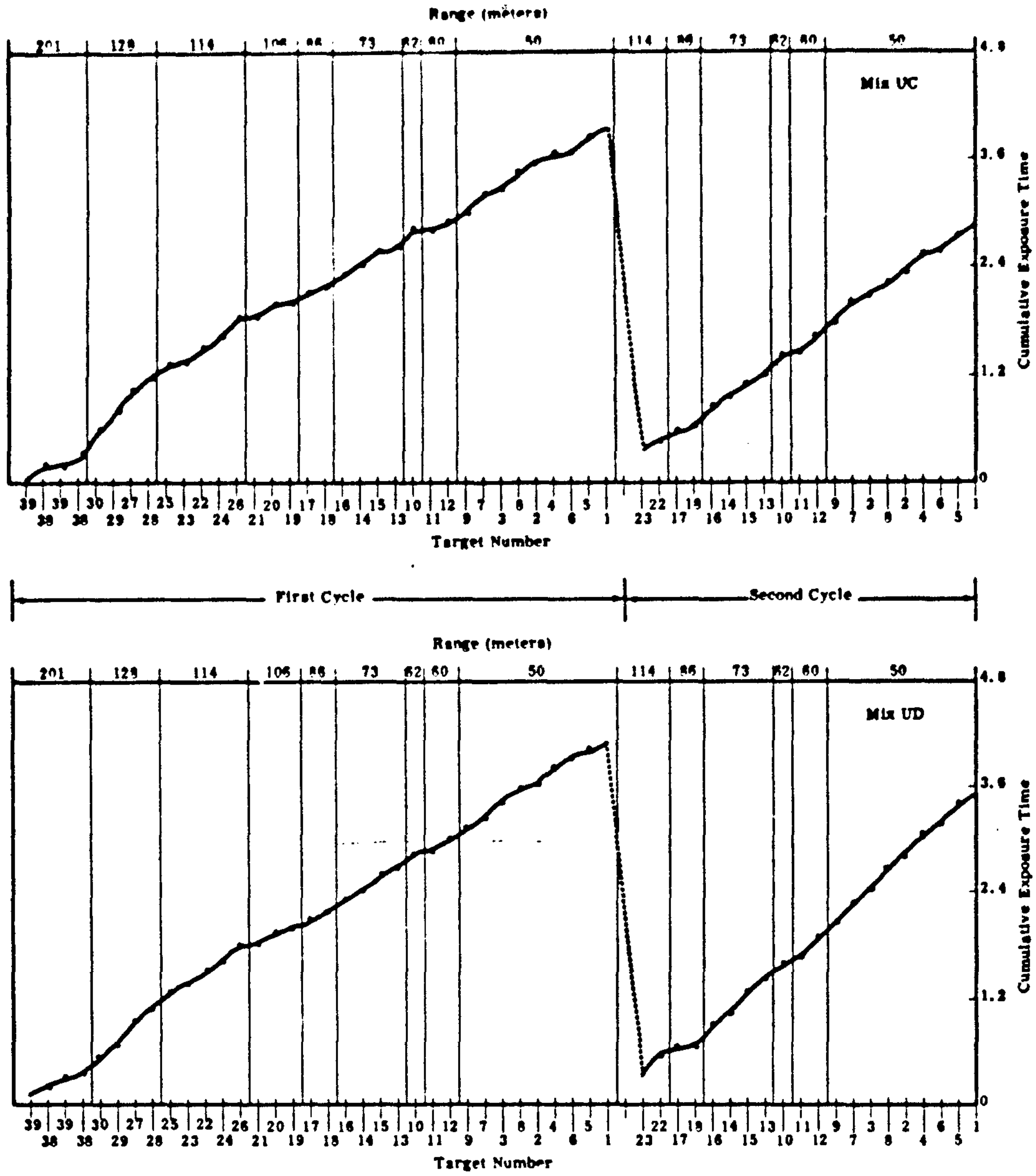


Figure 6-19 (Continued)

CUMULATIVE EXPOSURE TIME--SITUATION 8

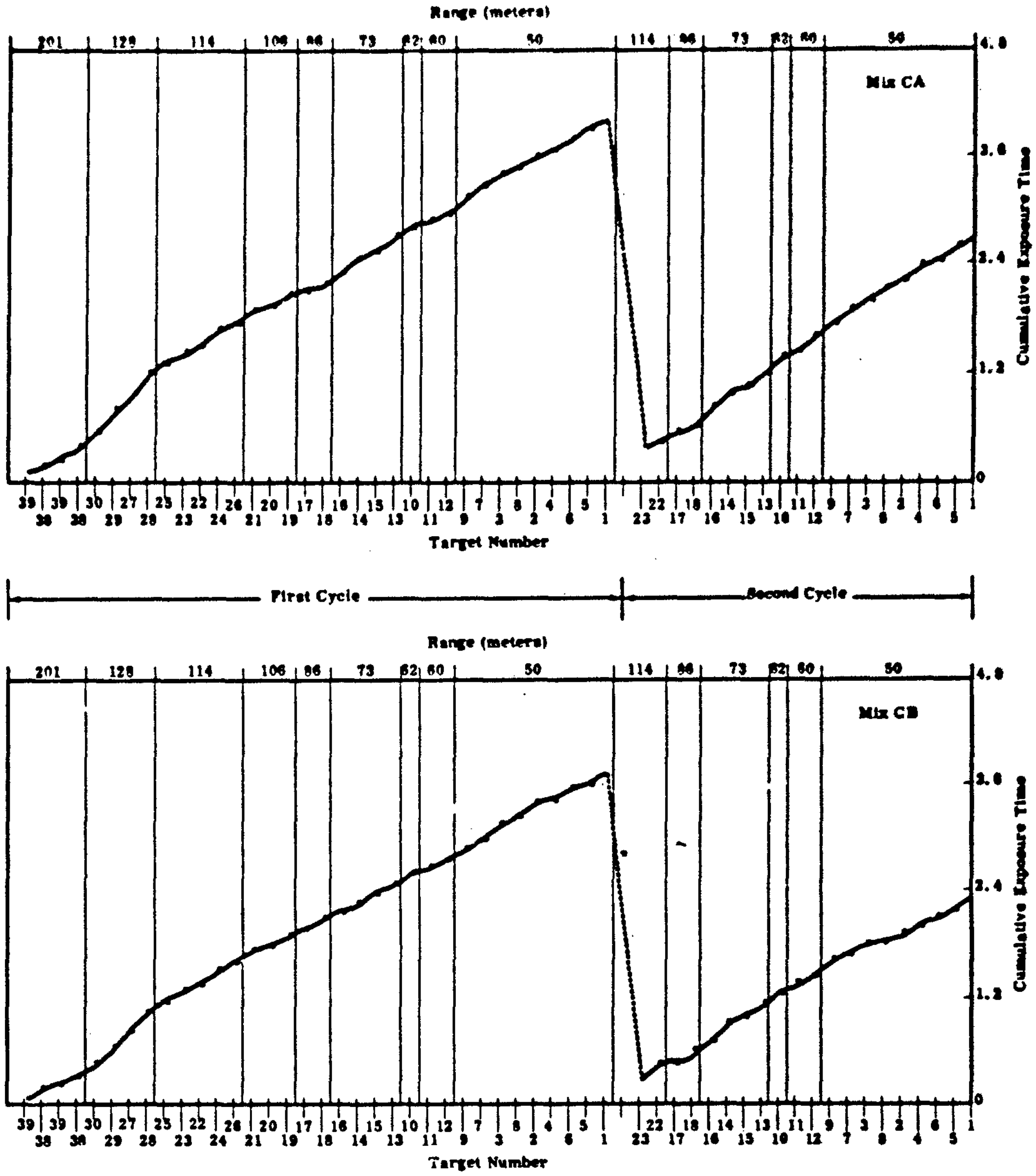


Figure 6-19 (Continued)

CUMULATIVE EXPOSURE TIME--SITUATION 8

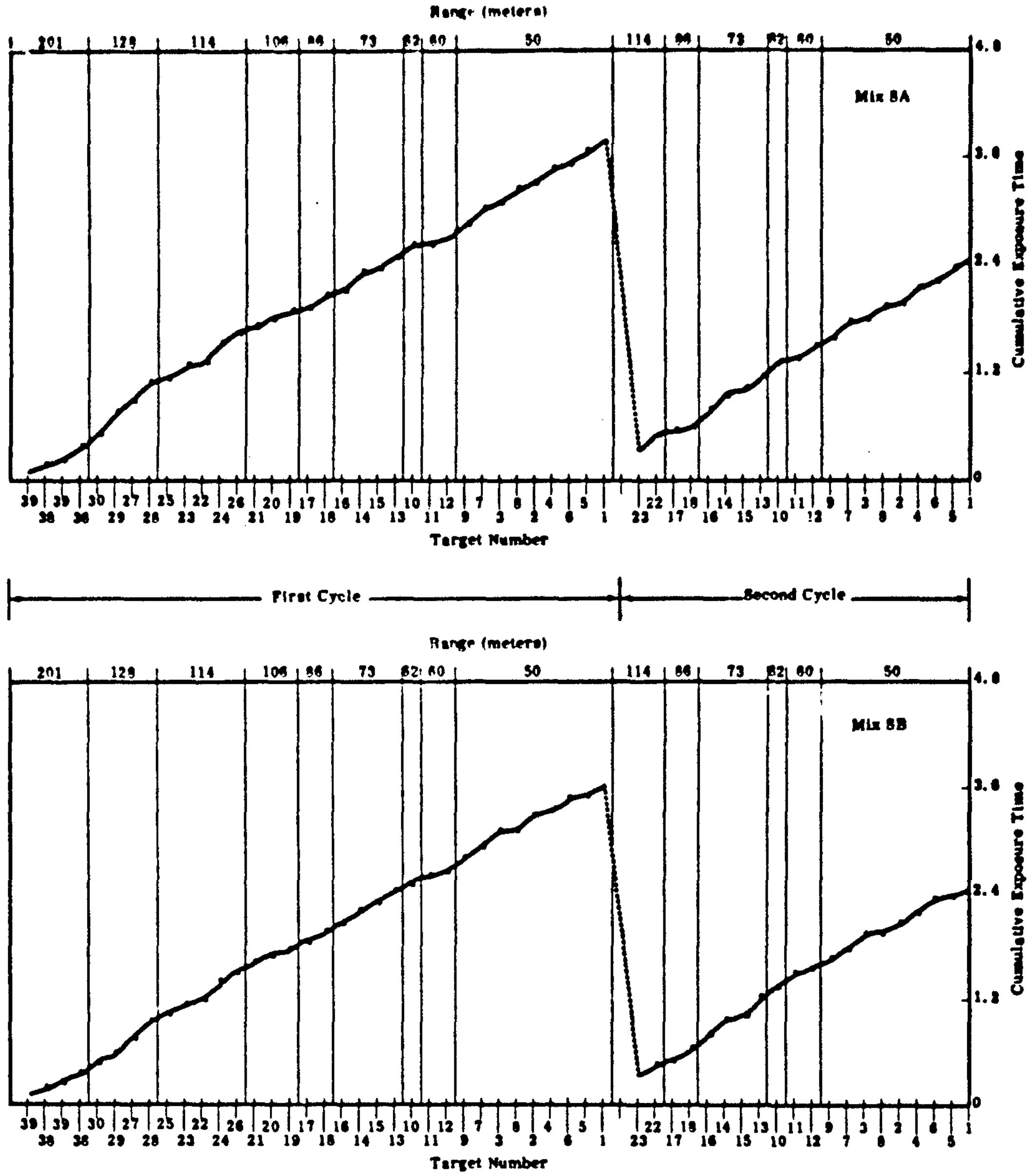


Figure 6-19 (Continued)

CUMULATIVE EXPOSURE TIME--SITUATION 8

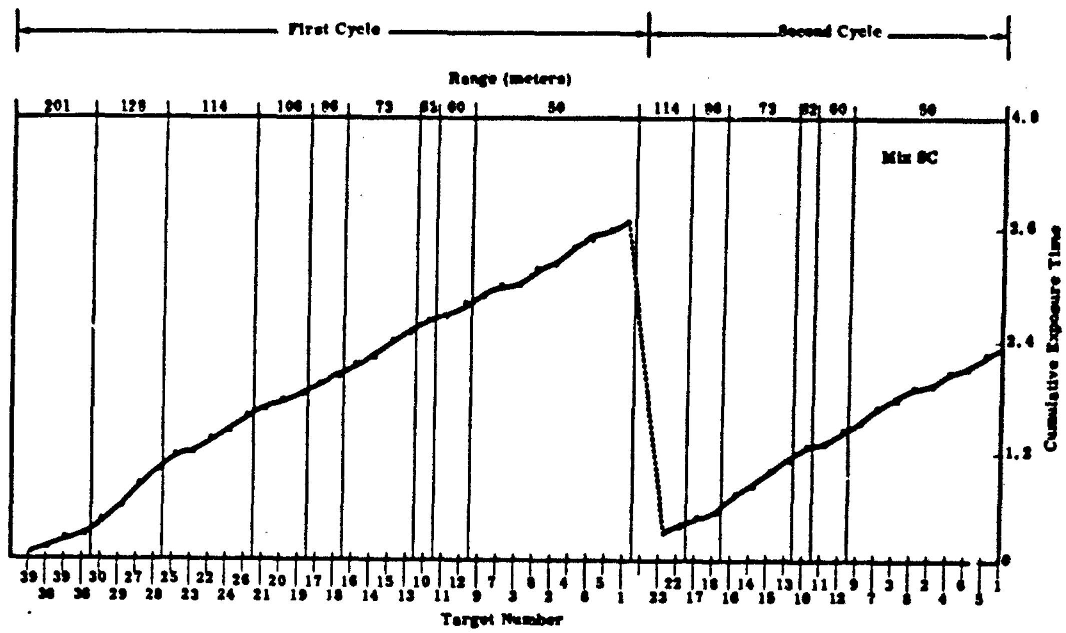


Figure 6-19 (Continued)

CUMULATIVE EXPOSURE TIME--SITUATION 8

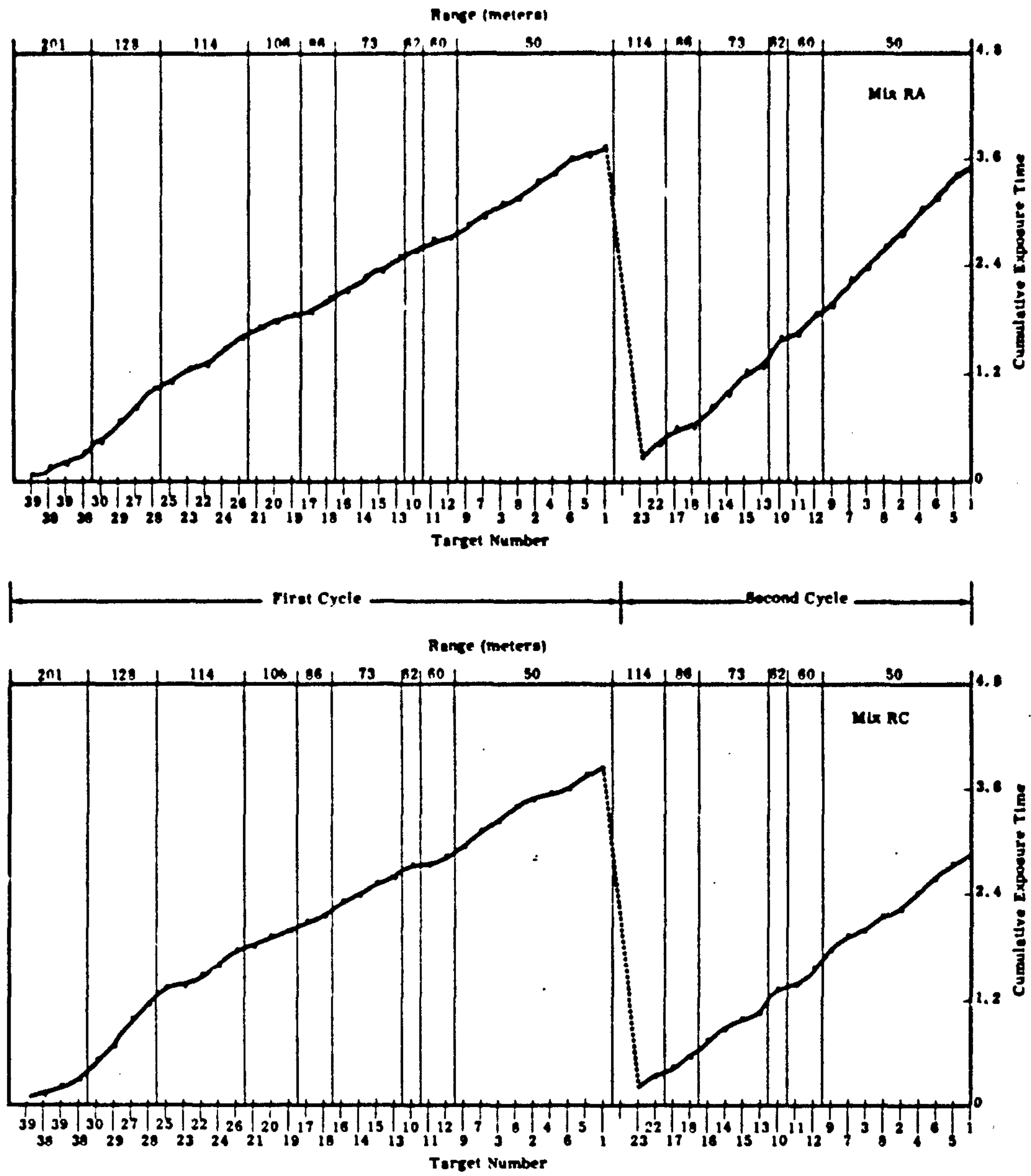


Figure 6-19 (Concluded)

CUMULATIVE EXPOSURE TIME--SITUATION 8

7. Combined Results - Rifle Squad Experiment

Target effects and overall effectiveness scores were averaged, for illustrative purposes, across all six rifle situations, with each situation arbitrarily assigned a weight of equal importance. This does not imply that each situation should be weighted equally. The numerical values presented below do little more than serve as a base for varying the judged value of the different situations. In like manner, overall standard scores for each situation should be considered the result of arbitrarily weighting target effects two-thirds and sustainability one-third.

Sensitivity analyses have shown, however, that the rank orders of the weapon systems are remarkably insensitive to changes in weighting. For example, because Mix UC (five M14 rifles and two M60 machineguns) never ranks higher in target effects than seventh place in any situation, Mix UC can never rank higher than the bottom half in target effects, no matter how much weight is given to a particular situation. Mix UC was also inferior in target effects to Mix UA (composed entirely of M14 rifles) in every situation but the night defense, and even in this situation Mix UC was in seventh place, with Mix UB in sixth place and Mix UA a close eighth. In overall effectiveness, Mix UA was also superior to Mix UC in five of the six situations. It is therefore concluded that the M60 machinegun is not satisfactory for inclusion in the rifle squad.

The deficiencies of the M60 machinegun and its low standing among other weapon mixes are attributed to the heavy system weight that required a two-man crew, the difficulty of managing such a heavy weapon in the moving firing situations, and the fact that even with a two-man crew its sustainability is marginal.

The opposite is true for Mix SC (seven Stoner rifles and two Stoner machineguns). This mix was among the top three in target effects in every situation. It was also superior in target effects to every US 7.62mm weapon mix, regardless of the situation. In sustainability, it dropped in rank order, but in overall effectiveness combined across all situations, it ranked fourth, again superior to every US 7.62mm mix. This was despite the Stoner machinegun being subject to numerous malfunctions and stoppages caused by faulty ammunition and improperly manufactured belt links. It was nevertheless still able to finish first in combined target effects for all situations. It is therefore concluded that the Stoner machinegun can be feasibly included in the rifle squad in the automatic rifle role, or possibly in a new squad organization in the role of a machinegun.

Mix UA (composed entirely of M14 rifles) is superior to all other US 7.62mm mixes in target effects, sustainability, and overall effectiveness, while Mix UB (seven M14s and two M14E2) and Mix UD (nine M14E2s) are seventh and ninth, respectively, in target effects, and seventh and tenth in overall effectiveness. It is therefore concluded that a squad equipped entirely with M14 rifles is superior to a squad equipped with any other US 7.62mm weapon or combination of these weapons. In like manner, it is concluded that the M14E2 is not satisfactory for use in the rifle role.

It had been hypothesized before the experiment that the Colt rifle and similar weapons with straight stocks and high sights would be inferior in pointing fire, because the barrel is low in relation to the sights and because the weapon is short. This was not supported by experimentation data. To the contrary, Situation 4 (Approach to Contact), which was specifically developed to investigate pointing fire, shows that the top ranking mix in overall effectiveness was the mix composed of nine Colt rifles. This mix also ranked second in target effects. The variability of squads was large in this situation, and while Mix CA was first, Mix CB was only fifth in overall effectiveness and seventh in target effects. Although the variability of the rank orders and weapon system scores is too much to conclude that there is a real difference, the trend favors the Colt rifle with its high sight and straight stock.

The AK47 scores are low in all situations except in the pointing fire in Situation 4. However, it cannot be concluded that the low target effects of the AK47 rifle in this experiment are necessarily indicative of the performance of the AK47 in general. Its barrel is only 16 inches long and the sights are close together. It seems to be designed primarily as a submachinegun-type weapon. If the SAWS results were weighted by range in accordance with the frequency of ranges of actual combat, it would be expected to do much better. These weapons had also received heavier wear than the other experimentation weapons. They had all been well used when received for the SAWS experiment, and the number of rounds previously fired from them was unknown. Because of the limited number of weapons, five firers usually shared each weapon. There were no spares for worn or broken parts, except for other worn parts cannibalized from other weapons, and there was a variability in the design and quality of the ammunition. All of these things may have contributed to the relatively poor performance of the AK47.

The results in terms of rank order and standard scores for overall target effects and overall effectiveness across all situations are presented in the following tables.

These tables, examined in connection with the statistical tables and graphs for each situation, lead to the conclusion that low impulse 5.6mm weapons are markedly superior to high impulse 7.62mm weapons in target effects, sustainability, and overall effectiveness. Mix SC (seven Stoner rifles and two Stoner machineguns) was superior in target effects, while Mix CB (seven Colt rifles and two Colt machineguns) was outstanding in overall effectiveness. However, results of later experimentation (described in Part B) indicate that a squad equipped with only Colt automatic rifles may be superior to any of the mixes listed in the tables here.

TARGET EFFECTS ONLY

Rank Order by Situation						
Rank	Situation					
	1	2	4	5	7	8
1	SB	CA	SC	SA	CB	SB
2	SA	SC	CA	CB	SC	SC
3	UB	UB	SB	SB	SB	CB
4	SC	UA	UA	SC	UA	SA
5	CB	CB	RA	UA	CA	CA
6	CA	UD	UB	UD	SA	UB
7	UA	SB	CB	UC	RA	UC
8	RA	UC	UD	CA	UB	UA
9	UC	SA	SA	UB	UC	RA
10	UD	RA	UC	RA	UD	UD

Rank Order (All Six Situations Combined)		
Rank	Mix	Std. Score
1	SC	63.35
2	CB	63.26
3	SB	60.30
4	SA	57.79
5	CA	53.70
6	UA	52.16
7	UB	46.61
8	UC	41.33
9	UD	34.93
10	RA	29.88

OVERALL EFFECTIVENESS [A]

Rank Order by Situation						
Rank	Situation 1	2	4	5	7 [B]	8
1	CB	CA	CA	SA	CB	CB
2	SB	CB	UA	CB	CA	SB
3	SA	UA	RA	SB	SC	SC
4	UB	SC	SC	SC	SB	SA
5	CA	UB	CB	CA	UA	CA
6	SC	UD	SB	UA	SA	UC
7	UA	SA	UB	UD	RA	UB
8	RA	SB	SA	UC	UC	UA
9	UD	UC	UC	RA	UB	RA
10	UC	RA	UD	UB	UD	UD

Overall Rank Order [B] (All Six Situations Combined)		
Rank	Mix	Std. Score
1	CB	67.70
2	CA	63.27
3	SA	59.47
4	SC	58.41
5	SB	58.23
6	UA	52.38
7	UB	45.32
8	UC	38.93
9	RA	35.12
10	UD	33.93

[A] Sustainability weighted 1/3; target effects weighted 2/3

[B] Series 1 Integrated Scores

Key:

UA - 9 M14 Rifles

UD - 9 M14E2 Rifles

UB - 7 M14 Rifles and 2 M14E2 AR

UC - 5 M14 Rifles and 2 M60 MG

SA - 9 Stoner Rifles

RC - 7 AK47 Rifles and 2 RPD MG

SB - 7 Stoner Rifles and 2 Stoner AR

SC - 7 Stoner Rifles and 2 Stoner MG

CA - 9 Colt Rifles

CB - 7 Colt Rifles and 2 Colt AR

RA - 9 AK47 Rifles

B. SUPPLEMENTARY RIFLE SQUAD EXPERIMENT

Three special weapons mixes were fired in addition to the weapon mixes already described. These mixes were MC (seven Colt rifles and two Stoner machineguns), CY(S) (nine Colt automatic rifles), and CY(T) (nine Colt rifles). Three control mixes were fired: MB (seven Colt rifles and two Colt automatic rifles), CX(T) (nine Colt rifles), and CX(S) (nine Colt rifles). The (S) and (T) denote semiautomatic and two-round burst, respectively. The effects of these mixes for Situations 1, 2, 4, 5, 7, and 8 are presented in Table 6-1.

1. MC Versus MB

Analysis of the table shows that in terms of both target effects and sustainability there is a great deal of variation across the six rifle situations. Generally speaking, Mix MC is better in target effects in three of the six situations, although never by a tactically significant amount. In the other three situations, Mix MC and Mix MB are equal in target effects. In three of the six situations, however, MB is better than MC in sustainability, while in two situations the mixes are equal. Mix MC is slightly better (4 percent) in the remaining situation--an advantage that could be due to chance factors. Therefore, it is concluded that there are no tactically significant differences in overall effectiveness between Mix MC (seven Colt rifles and two Stoner machineguns) and Mix MB (seven Colt rifles and two Colt automatic rifles). In effect, as both mixes had seven rifles, it can be concluded that two Colt automatic rifles are equivalent to two Stoner machineguns. Note that in experimentation results for the September 1965 to December 1965 experimentation, it was concluded that the Stoner and Colt rifles were approximately equivalent in target effects. Also the scores of Mix SC (seven Stoner rifles and two Stoner machineguns) and Mix CB (seven Colt rifles and two Colt automatic rifles), when totalled for all six situations, were the two top ranking mixes with almost identical scores in overall target effects: 64.5 and 62.8. Thus the equivalence of Stoner rifles and Colt rifles, as well as Colt automatic rifles and Stoner machineguns, becomes apparent. When sustainability is considered, however, a mix composed of seven Colt rifles and two Colt automatic rifles becomes clearly superior in overall effectiveness.

2. CX Versus CY

Results show that Mix CY (nine Colt automatic rifles) is superior to Mix CX (nine Colt rifles) in terms of target effects achieved. However, this increase in target effects is traded for an approximate 11.5 percent loss in sustainability caused by the increased weight of the Colt automatic rifle. Mix CX (nine Colt rifles) is superior to Mix CY in sustainability. However, the Colt automatic rifle, although heavier than the Colt rifle, can still, within its 17-pound system weight, carry 265

Table 6-1

EFFECTS OF SPECIAL WEAPON MIXES

Mix	CET (Minutes)	Near Misses	Sustainability	Target Hits	Total Hits
Situation 1					
MC	26.35	632.76	56.75	3.37	3.49
MB	26.82	590.34	64.43	3.69	3.96
CY(T)	25.86	593.81	61.45	4.06	4.56
CY(S)	25.92	571.39	64.08	5.64	5.64
CX(T)	26.84	529.67	68.86	2.28	2.28
CX(S)	25.50	441.57	71.26	4.91	5.43
Situation 2					
MC	82.20	421.25	31.25	9.00	9.20
MB	85.47	420.25	40.09	8.38	8.54
CY(T)	85.19	441.00	38.86	8.25	8.75
CY(S)	79.93	426.00	38.62	10.75	10.75
CX(T)	86.38	405.75	44.72	7.75	8.00
CX(S)	85.59	364.25	56.13	8.25	9.00
Situation 4					
MC	1.94	--	76.54	29.62	45.88
MB	2.00	--	78.08	30.50	50.12
CY(T)	1.91	--	73.01	32.00	52.75
CY(S)	1.97	--	87.86	32.25	52.50
CX(T)	1.91	--	77.85	31.00	46.75
CX(S)	1.82	--	90.61	31.75	45.75

Table 6-1

EFFECTS OF SPECIAL WEAPON MIXES (Concluded)

Mix	CET (minutes)	Near Misses	Sustainability	Target Hits	Total Hits
Situation 5					
MB	32.99	257.50	63.78	12.12	13.76
MC	35.48	279.62	58.95	10.88	11.42
CY(T)	38.10	268.75	34.68	8.75	10.25
CY(S)	39.63	256.50	35.51	8.50	8.50
CX(T)	38.52	255.00	49.38	8.50	9.00
CX(S)	41.49	184.00	45.42	6.25	6.50
Situation 7					
MC	4.38	--	68.62	52.50	93.38
MB	4.39	--	64.82	53.50	94.63
CY(T)	4.60	--	71.03	50.25	87.25
CY(S)	4.76	--	84.75	51.50	83.00
CX(T)	5.01	--	75.61	51.50	80.25
CX(S)	4.61	--	85.18	51.25	78.25
Situation 8					
MC	5.47	--	55.41	31.13	55.25
MB	5.58	--	54.45	29.00	48.86
CX(T)	5.30	--	58.57	33.50	59.75
CX(S)	4.69	--	55.57	36.25	64.25
CY(T)	4.92	--	57.55	35.75	65.50
CY(S)	4.83	--	56.93	34.50	58.00

rounds as opposed to 100 for the M14, 180 for the Stoner rifle, and 300 for the Colt rifle. The additional weight of the barrel is equal to one full 30-round magazine plus five rounds. Thus, the Colt automatic rifle although able to carry 35-rounds less ammunition than the Colt rifle, is still a lighter weapon, and can carry more ammunition than any of the other rifles or automatic rifles. The heavier barrel also allows the weapon to sustain its fire longer than the Colt rifle without damage to the barrel.

3. MC Versus CY

A comparison of Mix CY (nine Colt automatic rifles) with Mix MC (seven Colt rifles and two Stoner machineguns) shows the two mixes are approximately equal in target effects but that Mix CY has a slight advantage in sustainability. This portion of the experiment therefore indicated that the most feasible weapon mix may be one equipped entirely with Colt automatic rifles.

In all identical rifle situations during the entire experiment, mixes composed of nine rifles compared favorably, and did better in some cases, with mixes composed of seven rifles and two machineguns. Furthermore, when the scores secured by seven-man machinegun squads in the machinegun experiment are compared to the scores of the nine-man rifle squads in corresponding situations, the nine-man rifle squads are found generally superior to the machinegun squads in target effects, sustainability, and overall effectiveness. Table 6-2 compares the scores for the top ranking rifle squad mixes and the scores representing the average of all rifle squad mixes for each measure of each situation with the scores for the top ranking machinegun squad for each measure of each situation. Also given are the scores of the squad mix equipped entirely with Colt automatic rifles in their best mode of fire. The scores for the machinegun squads mix and the mix composed of Colt automatic rifles are inflated because some of their members had previously fired in the various situations in the original rifle squad experiment.

These factors lead to the hypothesis that seven riflemen should be more effective than a seven-man machinegun squad (two guns with a squad leader, two gunners, two assistant gunners, two ammunition bearers). It does not seem unreasonable then to hypothesize the elimination of all small arms weapons but one. Squads equipped only with Colt automatic rifles might then replace all machinegun squads and all squads using both rifles and automatic rifles.

Further, it is judged that the increased target effects of Colt automatic rifles over the rifle are due to the additional stability offered by the heavier barrel. If this is so, the newly developed XM148 grenade launcher attachment for use on the Colt rifle should provide the extra weight necessary to achieve a stability for the Colt rifle comparable to

Table 6-2 COMPARATIVE SCORES OF SPECIAL WEAPON MIXES

Mix	CET (Minutes)	Near Misses	Sustainability	Target Hits	Total Hits
(Rifle Situation 1 - No Comparable Machinegun Situations)					
Rifle Situation 2 - Machinegun Situation 3					
Top MG Mix	87.8	273.8	41.8	6.8	7.8
Top Rifle Mix	77.5	345.0	50.5	10.7	12.6
Average All Rifle Squad Mixes	80.9	283.7	23.8	9.1	9.6
All Colt AR Mix	79.9	426.0	38.6	10.8	10.8
(Rifle Situation 4 - No Comparable Machinegun Situation)					
Rifle Situation 5 - Machinegun Situation SA					
Top MG Mix	40.0	198.5	69.3	7.9	8.3
Top Rifle Mix	38.6	207.3	84.8	8.9	10.2
Average All Rifle Squad Mixes	40.6	141.5	63.1	6.5	6.9
All Colt AR Mix	38.1	268.8	34.7	8.8	10.3
(Machinegun Situation G - No Comparable Rifle Situations)					
Rifle Situation 7 - Machinegun Situation 9					
Top MG Mix	8.0	--	79.9	43.0	67.0
Top Rifle Mix	4.1	--	94.8	56.0	90.5
Average All Rifle Squad Mixes	5.6	--	69.1	50.5	76.7
All Colt AR Mix*	4.60	--	71.0	50.3	87.3

* NOTE: Colt automatic rifle scores in this table are based on automatic fire. The best rifle mix in CET (4.1 min) in this situation was Mix CB (seven Colt rifles and two Colt automatic rifles) when the rifles were firing semiautomatic fire. In Series 1, when the same mix CB fired automatic fire, the CET was an unsatisfactory 5.98 minutes. If the Colt automatic rifle squads had fired semiautomatic, their expected score would have been less than 4 minutes, which is superior to all other mixes.

that of the Colt automatic rifle. The only disadvantage would be a shorter barrel life during sustained fire because of the rifle's lighter barrel. Thus, providing the Colt rifle with a SPIW-type dual "area fire-point fire" capability may, at the same time, provide the extremely desirable additional effect of providing added stability and better point fire target effects commensurate with those of the Colt automatic rifle and Stoner machinegun.

These fire effectiveness results and hypotheses warrant further testing. If these hypotheses are valid, their implications would be revolutionary. The cost effectiveness and associated logistic advantages of one weapon to replace the present rifle, automatic rifle, grenade launcher, and machinegun, are unquestionable.

Such a choice becomes more imperative if the one weapon, for example, Colt rifle with XM148 grenade launcher attachment) suggested to replace all other weapons has a proven fire superiority in every role over each of the weapons that it is proposed to replace--rifle, automatic rifle, machinegun, and M79 grenade launcher.

Within the current weapons inventory, the choice therefore, seems to become one of choosing among:

1) A squad equipped entirely with Colt automatic rifles
2) A squad equipped entirely with Colt rifles with XM148 grenade launchers
3) A squad equipped with a combination of Colt automatic rifles and separate grenade launchers (such as the M79)

The answer can come only through additional fire effectiveness experimentation. It should be dealt with in the IRUS study.

C. MACHINEGUN SQUAD EXPERIMENT

1. Situation 3: Machinegun Squad in Fire Support of the Assault

This situation evaluated machinegun squad weapon mixes firing supporting fire from hastily prepared foxholes at partially concealed and unconcealed targets in foxholes at a range of 269 to 326 meters. Machineguns of the squad were positioned 25 meters apart and fired at the same target array as in Situation 2.

Mixes firing in Situation 3 were UF (M60 tripod, T&E), UE (M60 bipod), SF (Stoner tripod T&E), SE (Stoner bipod), RF (Soviet DPM bipod), and RE (Soviet RPD bipod). The first five mixes were fired before Mix RE, which was not available at the time. Mix RF did not fire tracer ammunition the first time, and was fired again with tracer with the RE mix. Stoner Mixes SE and SF are not directly comparable to the other three mixes because of excessive misfires caused primarily by faulty ammunition (see Table 5-1).

Results for Situation 3 appear below, the first five squad firings first, followed by the later RE and RF firings.

Mix	CET	Near Misses	Percent Ammunition Remaining	Targets Hit	Total Hits
UF	87.79	273.8	41.8	6.8	7.8
UE	92.58	246.3	51.2	4.2	5.0
SF	94.09	139.3	84.7	3.4	4.0
SE	95.38	99.2	88.3	3.0	3.1
RF	96.03	109.2	70.5	3.3	3.8

Mix	CET	Near Misses	Percent Ammunition Remaining	Targets Hit	Total Hits
RE	92.87	246.6	51.2	5.8	6.0
RF	99.06	119.5	64.0	3.0	3.3

2. Situation 5A: Machinegun Squad as a Base of Fire Supporting the Advance (375 to 560 meters)

Machinegun squad mixes fired on two arrays of enemy targets from unprepared firing positions. Duration of fire was 4 minutes, with the first 2 minutes directed toward an array of 14 targets occupying an area 60 meters wide and 42 meters deep. The range from firers to targets was 379 to 445 meters. The second 2 minutes of fire was delivered against an array of 13 targets occupying an area 45 meters wide and 62 meters deep, at ranges of 477 to 560 meters. The technique of fire employed was distributed fire throughout the sector, with point fire used when targets were seen or when weapon simulators gave specific cues to a target location. All firers had previously fired on these same arrays but from different positions. A summary of data is presented below.

Mix	CET	Near Misses	Percent Ammunition Remaining	Targets Hit	Total Hits
UF	40.03	198.5	69.29	7.92	8.30
UE	41.98	189.3	72.18	5.83	5.83
RE	42.25	120.0	89.52	5.10	6.10
SE	42.98	89.0	93.88	4.60	5.20
SF	44.13	107.3	91.80	3.17	3.67
RF	45.01	63.0	85.25	2.12	2.12

3. Situation 6: Machinegun Squad in Fire Support of the Advance (446 to 753 meters)

This situation evaluated machinegun squad weapon mixes against 40 targets with a programmed total target exposure time of 66.380 minutes. The targets were divided into three target arrays, X, Y, and Z. Ranges for Array X were from 603 to 646 meters, for Array Y from 690 to 753 meters, and Array Z from 446 to 488 meters. The programmed total target exposure time for Array X was 22.256 minutes (see Table B-21).

The machineguns firing Situation 6 were the same as those fired in Situation 3. Note that the Stoner machineguns had excessive stoppages (see Table 5-1) caused by faulty ammunition, and are therefore not directly comparable to the other mixes. Because of different firing conditions, the Soviet mixes (RE and RF) are also not directly comparable to the other machinegun mixes.

Mix	CET	Near Misses	Percent Ammunition Remaining	Targets Hit	Total Hits
UF	56.48	308.16	65.47	12.17	13.83
SF	63.07	183.17	89.86	6.00	7.00
UE	63.59	228.00	78.49	6.00	7.00
RE	64.49	133.20	93.41	6.40	6.80
SE	66.78	100.67	94.85	4.33	4.83
RF	68.82	50.75	82.61	2.25	1.26

4. Situation 9: Machinegun Squad in Defense Against Attack

This situation evaluated the machinegun squad and mixes firing from hastily prepared foxholes at visible targets advancing from 345 to 45 meters. There were 50 targets, some of them appearing more than once. Their programmed total target exposure time was 15.976 minutes (see Table B-22 and Range B Sketch Map, Annex B.)

Mix	CET	Near Misses	Percent Ammunition Remaining	Targets Hits	Total Hits
UF	8.03	--	79.92	43.08	66.98
RF	8.59	--	82.33	40.37	57.23
SF	8.81	--	90.86	39.65	68.27
SE	8.94	--	95.24	38.92	59.78
UE	9.13	--	88.10	39.45	65.05

Mix	CET	Near Misses	Percent Ammunition Remaining	Targets Hit	Total Hits
RE	9.37	--	87.87	35.40	60.20
RF*	9.96	--	80.98	34.50	51.50

* Second series for Mix RF

5. Discussion

The M60 tripod mounted machinegun mix was consistently better than the M60 bipod mounted mix. The poor performance of the Stoner machinegun mixes, particularly in sustained fire (Situations 3 and 6), was caused by a high rate of misfires. The Stoner machinegun fired 20 percent less ammunition than the M60 although it has a higher rate of field fire. (See Section V, Materiel Reliability.) Gunners often had to recharge the Stoner weapons. This necessitated relaying and prevented effective adjustment of fire.

The Stoner machineguns did better in the day defense situation than in the other two situations. They ranked third and fourth behind the tripod mounted M60 and Soviet DPM and ahead of the bipod mounted M60 in CET. This situation, because it did not emphasize sustained fire, made fewer demands on mechanical reliability than did the base of fire situations. There were intervals between target appearances that sometimes allowed stoppages to be cleared, but firing time was still lost.

For these reasons, and because of a difference in time frame for the firing of the Soviet weapons, the experimentation results provide no basis for directly evaluating any of the experimentation machinegun types against one another in the machinegun role.

SECTION VII

DUPLEX AMMUNITION EXPERIMENT

A. RIFLE DUPLEX AMMUNITION EXPERIMENT

The US 7.62mm M14 rifle squad mixes (UA and UB) were fired in December 1965 and January 1966 in an experiment designed to compare the effectiveness of duplex ball ammunition and simplex ball ammunition for rifles.

Because the squads had already fired each situation during the earlier rifle experiment, they were generally familiar with the ranges; consequently, the duplex scores could not be compared directly with the earlier scores of the other 5.56mm and 7.62mm rifle mixes.

To allow an adjustment whereby the effects of squads firing duplex ammunition could be directly compared with other mixes, Mixes UA (nine M14 rifles) and UB (seven M14 rifles and two M14E2 automatic rifles) were divided. Three squads of each mix fired the duplex experiment, while a control group fired ball ammunition and the other three squads fired duplex ammunition. In both the duplex and ball ammunition squads, the firers in the two automatic rifle foxholes fired tracer and ball ammunition in the same modes of fire as in Series 1. Thus, the ammunition and firing modes for the two automatic rifle position remained constant for both duplex and ball ammunition squads for both mixes. Consequently, any differences in fire effectiveness can be attributed to the effects of the ball ammunition or duplex ammunition being used by the riflemen in the seven positions other than the automatic rifle positions (2 and 8 in Situation 1; 3 and 7 in Situations 2, 4, and 5; 4 and 7 in Situations 7 and 8).

By the use of control groups firing ball ammunition, the increase in scores as a result of learning and similar effects could be computed. Thus, the percentage of the increase in scores of squads firing duplex that was due to learning and the percentage that was due to duplex ammunition could be determined. These figures were then used to compute the score for the UA and UB mixes that would have been expected had the mixes fired duplex ammunition instead of ball ammunition their first time in each situation (Series 1). These adjusted scores ("expected" duplex scores) are directly comparable with the scores of other rifle mixes in the original rifle squad experiment.

The results are presented in two tables. Table 7-1 shows the raw scores of the duplex squads compared with the control squads firing ball ammunition for each of the six rifle squad situations. Probability

Table 7-1

RAW SCORE RESULTS
(Rifle Duplex Experiment)

Effectiveness Measures	Duplex		Ball		t	p
	$\bar{X}$	SD	$\bar{X}$	SD		
Situation 1 - Rifle Squad in Line Assault						
CET (min.)	21.66	2.06	21.52	3.27	0.090	>0.400
Near Misses	680.00	44.20	399.83	71.25	8.186	< .001
Sustainability	65.10	5.64	61.42	5.60	1.135	.142
Targets Hit	7.31	2.81	7.66	2.26	0.239	> .400
Total Hits	8.33	2.69	8.46	2.44	0.090	> .400
Situation 2 - Rifle Squad as Base of Fire Supporting the Assault						
CET (min.)	74.03	8.64	80.50	6.27	1.372	.103
Near Misses	412.20	93.29	308.00	44.33	2.470	.018
Sustainability	14.57	8.64	15.58	5.47	0.226	> .400
Targets Hit	13.50	3.39	11.25	2.22	1.269	.124
Total Hits	15.17	3.76	12.00	2.94	1.488	.090
Situation 4 - Rifle Squad in Approach to Contact						
CET (min.)	1.78	0.054	1.87	0.26	0.827	.216
Near Misses	--	--	--	--	--	--
Sustainability	59.05	9.87	69.58	7.43	2.088	.034
Targets Hit	31.83	2.48	32.17	3.06	0.211	> .40
Total Hits	78.67	8.31	48.50	11.15	5.314	< 0.001

Table 7-1

RAW SCORE RESULTS
(Rifle Duplex Experiment) (Concluded)

Effectiveness Measures	Duplex		Ball		t	p
	$\overline{X}$	SD	$\overline{X}$	SD		
Situation 5 - Rifle Squad as Base of Fire Supporting the Advance						
CET (min.)	37.88	3.99	39.14	4.61	0.506	0.313
Near Misses	229.33	76.15	138.33	67.75	2.187	.027
Sustainability	46.83	9.03	52.37	6.20	1.239	.124
Targets Hit	7.33	2.25	7.67	2.66	0.239	>.400
Total Hits	9.50	4.09	8.17	3.19	0.628	.273
Situation 7 - Rifle Squad in Defense Against Attack						
CET (min.)	4.35	0.7	4.40	1.1	0.12	>.40
Near Misses	--	--	--	--	--	--
Sustainability	43.2	13.0	50.5	12.5	1.21	.12
Targets Hit	53.0	2.1	52.7	2.3	0.29	.39
Total Hits	114.3	10.4	91.1	11.5	4.49	.0005
Situation 8 - Rifle Squad in Night Defense						
CET (min.)	6.33	0.3	6.78	0.2	3.7	.002
Near Misses	--	--	--	--	--	--
Sustainability	19.4	3.5	27.1	12.5	1.8	.04
Targets Hit	17.6	3.4	17.0	2.9	0.4	.35
Total Hits	39.0	12.3	30.9	7.9	1.7	0.07

values (p) have been computed, using a two-sample t-statistic (see Section III, page 3-3, for an explanation of probability values).

Table 7-2 shows the expected duplex scores. These are the scores that would have been expected if the rifle squads had fired duplex instead of ball ammunition in this first firing of the various situations. The first firing scores were adjusted by applying mathematical corrections derived from the first firing scores of the original rifle squad experiment and the duplex experiment firing scores of all six squads of each mix. The scores are directly comparable and represent the contributions of all six squads of each mix. The scores in each case represent the average score of Mix UA and UB combined.

Duplex ammunition provides an advantage in near misses in the assault (125 to 15 meters). An advantage would then also be expected to accrue on the number of concealed undetected targets hit; however, in terms of hits and total number of hits on detected targets, there is no improvement evident as a result of firing duplex in the assault situation (Figures 7-1 and 7-2).

In the approach to contact situation (Pointing Fire, 15 to 163 meters), there are no tactically significant differences between duplex and ball ammunition, except for the total number of hits on targets that were hit. No more targets were hit by using duplex, but when a target was hit by a squad using duplex, it was hit with an average of 2.5 to 3 bullets (Figure 7-3).

In the longer range supporting fire of Situation 5 (390 to 545 meters), duplex ammunition provided a significant increase in the number of near misses and possibly a small increase in the total number of hits on targets that were hit. There was no increase in the number of targets hit. However, in the shorter range supporting fires of Situation 2 (300 meters), duplex ammunition resulted in increases in all target effects (CET, near misses, number of targets hit, and total number of hits) (Figures 7-4 through 7-7).

In Situations 7 and 8, aimed fire against visible point targets (45 to 320 meters), duplex ammunition provided a clear superiority in the total number of hits on targets that were hit. Although a small numerical advantage in the number of targets hit accrued in this situation, the large variability in squad scores indicates this difference is the result of chance variations (Table 7-1). See Figures 7-8 and 7-9 for cumulative exposure time by range and target.

In five of the six rifle situations, the number of rounds fired by the squads using duplex ammunition was greater than for the squads using ball ammunition. The reason cannot be explained. Since both groups had equal experience on the range, equal training, and equal weapons, it was hypothesized that both would fire the same amount of ammunition. This result merits further investigations.

Table 7-2

EXPECTED DUPLEX SCORE
(Rifle Duplex Experiment)

Effectiveness Measures	Original Ball Ammunition Score (UA and UB)	Expected Duplex Score
Situation 1 - Rifle Squad in Line Assault		
CET (min.)	24.8	26.3
Near Misses	314.2	448.0
Sustainability	46.4	59.7
Targets Hit	4.5	3.8
Total Hits	4.6	4.0
Situation 2 - Rifle Squad as Base of Fire Supporting the Assault		
CET (min.)	78.8	72.4
Near Misses	285.5	382.6
Sustainability	16.2	17.0
Targets Hit	10.4	14.2
Total Hits	11.5	18.1
Situation 4 - Rifle Squad in Approach to Contact		
CET (min.)	2.05	2.01
Near Misses	--	--
Sustainability	75.2	62.1
Targets Hit	30.4	27.9
Total Hits	47.1	83.1

Table 7-2

EXPECTED DUPLEX SCORE
(Rifle Duplex Experiment) (Concluded)

Effectiveness Measures	Original Ball Ammunition Score (UA and UB)	Expected Duplex Score
Situation 5 - Rifle Squad as Base of Fire Supporting the Advance		
CET (min.)	41.4	41.0
Near Misses	118.3	179.7
Sustainability	57.4	51.0
Targets Hit	5.7	6.7
Total Hits	5.7	6.7
Situation 7 - Rifle Squad in Defense Against Attack		
CET (min.)	5.9	5.6
Near Misses	--	--
Sustainability	61.3	51.3
Targets Hit	48.3	48.6
Total Hits	71.3	96.3
Situation 8 - Rifle Squad in Night Defense		
CET (min.)	6.8	6.4
Near Misses	--	--
Sustainability	44.9	36.3
Targets Hit	20.6	20.8
Total Hits	25.6	30.9

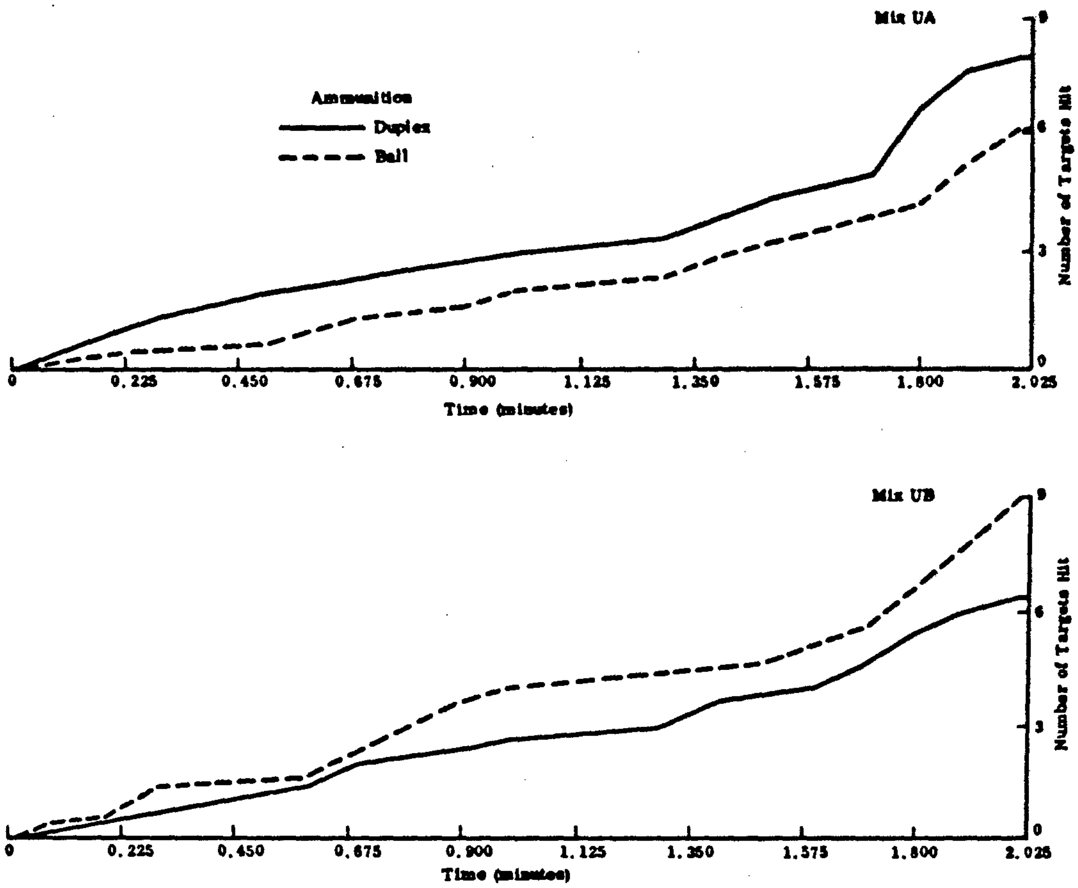


Figure 7-1

CUMULATIVE NUMBER OF TARGETS HIT--SITUATION 1

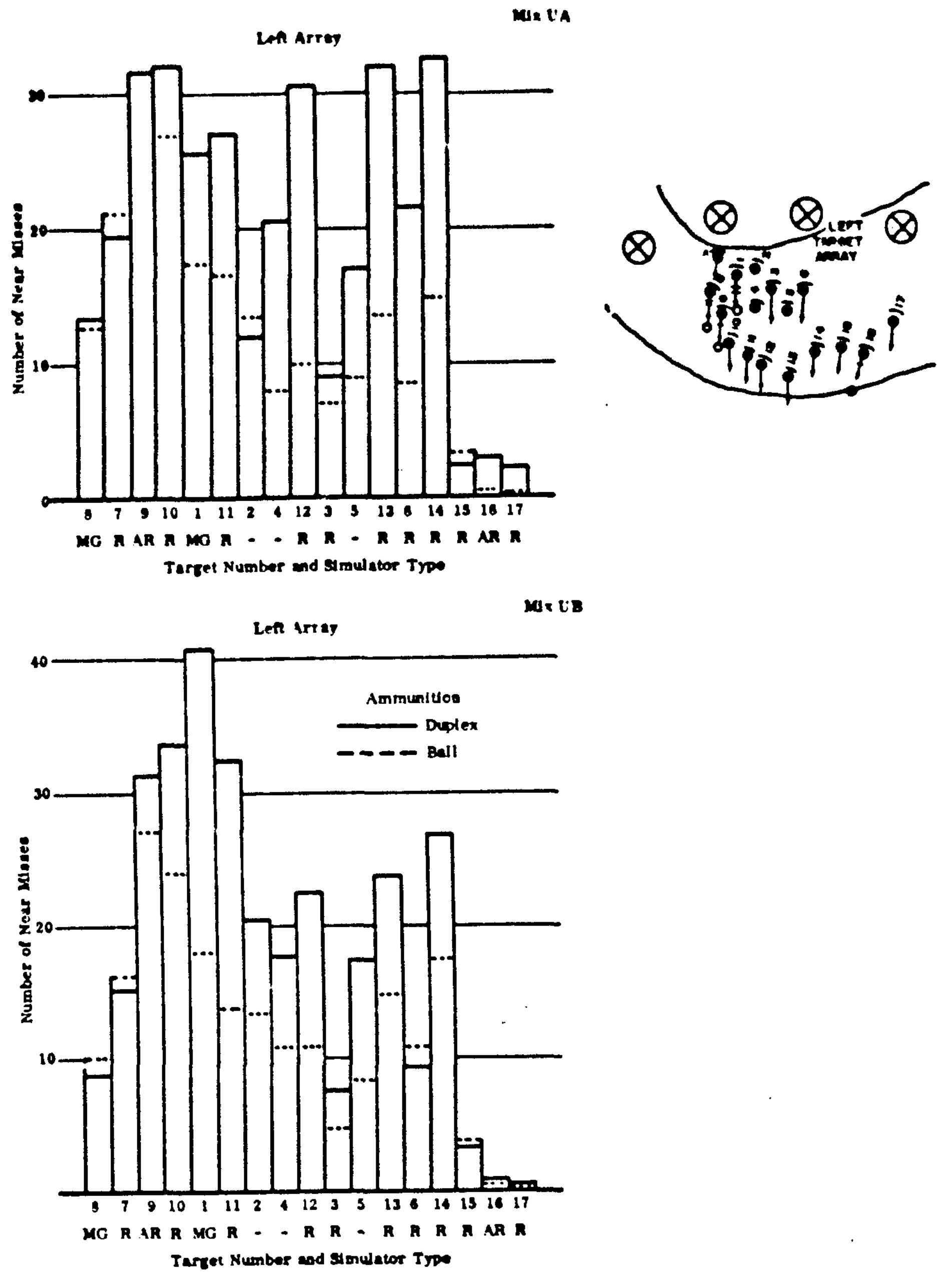


Figure 7-2

NUMBER AND DISTRIBUTION OF NEAR MISSES--
SITUATION 1

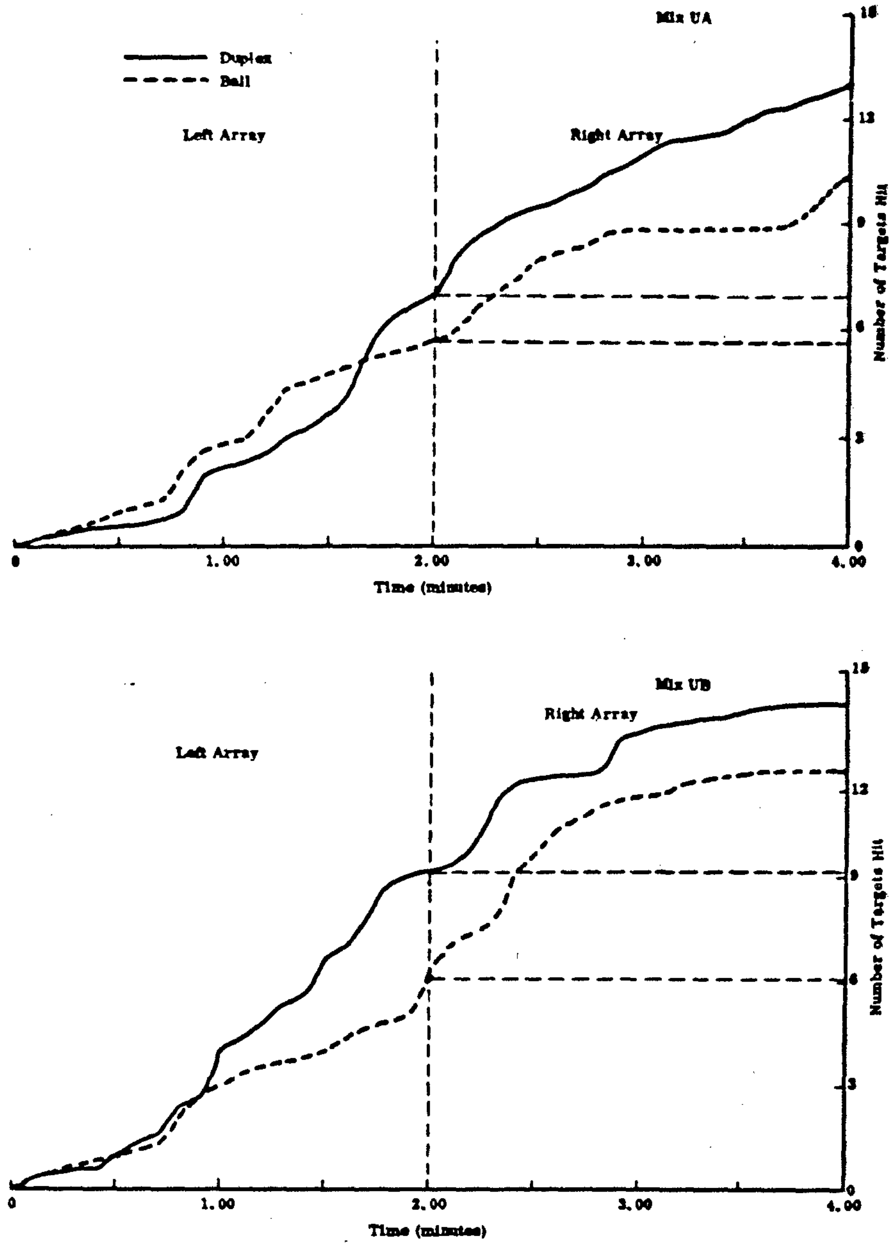
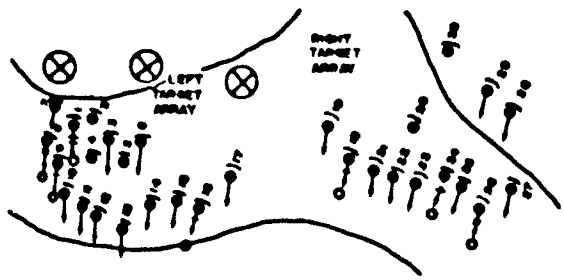
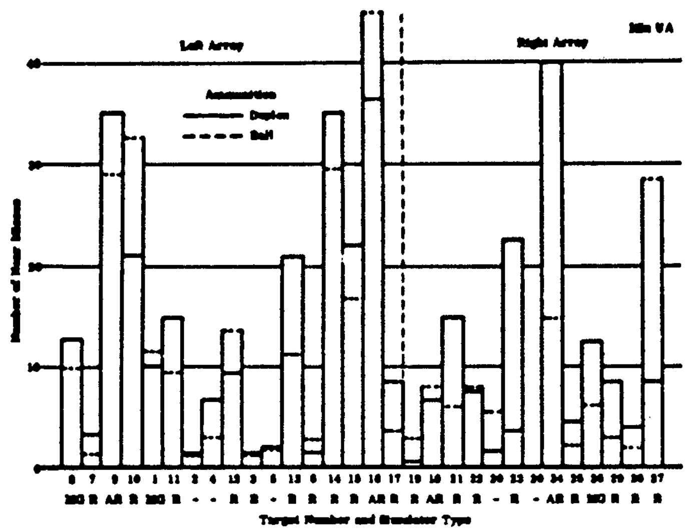


Figure 7-3

CUMULATIVE NUMBER OF TARGETS HIT--SITUATION 2





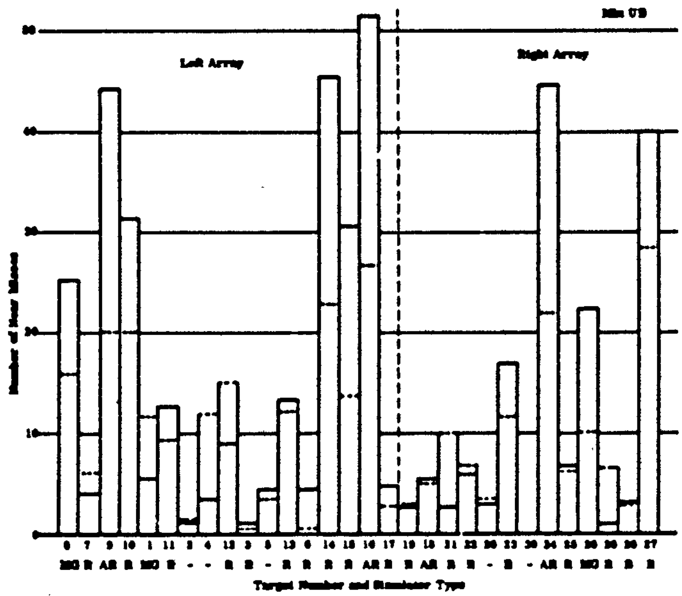
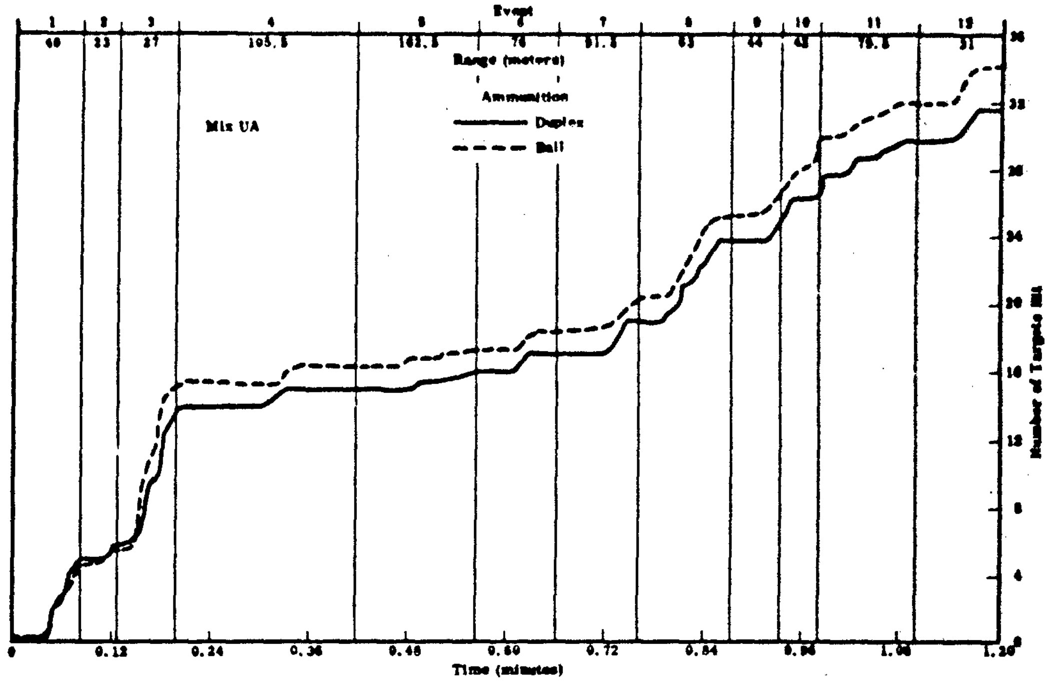


Figure 7-4 NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 2



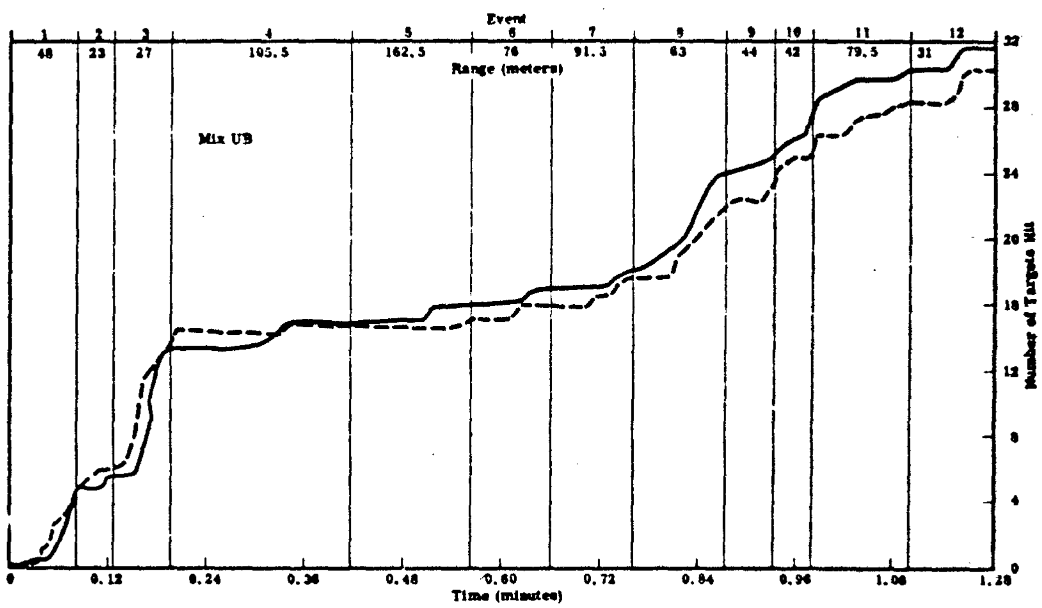


Figure 7-5

CUMULATIVE NUMBER OF TARGETS HIT--SITUATION 4

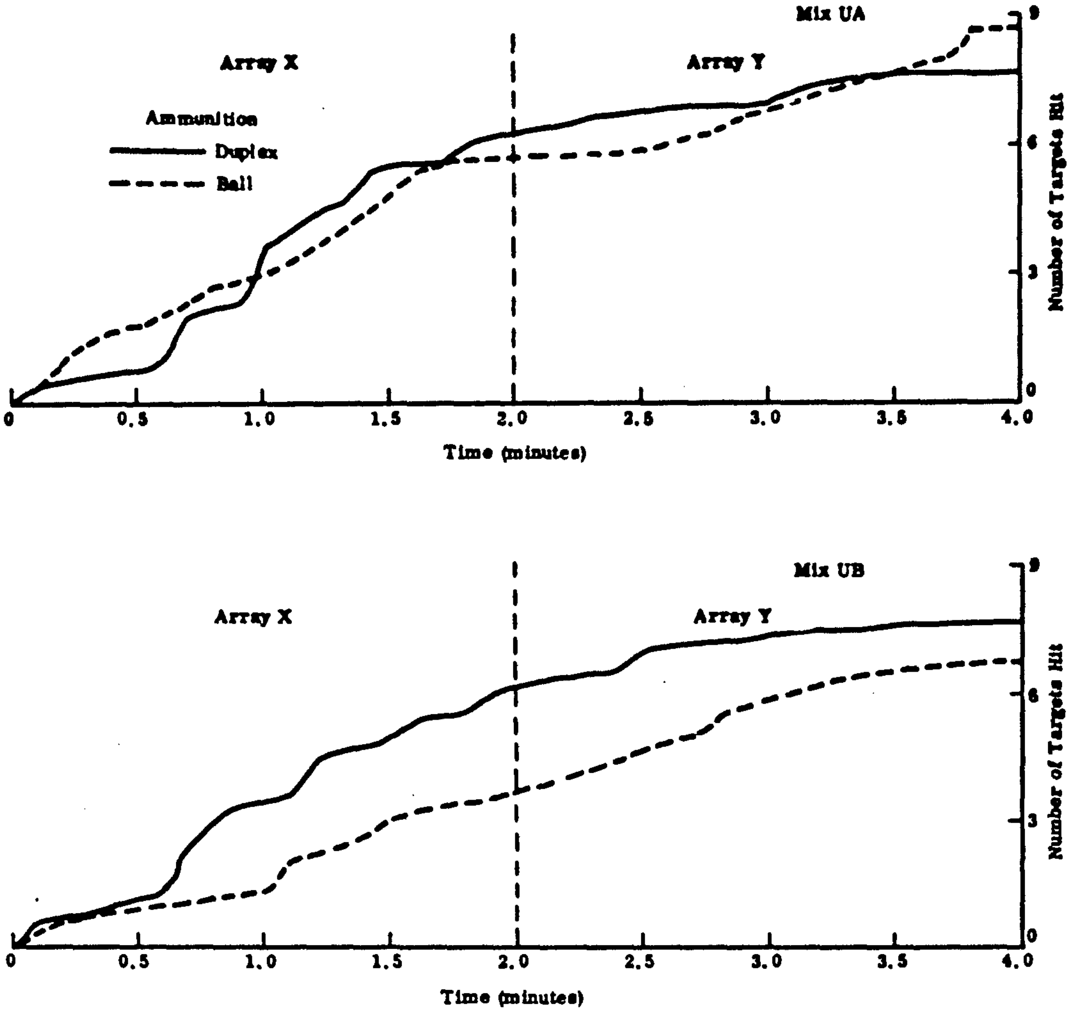


Figure 7-6

CUMULATIVE NUMBER OF TARGETS HIT--SITUATION 5

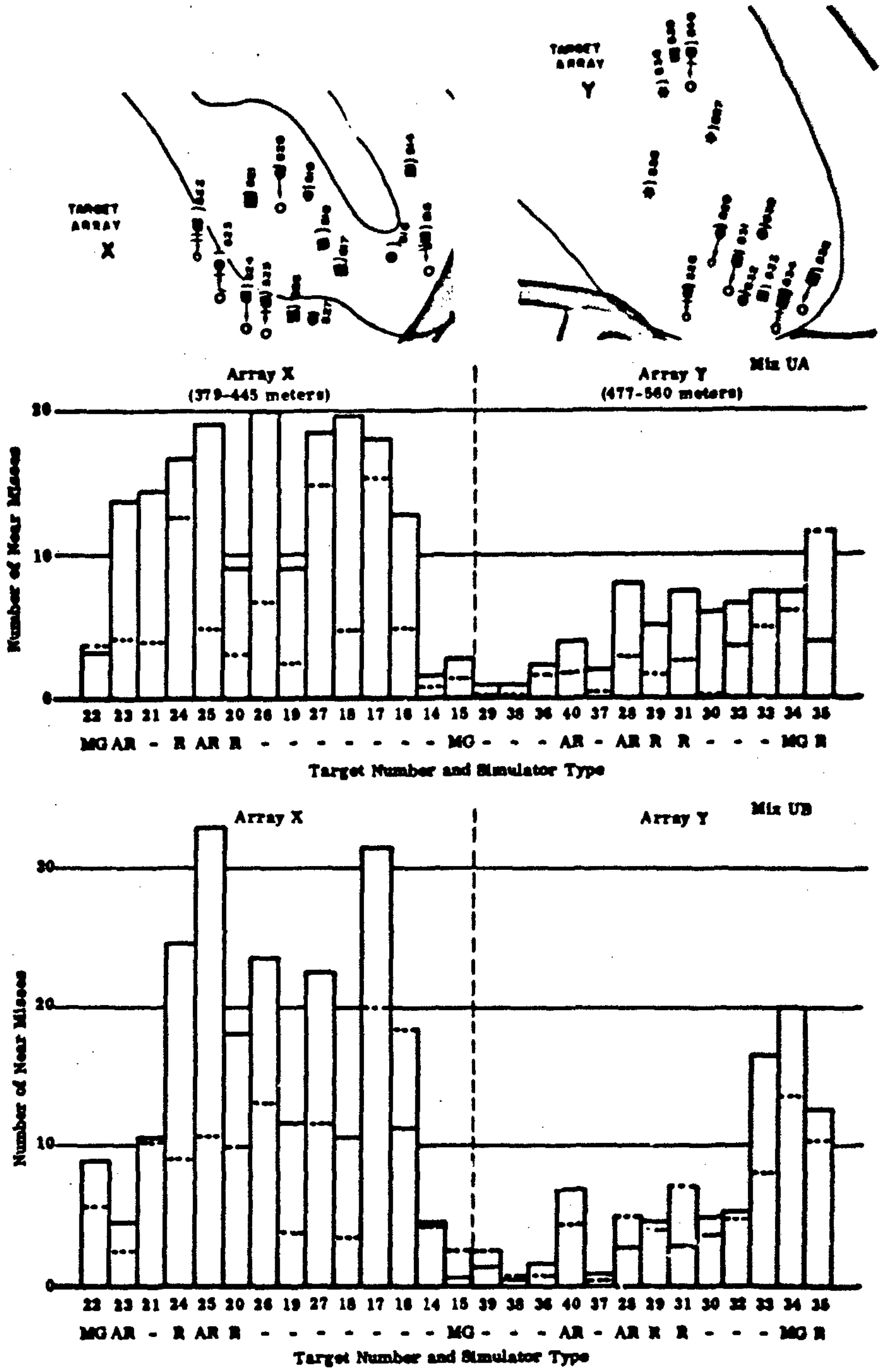


Figure 7-7

NUMBER AND DISTRIBUTION OF NEAR MISSES—
SITUATION 5

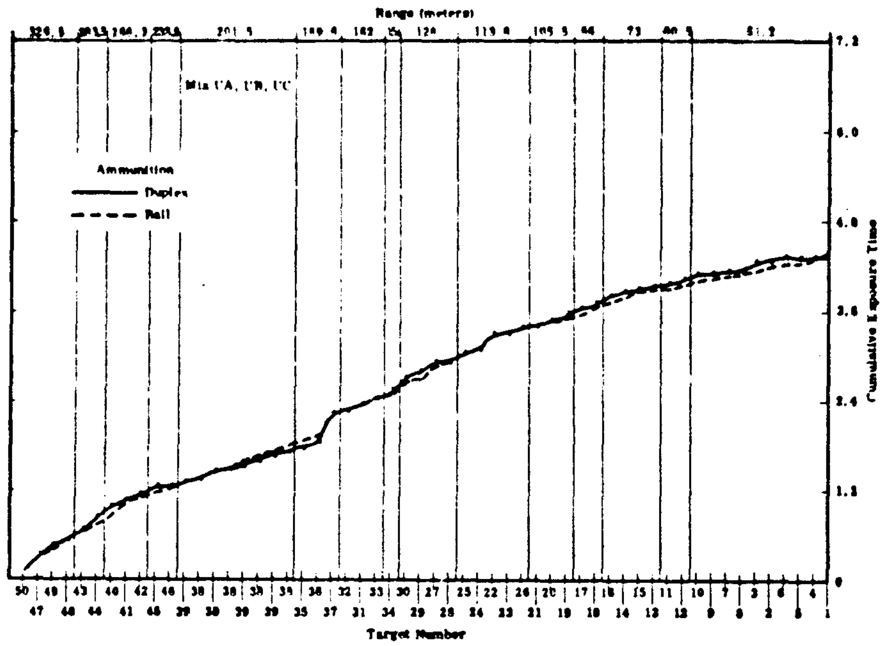


Figure 7-8 CUMULATIVE EXPOSURE TIME--SITUATION 7

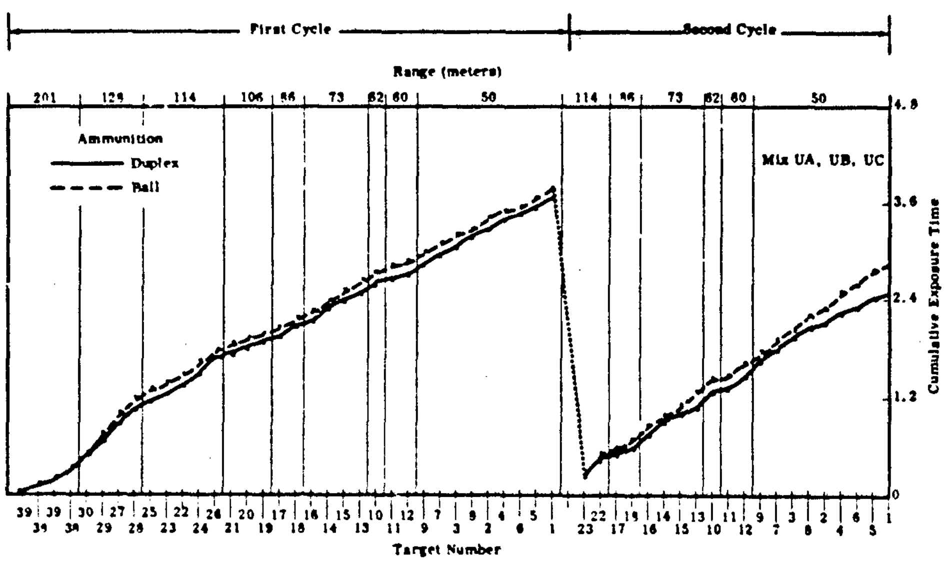


Figure 7-9 CUMULATIVE EXPOSURE TIME--SITUATION 8

It would be expected that as more duplex rounds were fired, an increase in target effects would be achieved, even if duplex had not been used. This could have been expected as a result of the greater number of rounds fired; however, although that might have accounted for the increases in the number of targets hit and the lower CETs, it was not great enough to account for the consistent superiority in both number of near misses and the total number of hits per target.

The use of duplex ammunition cannot be considered detrimental when used with the rifle in any situation at ranges between 15 and 545 meters. Moreover, duplex provided marked advantages under some circumstances, particularly in the area of number of near misses as an index of suppressive effect and distribution of fire. Within the framework of the USACDCEC experiment, it is concluded that duplex ammunition does not significantly decrease effectiveness under any circumstances, and under some circumstances, it increases effectiveness.

In Table 7-3, the expected duplex scores for the M14 rifle squads (UA and UB) are compared to the top ranking mix in each of the six rifle situations. The better score in each case is indicated by an asterisk.

The concept of duplex ammunition applies equally to both 7.62mm and 5.56mm ammunition. The increase in target effects achieved with 7.62mm duplex ammunition cannot be interpreted as a rationale for a choice of 7.62mm weapons over 5.56mm. Any advantages accruing to 7.62mm weapons from the use of duplex must also be attributed to 5.56mm weapons with duplex. Although not specifically tested in the experiment, 5.56mm duplex ammunition has been satisfactorily produced and tested in earlier laboratory and field experimentation by the Operations Research Office.[1] This ammunition weighs only about half that of 7.62mm duplex ammunition. Because current 5.56mm weapons are also lighter than 7.62mm weapons, an additional weight advantage is obtained. This combined weight advantage allows the soldier to carry up to three times as much 5.56mm ball ammunition as 7.62mm duplex ammunition for the same rifle system weight (Colt rifle versus M14).

Analysis shows that although the effects per round of ammunition are greater for 7.62mm duplex than for 5.56mm ball ammunition under certain circumstances, the effects per pound of ammunition are always significantly greater for 5.56mm ball than for 7.62mm duplex. Although duplex ammunition provided some advantages, greater advantages are considered possible, for it is believed that the duplex ammunition provided to USACDCEC did not meet all military ammunition requirement standards and that better quality control could have been exercised.

---

[1] Operations Research Office, SALVO II Rifle Experiment Preliminary Results (U), Johns Hopkins University, March 1958. CONFIDENTIAL

Table 7-3

EXPECTED DUPLEX SCORES COMPARED WITH TOP RANKED RIFLE MIXES (Rifle Duplex Experiment)

Effectiveness Measures	Best Mix and Raw Score (first firing)		UA Expected Duplex Score	UB Expected Duplex Score
Situation 1 - Rifle Squad in Live Assault				
CET (min.)	UB	24.1*	27.0	25.6
Near Misses	SC	499.6*	438.0	458.0
Sustainability	CA	72.2*	61.2	58.2
Targets Hit	UB	5.1*	3.4	4.4
Total Hits	SB	5.2*	3.5	4.5
Situation 2 - Rifle Squad as Base of Fire Supporting the Assault				
CET (min.)	UA	77.5	72.0*	72.8
Near Misses	CB	345.0	345.0	420.2*
Sustainability	CA	50.5*	23.0	13.0
Targets Hit	UA	10.7	14.4*	14.0
Total Hits	UA	12.6	19.8*	16.4
Situation 4 - Rifle Squad in Approach to Contact				
CET (min.)	SC	1.95*	1.99	2.03
Near Misses	--	--	--	--
Sustainability	CB	80.8*	65.1	59.1
Targets Hit	SC	30.8*	27.5	28.3
Total Hits	SC	53.8	87.1*	79.1

* Better score

Note: Although Mix UB was in first place in Situation 1 in CET and Targets Hit when using ball ammunition, its expected duplex scores result in a drop to 7th and 4th place, respectively.

Table 7-3

EXPECTED DUPLEX SCORES COMPARED WITH TOP RANKED RIFLE MIXES (Rifle Duplex Experiment) (Concluded)

Effectiveness Measures	Best Mix and Raw Score (first firing)		UA Expected Duplex Score	UB Expected Duplex Score
Situation 5 - Rifle Squad as Base of Fire Supporting the Advance				
CET (min.)	CB	38.6*	40.0	42.0
Near Misses	SA	207.3	207.5*	151.9
Sustainability	CA	84.8*	52.5	49.5
Targets Hit	SA	8.9*	7.6	5.8
Total Hits	SA	10.2*	7.6	5.8
Situation 7 - Rifle Squad in Defense Against Attack				
CET (min.)	CB	4.15*	5.0	6.2
Near Misses	--	--	--	--
Sustainability	CB	94.8*	61.5	41.1
Targets Hit	SB	56.0*	49.0	48.2
Total Hits	CB	90.5	92.0	100.6*
Situation 8 - Rifle Squad in Night Defense				
CET (min.)	SB	6.0	6.4	6.0
Near Misses	--	--	--	--
Sustainability	CB	69.4*	35.3	37.3
Targets Hit	CB	25.5*	18.3	22.3
Total Hits	SC	38.0*	29.0	32.8

Further immediate experimentation with duplex ammunition, particularly 5.56mm, is considered necessary.

B. AUTOMATIC RIFLE DUPLEX AMMUNITION EXPERIMENT

Mix UD (nine M14E2 rifles) was also fired in the duplex experiment. Three squads of the mix fired duplex ammunition and the other three fired ball as a control. All weapons fired two-round bursts, and the weapons in the automatic rifle positions (2 and 8 in Situation 1; 3 and 7 in Situations 2, 4 and 5; 4 and 7 in Situations 7 and 8) fired a mixture of half tracer and half ball ammunition in both the duplex squads and control squads. Results, presented in the same format as for the rifle duplex experiment, are given in tables for raw scores and expected scores (Tables 7-4 and 7-5).

Duplex provided a marked advantage in the assault and approach to contact -- (the two moving situations when the weapon was fired in shoulder pointed unaimed fire). In Situation 7 (aimed fire at point targets) duplex provided a tactically significant increase in the number of hits on targets that were hit. Although duplex provided an advantage in some situations, the numerical results of the firing in other situations (for example, Situation 5) indicated that ball ammunition is superior in automatic fire at longer ranges. The sample size, however, was small (three squads per group), and the variability of performance great. These differences may have occurred as the result of such chance factors as weather (Figures 7-10 through 7-12).

C. M60 MACHINEGUN DUPLEX AMMUNITION EXPERIMENT

The M60 bipod and tripod machinegun mixes that had originally fired during the September-December 1965 experimentation period fired each of the three machinegun situations again in January 1966. At that time, half of each mix fired ball ammunition and the other half duplex. Both halves used a mixture of one tracer to four rounds of nontracer ammunition.

Results are presented below in two tables. Table 7-6 presents the raw scores of the duplex squad compared to the control squads firing ball ammunition. Scores are given for squads using bipod machineguns (UE) and squads using tripod machineguns (UF) for each of the three machinegun situations (Situation 3, fire support of the assault; Situation 6, fire support of the advance; Situation 9, defense against attack). These raw scores represent small sample sizes (three squads) and the scores obtained after having already fired the various situations previously. To reduce the effects of inherent squad variabilities and put the scores in a format that would give the best estimate of what scores would have been obtained by all squads of the mixes if they had fired duplex instead of ball on their first firing in each situation, the scores were mathematically adjusted to eliminate the effects of learning and squad proficiency

Table 7-4

RAW SCORE RESULTS
(Automatic Rifle Duplex Experiment)

Effectiveness Measures	Ammunition				t	p
	Duplex		Ball			
	X̄	SD	X̄	SD		
Situation 1 - Rifle Squad in Line Assault						
CET (min.)	24.73	2.12	26.07	0.60	1.06	0.18
Near Misses	562.67	53.38	288.00	95.14	4.36	.006
Sustainability	72.67	6.27	65.93	4.06	1.56	.10
Targets Hit	5.29	0.64	2.83	1.93	2.10	.05
Total Hits	5.66	1.28	2.83	1.93	2.12	.05
Situation 2 - Rifle Squad as Base of Fire Supporting the Assault						
CET (min.)	77.06	1.01	82.09	6.43	1.34	.13
Near Misses	258.3	36.68	250.17	13.01	0.34	.38
Sustainability	7.23	7.07	11.73	7.80	0.74	.23
Targets Hit	11.33	1.15	9.33	2.31	1.34	.13
Total Hits	11.33	1.15	9.33	2.31	1.34	.13
Situation 4 - Rifle Squad in Approach to Contact						
CET (min.)	1.82	0.093	1.87	0.11	0.62	.29
Near Misses	--	--	--	--	--	--
Sustainability	21.10	24.13	20.40	27.0	.03	> .40
Targets Hit	33.33	1.15	30.33	1.5	2.71	.03
Total Hits	69.00	6.24	43.67	1.2	6.91	.002

Table 7-4

RAW SCORE RESULTS
(Automatic Rifle Duplex Experiment) (Concluded)

Effectiveness Measures	Ammunition				t	p
	Duplex		Ball			
	$\bar{X}$	SD	$\bar{X}$	SD		
Situation 5 - Rifle Squad as a Base of Fire Supporting the Advance						
CET (min.)	38.50	8.44	37.80	2.6	0.137	>.40
Near Misses	141.67	107.39	173.33	40.8	0.477	.33
Sustainability	47.60	4.16	56.57	6.8	1.949	.07
Targets Hit	7.33	4.58	7.67	4.2	0.467	.33
Total Hits	7.33	5.13	8.67	4.2	0.351	.37
Situation 7 - Rifle Squad in Defense Against Attack						
CET (min.)	5.2	1.1	5.3	.4	.37	.37
Near Misses	--	--	--	--	--	--
Sustainability	65.6	1.0	61.0	5.5	1.44	.11
Targets Hit	50.8	2.4	48.7	4.2	.78	.21
Total Hits	99.8	12.8	77.8	3.5	2.86	.02
Situation 8 - Rifle Squad in Night Defense Against Attack						
CET (min.)	6.6	.34	6.73	.59	.37	.37
Near Misses	--	--	--	--	--	--
Sustainability	1.0	1.7	4.0	3.6	1.30	.13
Targets Hit	14.7	1.5	15.0	3.0	.17	>.40
Total Hits	30.3	4.9	27.7	6.8	.55	0.31

Table 7-5

EXPECTED DUPLEX SCORES
(Automatic Rifle Duplex Experiment)

Effectiveness Measures	Original Ball Ammunition Score (UD)	Expected Duplex Score
Situation 1 - Rifle Squad in Live Assault		
CET (min.)	25.5	22.5
Near Misses	203.3	402.5
Sustainability	43.4	59.4
Targets Hit	2.9	7.5
Total Hits	2.9	7.5
Situation 2 - Rifle Squad as Base of Fire Supporting the Assault		
CET (min.)	78.6	75.4
Near Misses	272.0	227.1
Sustainability	7.8	25.9
Targets Hit	8.8	7.6
Total Hits	9.5	7.8
Situation 4 - Rifle Squad in Approach to Contact		
CET (min.)	2.1	1.9
Near Misses	--	--
Sustainability	42.0	46.2
Targets Hit	27.8	34.9
Total Hits	38.6	76.3

Table 7-5

EXPECTED DUPLEX SCORES
(Automatic Rifle Duplex Experiment) (Concluded)

Effectiveness Measures	Original Ball Ammunition Score (UD)	Expected Duplex Score
Situation 5 - Rifle Squad as Base of Fire Supporting the Advance		
CET (min.)	40.3	43.7
Near Misses	125.5	83.5
Sustainability	52.1	43.8
Targets Hit	6.5	4.2
Total Hits	6.7	4.2
Situation 7 - Rifle Squad in Defense Against Attack		
CET (min.)	6.8	8.0
Near Misses	--	--
Sustainability	43.1	37.5
Targets Hit	44.9	42.7
Total Hits	70.2	80.9
Situation 8 - Rifle Squad in Night Defense Against Attack		
CET (min.)	7.6	7.8
Near Misses	--	--
Sustainability	38.1	32.1
Targets Hit	15.3	8.3
Total Hits	19.2	16.7

Table 7-6

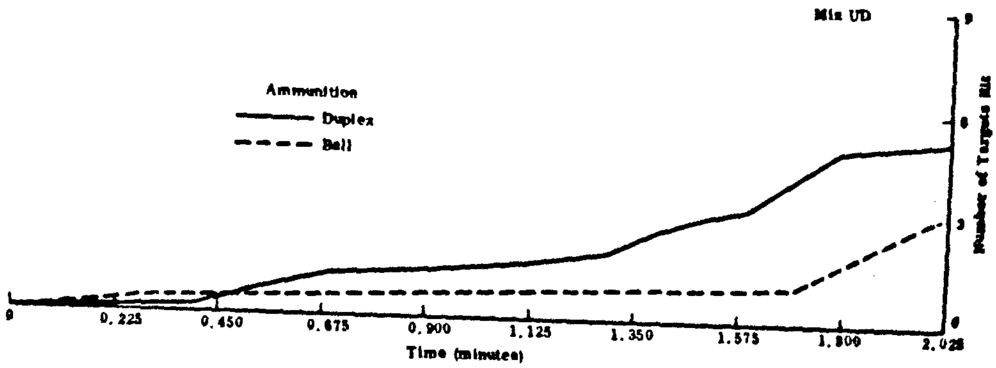
RAW SCORE RESULTS
(Machinegun Duplex Experiment)

Effectiveness Measures	Ammunition				t	p
	Duplex		Ball			
	$\bar{X}$	SD	$\bar{X}$	SD		
Situation 3 - Fire Support of Assault Mix UE, M60 Bipod Machinegun						
CET (min.)	80.90	6.40	94.36	3.07	3.284	.017
Near Misses	352.0	53.36	249.7	36.12	2.751	.026
Sustainability	41.45	8.09	50.70	17.45	0.833	.227
Targets Hit	9.33	0.579	4.67	2.08	3.738	.010
Total Hits	10.67	0.579	4.67	2.08	4.813	.005
Mix UF, M60 Tripod Machinegun (with T&E mechanism)						
CET (min.)	83.79	4.50	95.42	5.73	2.765	.025
Near Misses	371.3	78.47	324.3	51.21	0.864	.218
Sustainability	50.20	13.50	27.16	7.39	2.593	.032
Targets Hit	9.67	3.11	3.67	2.08	2.778	.025
Total Hits	12.33	2.58	4.33	3.21	3.365	.016
Situation 6 - Fire Support of the Advance Mix UE - M60 Bipod Machinegun						
CET (min.)	58.67	2.00	59.69	5.30	0.311	.387
Near Misses	307.33	68.30	270.33	102.08	0.522	.316
Sustainability	69.43	15.06	65.93	12.47	0.310	.387
Targets Hit	11.67	3.79	10.35	3.06	0.475	.332
Total Hits	12.33	4.04	12.33	3.06	0.000	>.40

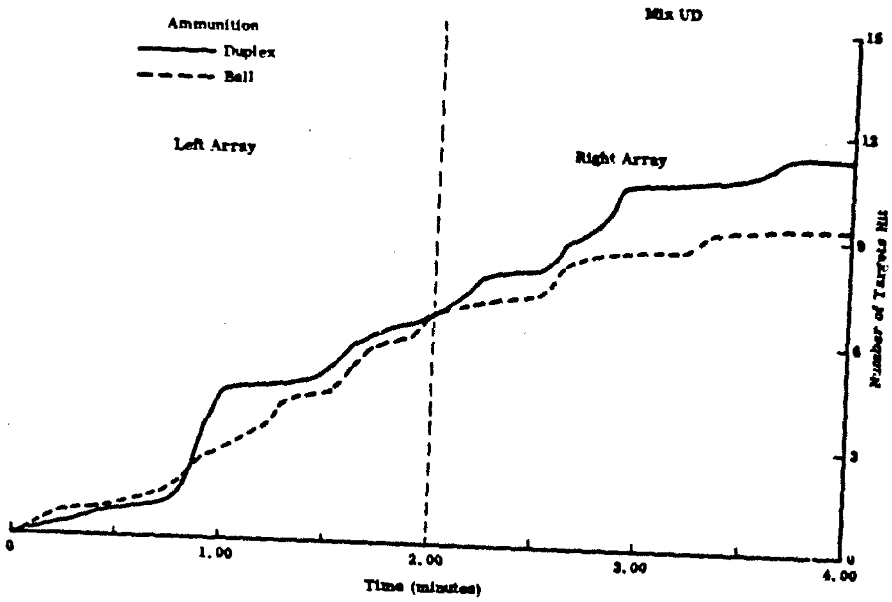
Table 7-6

RAW SCORE RESULTS
(Machinegun Duplex Experiment) (Concluded)

Effectiveness Measures	Ammunition				t	p
	Duplex		Ball			
	$\overline{X}$	SD	$\overline{X}$	SD		
Situation 6 - Mix UF, M60 Tripod Machinegun (no T&E mechanism)						
CET (min.)	62.94	2.11	59.77	1.72	2.018	.060
Near Misses	240.67	48.81	325.33	94.32	1.381	.122
Sustainability	66.83	1.45	60.20	10.25	1.110	.166
Targets Hit	6.00	3.00	13.33	4.93	2.20	.047
Total Hits	6.67	2.52	14.67	7.23	1.809	.027
Situation 9 - Defense Against Attack Mix UE, M60 Bipod Machinegun						
CET (min.)	8.36	1.24	8.75	1.22	0.388	.361
Near Misses	--	--	--	--	--	--
Sustainability	79.8	2.79	88.6	1.74	4.635	.005
Targets Hit	42.33	1.39	38.67	5.51	1.116	.165
Total Hits	83.67	6.11	61.33	14.47	2.463	.037
Mix UF, M60 Tripod Machinegun (no T&E mechanism)						
CET (min.)	7.52	0.51	7.45	0.35	0.196	>.400
Near Misses	--	--	--	--	--	--
Sustainability	79.2	4.31	84.2	3.44	1.570	.097
Targets Hit	43.00	1.00	45.00	3.46	0.962	.196
Total Hits	91.33	13.58	63.67	8.39	3.002	.022

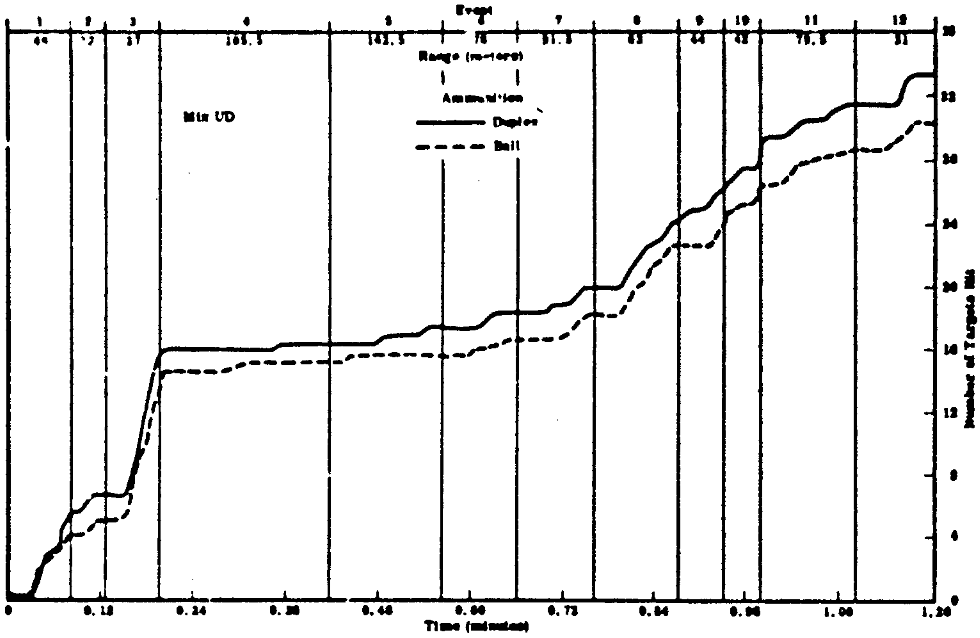


Situation 1

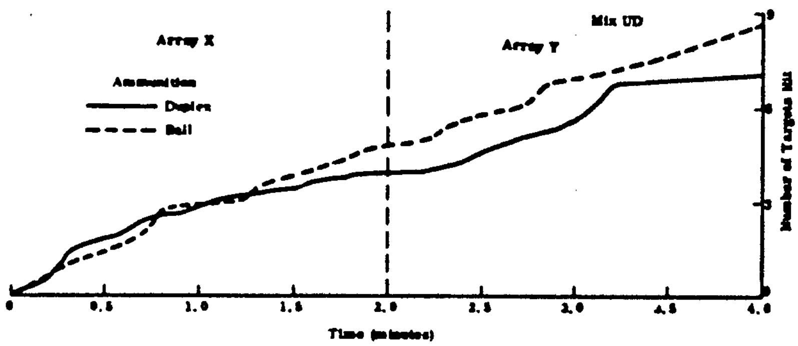


Situation 2

Figure 7-10 CUMULATIVE NUMBER OF TARGETS HIT



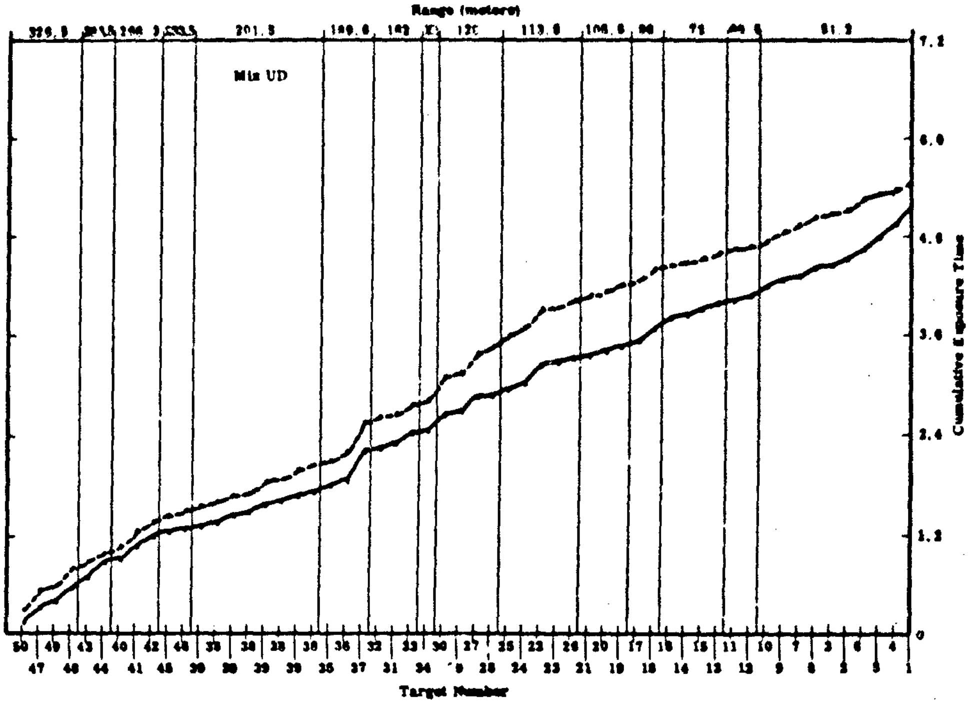
Situation 4



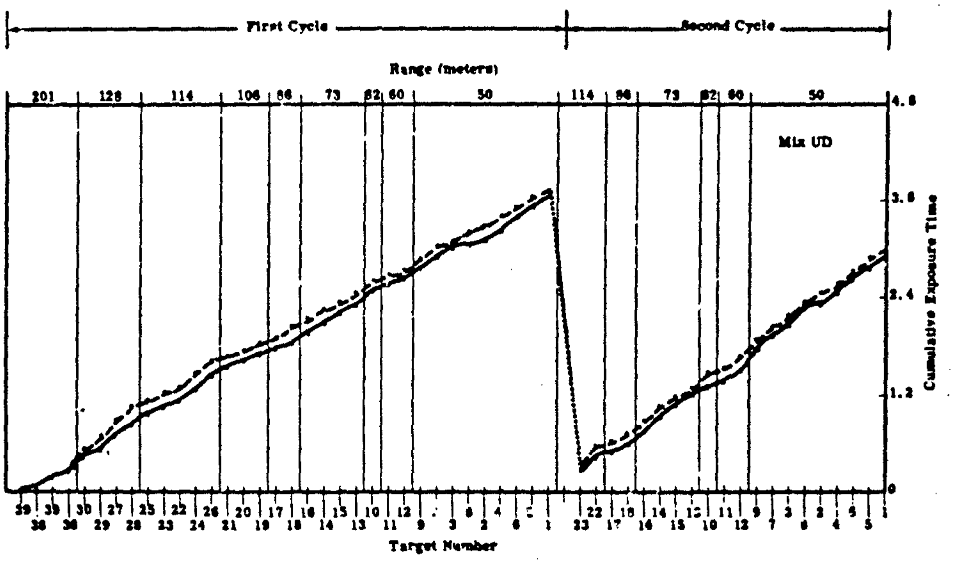
Situation 5

Figure 7-10 (Concluded)

CUMULATIVE NUMBER OF TARGETS HIT



Situation 7



Situation 8

Figure 7-11 CUMULATIVE EXPOSURE TIME

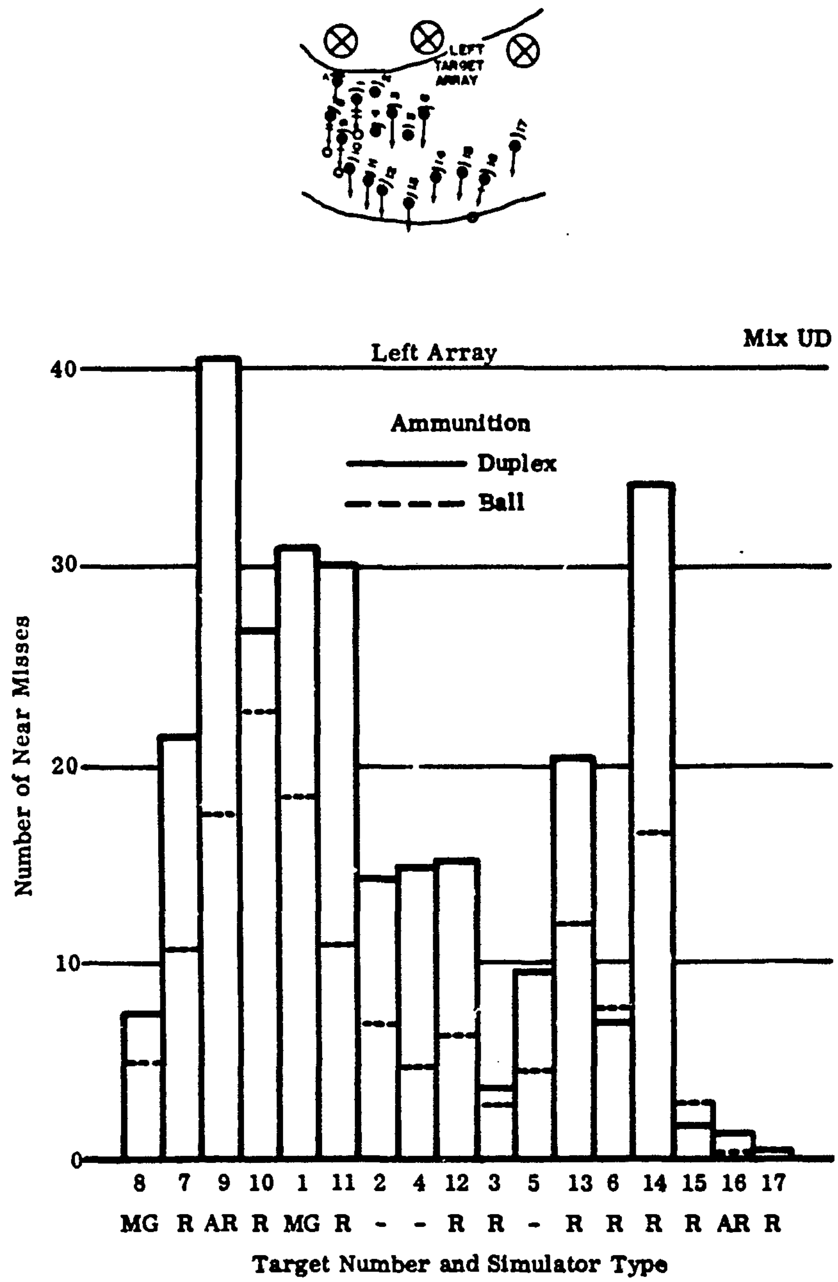
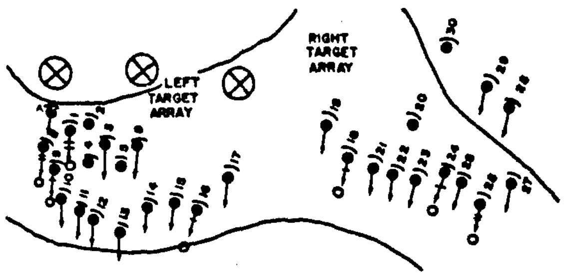


Figure 7-12

NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 1



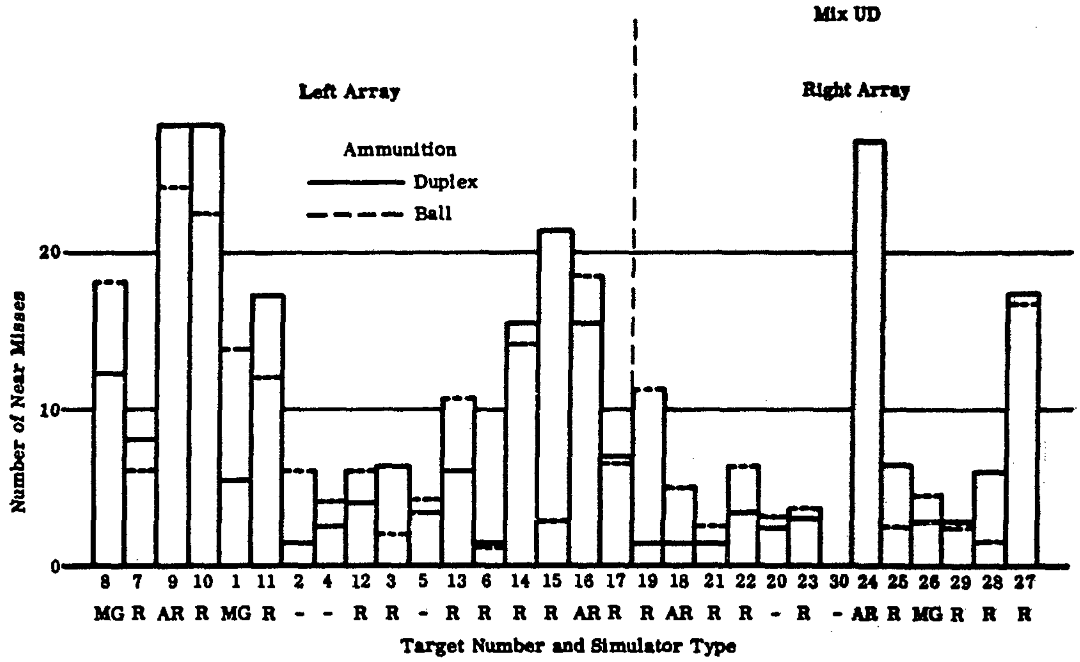


Figure 7-12 (Continued)

NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 2

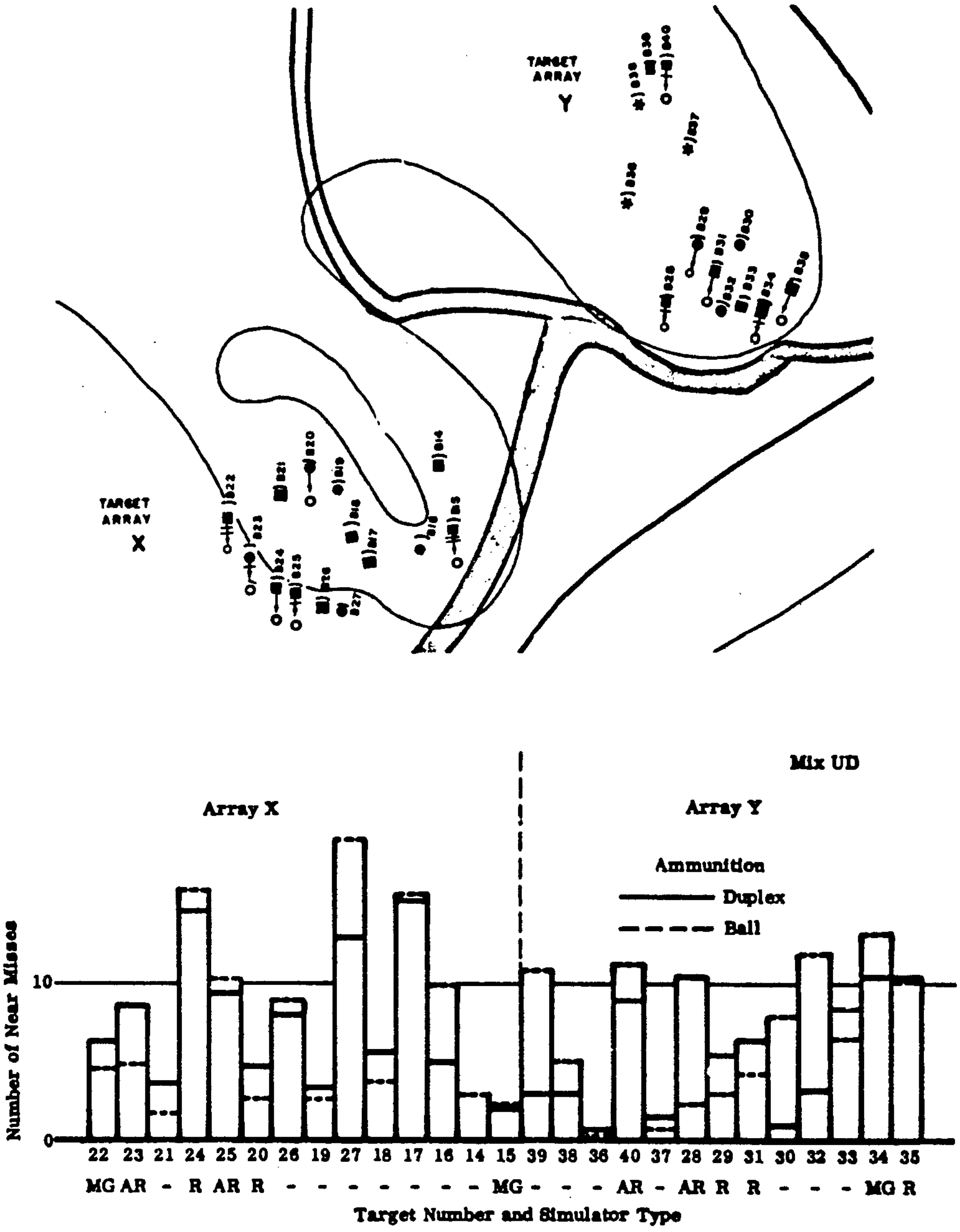


Figure 7-12 (Concluded)

NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 5

variable (expected duplex scores). These results are the most meaningful, precise, and valid of the two sets. However, the results and conclusions drawn from them prove almost identical, regardless of the set (raw scores or adjusted scores) used. Distribution of hits and near misses (not adjusted) are also provided (Figures 7-13 through 7-15).

Table 7-7 shows expected duplex scores. These are the scores that would have been expected if the machinegun squads had fired duplex instead of ball ammunition during their first firing of the various situations. The first firing scores were adjusted by applying mathematical corrections derived from the first and second firing scores of all six squads of the mix (squads firing duplex and squads firing ball). These expected duplex scores are directly comparable and each represents the contribution of all six machinegun squads of each mix.

In Table 7-6, the probability values (p) have been computed using a two-sample t-statistic. (See page 3-3 for explanation of probability values.)

In firing supporting fires at concealed and partially concealed targets (primarily distributed area fire) at a 300 meter range (Situation 3) duplex ammunition proved superior to ball ammunition for both bipod and tripod machineguns in target effects and overall effectiveness. While being fired at visible point targets (Situation 9) at ranges of 45 meters to 320 meters duplex ammunition proved superior to ball in target effects and overall effectiveness. Thus, the experimental results indicate that for both the bipod and tripod machineguns, at ranges out to 300 meters in both point fire and distributed area fire, duplex ammunition is superior to ball ammunition. However, at ranges of 450 meters to 750 meters (Situation 6) ball ammunition proved superior to duplex for both bipod and tripod machineguns firing primarily distributed area fire but with some aimed point fire whenever an actual target appeared.

Results indicate therefore that, for the machinegun, duplex ammunition is superior at ranges out to 300 meters while ball ammunition is superior at ranges beyond 450 meters. At an unknown point somewhere between 300 and 450 meters the effectiveness of ball ammunition for machineguns surpasses that of duplex.

Table 7-7

EXPECTED DUPLEX SCORES
(Machinegun Duplex Experiment)

Effectiveness Measures	Original Ball Ammunition Score	Expected Duplex Score
Situation 3 - Fire Support of Assault Mix UE, M60 Bipod Machinegun		
CET (min.)	92.6	82.83
Near Misses	246.4	277.18
Sustainability	51.2	42.11
Targets Hit	4.2	7.66
Total Hits	5.0	8.67
Mix UF, M60 Tripod Machinegun (with T&E mechanism)		
CET (min.)	87.8	75.61
Near Misses	273.8	343.49
Sustainability	41.8	51.20
Targets Hit	6.8	21.85
Total Hits	7.8	22.30
Situation 6 - Fire Support of the Advance Mix UE, M60 Bipod Machinegun		
CET (min.)	63.6	65.56
Near Misses	228.0	220.64
Sustainability	78.5	82.31
Targets Hit	6.0	4.32
Total Hits	7.0	3.51

Table 7-7

EXPECTED DUPLEX SCORES
(Machinegun Duplex Experiment) (Concluded)

Effectiveness Measures	Original Ball Ammunition Score	Expected Duplex Score
Situation 6 - Mix UF, M60 Tripod Machinegun (no T&E mechanism)		
CET (min.)	56.5	52.91
Near Misses	308.2	261.05
Sustainability	65.5	66.91
Targets Hit	12.2	7.43
Total Hits	13.8	7.10
Situation 9 - Defense Against Attack Mix UE, M60 Bipod Machinegun		
CET (min.)	9.1	8.36
Near Misses	--	--
Sustainability	88.1	78.95
Targets Hit	39.5	43.67
Total Hits	65.1	78.27
Mix UF, M60 Tripod Machinegun (no T&E mechanism)		
CET (min.)	8.0	7.21
Near Misses	--	--
Sustainability	79.9	82.74
Targets Hit	43.1	40.39
Total Hits	67.0	83.85

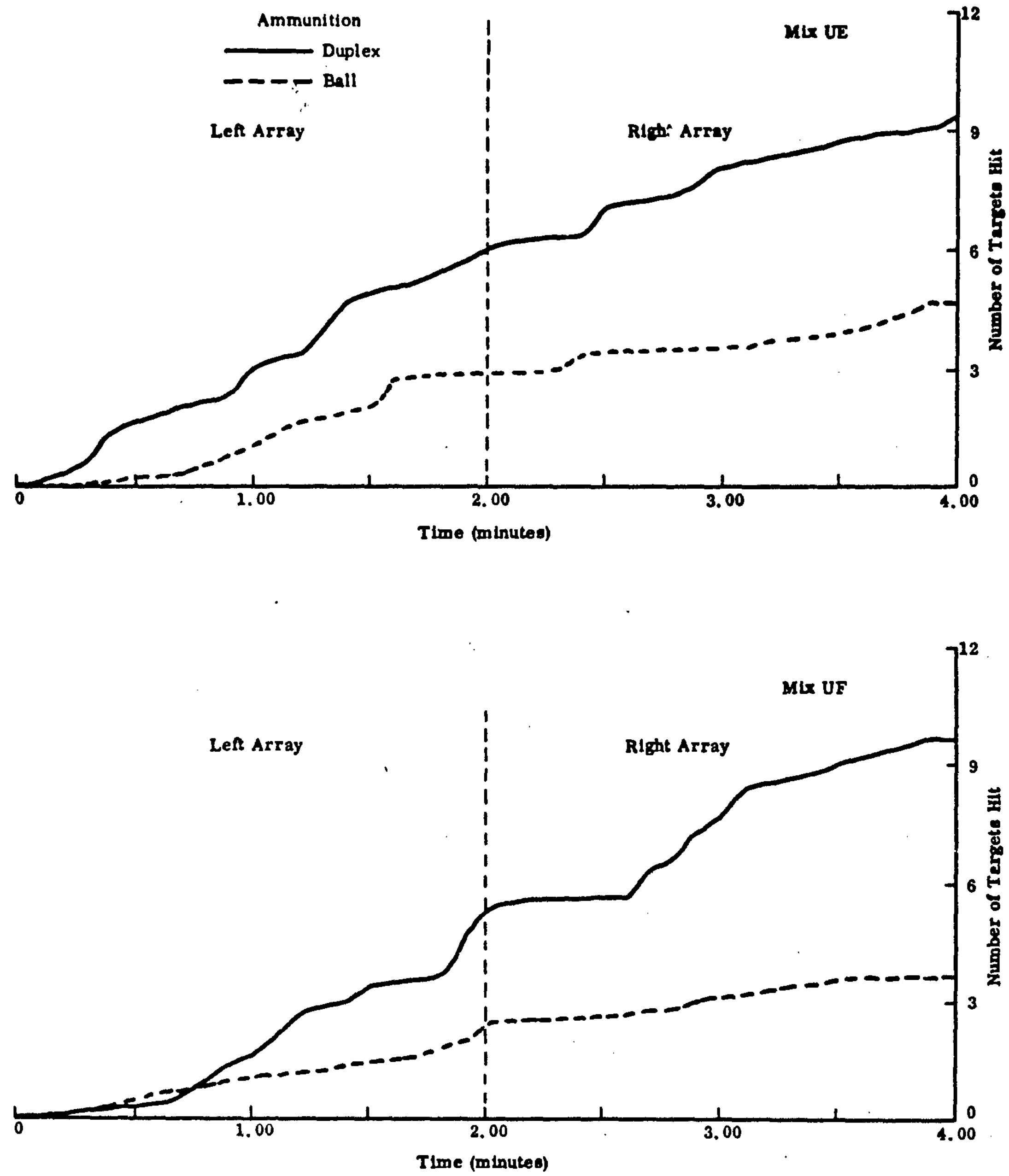
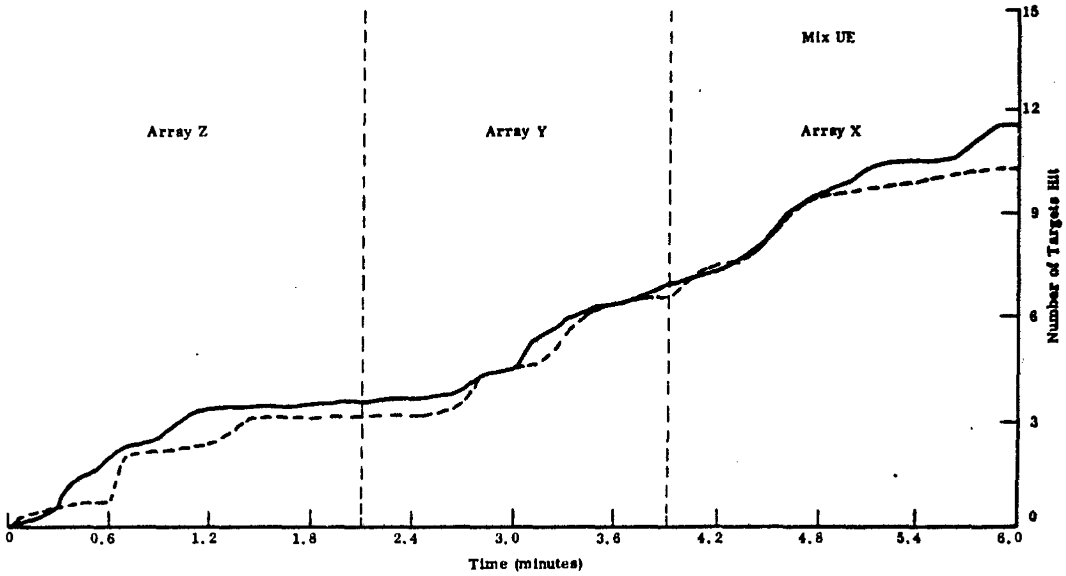


Figure 7-13

CUMULATIVE NUMBER OF TARGETS HIT--SITUATION 3



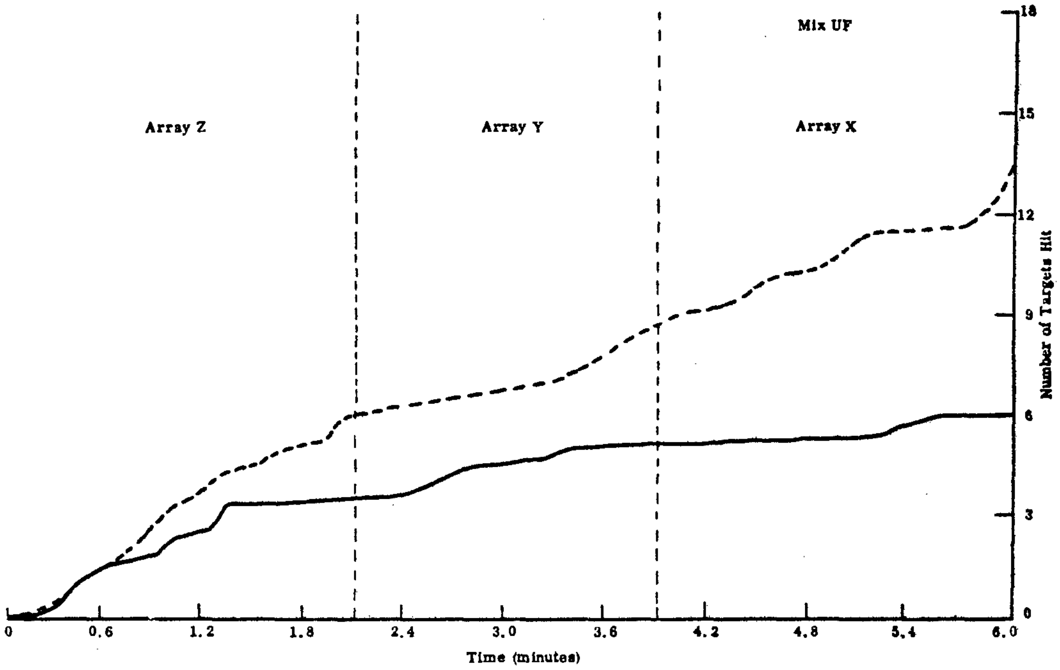


Figure 7-13 (Concluded)

CUMULATIVE NUMBER OF TARGETS HIT--SITUATION 6

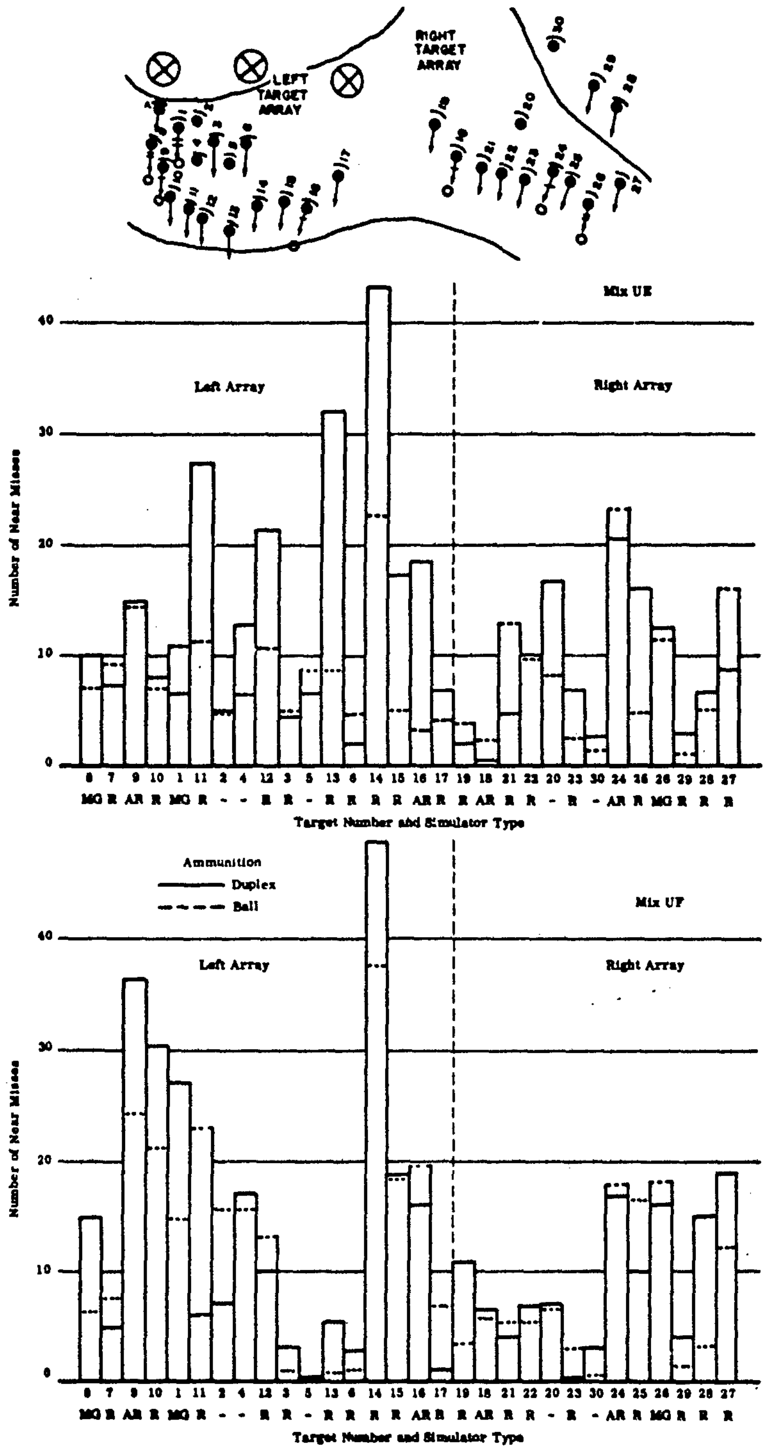
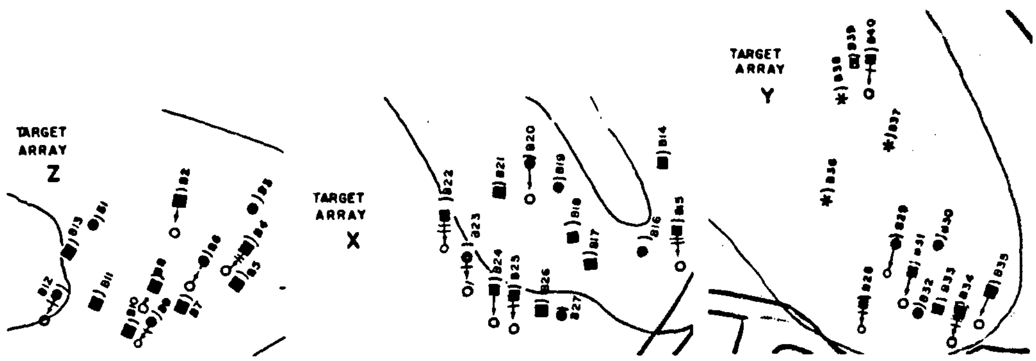
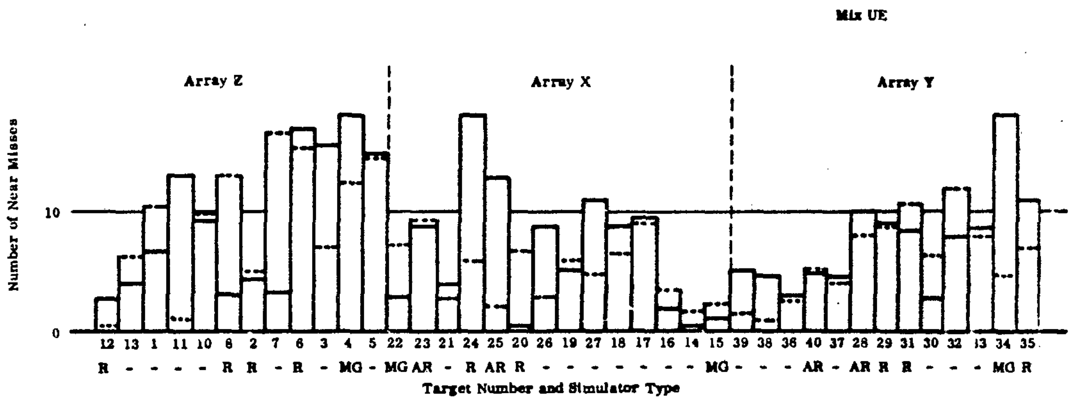


Figure 7-14 NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 3





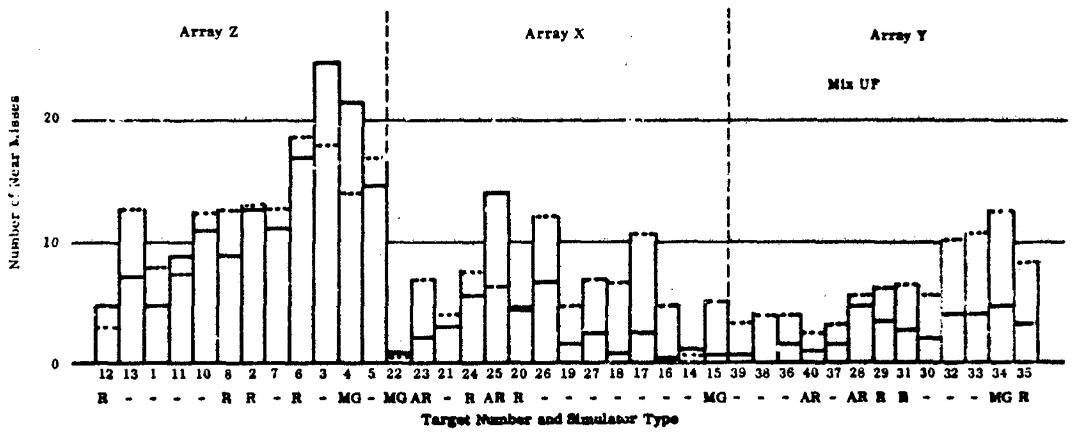


Figure 7-14 (Concluded)

NUMBER AND DISTRIBUTION OF NEAR MISSES--SITUATION 6

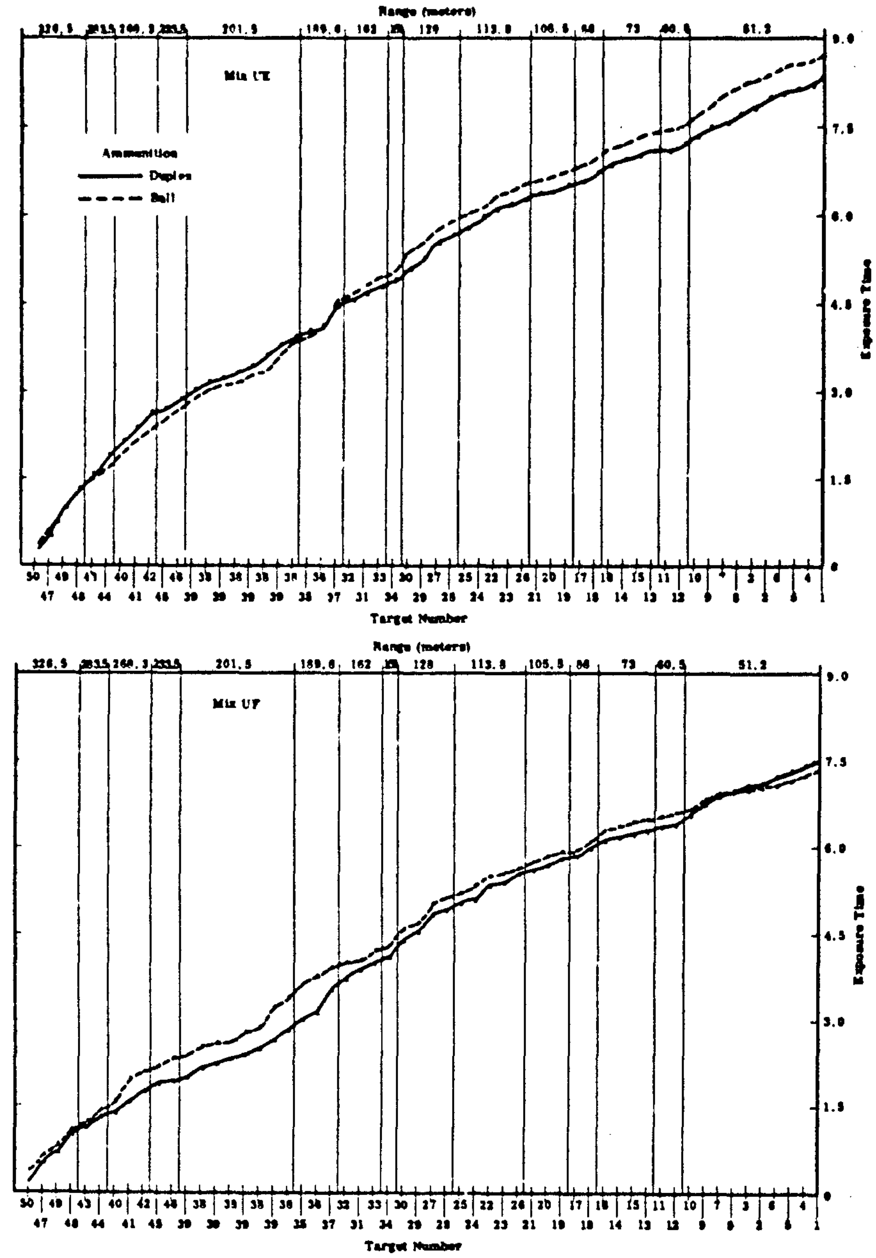


Figure 7-15

CUMULATIVE EXPOSURE TIME--SITUATION 9

SECTION VIII

LETHALITY DATA IMPLICATIONS

Pertinent lethality data were analyzed and studies performed. This included a review and analysis of the literature from 1928 to the present.

Current existing lethality data were carefully evaluated in relation to existing 5.56mm and 7.62mm ball ammunition and the candidate weapons used in the USACDCEC SAWS experiment. As a result of this analysis by a team of military and medical personnel and operations analysts, it is concluded that considerations of lethality support the USACDCEC conclusions presented in Section IX of this report.

A summary and analysis of the lethality data appears in Annex E, Small Arms Lethality.

BLANK PAGE

SECTION IX

CONCLUSIONS

These conclusions are derived from analyses of the results presented in Sections IV, V, VI, and VII. The terms "target effects," "sustainability," and "overall effectiveness" are used as defined and illustrated in Section II and III.

1. Rifle squads armed with low muzzle impulse weapons are markedly superior in overall effectiveness to rifle squads armed with high muzzle impulse weapons.

2. Rifle squads armed with Colt weapons and rifle squads armed with Stoner weapons are approximately equivalent in target effects achieved.

3. Because of the lighter system weight and related advantages in sustainability, rifle squads armed with Colt weapons are superior to squads armed with Stoner weapons.

4. Rifle squads equipped only with Colt automatic rifles appear superior to all other squads evaluated in overall effectiveness. Further testing of this hypothesis and evaluation should be undertaken.

5. The hypothesis that the most effective squad is a squad equipped with Colt rifles with XM148 grenade launchers attached (to provide a SPIW-type dual "area fire-point fire" capability) is promising and should undergo further testing.

6. Hypotheses that high muzzle impulse weapons are superior to low muzzle impulse weapons at longer ranges (300 to 550 meters) are not supported.

7. Hypotheses that lightweight rifles with high sights and straight stocks, such as the M16E1, are inferior or inadequate in pointing fire are not supported.

8. Low muzzle impulse weapons are superior to high muzzle impulse weapons in both automatic and semiautomatic fire in night firing in the defense.

9. A squad equipped only with M14 rifles is superior to a squad equipped with any other single US 7.62mm weapon, or combination of these weapons.

10. The M14E2 automatic rifle is unsatisfactory in overall effectiveness for use in the rifle role in the rifle squad.

11. It cannot be concluded that the low target effects of the AK47 rifle in the USACDCEC SAWS Field Experiment are indicative of the performance of the AK47 rifle in general.*

12. The AK47 rifle (Soviet, East German and Chinese Communist) is significantly more reliable than any US 7.62mm or 5.56mm weapon.

13. The M60 machinegun is not suitable for use in the rifle squad because: 1) the system weight requires a two-man crew; 2) the sustainability of the weapon is marginal, even with a two-man crew; and 3) the size and weight of the weapon make it extremely difficult to manage in a moving firing situation.

14. The low muzzle impulse machinegun is a feasible weapon of incorporation into the rifle squad in the conventional automatic rifle role, or into a new squad organization context in the machinegun role.

15. The 5.56mm Stoner machinegun is judged to have a high reliability potential.

16. The standard 5.56mm ammunition provided for the experiment is not satisfactory because of fouling characteristics, the pressure mismatch of propellants in the ball and tracer cartridges, and primer sensitivity. These ammunition deficiencies are judged readily correctable.

17. The 5.56mm machinegun belt links provided for the experiment were not made to design specifications and are not satisfactory for use with the Stoner machinegun. This deficiency is readily correctable.

18. Neither the 7.62mm nor the 5.56mm tracer rounds are considered satisfactory for use by the firer in adjusting fire during daylight hours.

19. For aimed fire on visible point targets during daylight, semiautomatic fire is superior to automatic fire. This is true for all rifles, both low and high muzzle impulse. This does not imply, however, that automatic fire may not be superior in suppression effects and hits on adjacent concealed targets.

20. At ranges of less than 500 meters duplex ammunition under most circumstances provides a significant increase over simplex ball

* The nine AK47 rifles used in the experiment were shared by all experimentation subjects. Amount of use of the weapons before the experiment was unknown, and a variety of types of foreign ammunition was used in the experiment.

ammunition in the number of targets hit, the number of total hits on targets that are hit, the timeliness of hits, and the number of near misses as an indication of suppression. Under no circumstances does its use significantly decrease effectiveness at ranges of less than 500 meters.

21. Duplex ammunition is most effective at close ranges with its advantage in effectiveness over simplex ammunition decreasing as range increases.

22. The concept of duplex ammunition applies equally to 7.62mm and 5.56mm ammunition.

23. Considerations of the relative lethality of 5.56mm and 7.62mm ammunition (with the possible exception of duplex) support all of the CDCEC SAWS conclusions. It is concluded that there are no tactically significant differences between 5.56mm and 7.62mm ammunition per round of ammunition; however, 5.56mm ammunition is significantly superior to 7.62mm ammunition in lethality per pound of ammunition or per basic load carried by the soldier.

END

DATE FILMED

11-7-66

EXHIBIT 3

SECURITY SECRET INFORMATION

Unclassified

OPERATIONAL REQUIREMENTS FOR AN INFANTRY HAND WEAPON

INTRODUCTION

The subject of this study is of a basic nature for it applies to the basic weapon of the basic branch—the rifle carried by the infantry. Because the hand arm offers certain capabilities not duplicated by any other means, and because it is basic to the whole weapons system, the effectiveness of that weapon in battle is a subject of first importance in any general consideration of the whole fire system. It follows that any study directed toward a comprehensive examination of the aggregate of weapons for the purpose of designing and proportioning a "balanced" system (the mission of Project BALANCE) may logically take a beginning with this basic ground weapon.

Such an approach is, moreover, timely at the moment in the sense that the NATO is confronted now by an urgent requirement for standardization of a general purpose hand weapon for the infantry. Thus, any information which may be cogently pertinent to such weapons will have a bearing on an immediate problem of some moment.

The study here presented has been carried out not only in full recognition of the importance of improving the effectiveness of infantry, but also in growing awareness that the task—even though so basic in nature—is an exceedingly complex one. The effort has thus far been only preliminary. Limited time, and inadequate knowledge of basic unit operations in combat, have restricted the degree to which the whole problem might be examined. Consequently, no complete solution is offered by this memorandum; rather, some analytical findings are presented, which suggest the principles governing certain measures which could be undertaken to improve infantry effectiveness with respect to aimed rifle fire.

This memorandum bears directly upon the importance and the use by infantry of aimed small arms fire in the front line

Unclassified

SECURITY SECRET INFORMATION

tactical fire fight, but does not consider expressly the importance, the techniques or the effects of unaimed "covering fire" delivered by small arms. The reason for directing the study effort toward aimed fire is that the common arm of the infantry, the rifle, is designed primarily for the aimed fire role; that is, the weapon is designed expressly to afford a capability of directing missiles at observed man-targets with high inherent precision, in both offensive and defensive action. Delivery by such a weapon of covering fire to neutralize or pin down the enemy and permit friendly maneuver is tactically useful, but nonetheless amounts to a secondary role for which design has provided only incidentally. The important question at hand, therefore, is not so much connected with the varying actual use of the present firearm as with the need of the infantry to engage the close enemy effectively by the use of aimed rifle fire, and with the feasibility of incorporating in the rifle of general issue the capability of answering this real requirement.

Recent ORO investigations in Korea have shed some light on this subject by indicating quantitatively the comparative importance of aimed and unaimed fire as related to offensive and defensive operations. Generally, aimed fire plays a more important part in defense than unaimed or volume fire, whereas in the offensive, the reverse is true Almost irrespective of the part played by the supporting weapons before or during the final phase of close combat, the decision in each small tactical battle rests ultimately in large measure with the infantryman and his ability to use his hand weapon effectively. If hand-to-hand fighting develops at all, decision thus rests almost entirely with the infantry in this last time-phase of the tactical situation. To attach importance to this aspect of battle is therefore logical, and the attempt to maximize the capability of infantry in this role cannot be misdirected effort.

The study has yielded suggestions for increasing infantry effectiveness by improving the effects of aimed rifle fire. It appears almost certain that future large-scale ground operations will involve a numerically superior enemy and necessitate, at first, a defensive strategy on our part. Morever, frequent attempts to overrun infantry positions, with attendant close combat, are to be anticipated. Thus, to increase each infantryman's capability with respect to defensive rifle fire becomes highly desirable.

In the light of such considerations as these, it appears correct to assume that: 1) it is desirable to increase in both number and

EXHIBIT 4

M27 Infantry Automatic Rifle
5.56 mm x 45

The M27 Infantry Automatic Rifle is a variant of the HK416. The HK416 was originally developed by Heckler & Koch for U.S. special operations forces as a major product improvement of M4/M16-type carbines and rifles. Using the HK-proprietary gas piston system found on the company's G36 rifle, the HK416 prevents propellant gases and carbon from fouling the weapon's interior, making it the most reliable of any M4/M16 type weapon.

During the last decade, the HK416 has been combat-proven in Southwest Asia and has also gained the attention of military, law enforcement, and security users outside of the U.S. In April 2007, the HK416 was selected as the new Norwegian Army rifle.

The HK operating system, as well as other improvements made to various components and parts ensure reliability and performance in all scenarios, with all types of ammunition, with all barrel lengths, and with and without sound suppressors attached. An innovative free-floating four-quadrant rail system/handguard designed by HK allows all current accessories, sights, lights, and aimers used on M4/M16-type weapons to be fitted to the HK416. This HK rail system handguard can be installed and removed without tools.

The HK416 uses barrels produced by Heckler & Koch's famous cold hammer forging process. The highest quality steel is used in this unique manufacturing process producing a barrel that provides superior performance with minimal degradation of accuracy and muzzle velocity even after thousands of rounds are fired.

Many HK416 variants also have "OTB" (over-the-beach) features and can be safely fired after being submerged in water and not completely drained. In addition to the improvements in the baseline weapon, HK has produced corrosion resistant steel and polymer magazines and a proprietary buffer to further enhance functional reliability.

M27 EQUIPPED OR INTEGRATED AT SERVICE LEVEL WITH:

- KNIGHT'S ARMAMENT CO. 600 METER MICRO/BACKUP IRON SIGHTS
- BLUE FORCE GEAR SLING RAIL MOUNT & VCAS SLING
- AIM MANTA RAIL COVERS
- HARRIS LARUE TACTICAL BIPOD WITH QUICK DETACH OR GRIPOD
- U.S.-STYLE BLANK FIRING ADAPTOR (BFA)
- OPERATOR'S MANUAL
- OTIS CLEANING KIT
- U.S. GOVERNMENT 30-ROUND MAGAZINES (HK MAGAZINES OPTIONAL)
- TRIJICON SQUAD AUTOMATIC WEAPON DAY OPTIC (S.D.O.)
- USMC BAYONET

TECHNICAL DATA

NSN	1005-01-579-5325
Manufacturer	Heckler & Koch / HK416 variant
Caliber	5.56 NATO (.223 Caliber)
Length	33.5–37.5 inches
Weight	8.16 pounds (weapon only) Approximately 12.67 pounds (weapon, 30-round loaded magazine, accessories including: iron sights, SDO-optic, PEQ-16, VCAS sling, QD 9-13" bipod, vertical foregrip, and rail cover set)
Barrel	16.5 inches, cold hammer forged with bayonet lug
Rifling	1 in 7 inches, right-hand twist, 6 grooves
Sights	As assigned by USMC — Knights Armament Company 600 meter backup iron sights (BUIS)
Optic	As assigned by USMC — Trijicon S.D.O., 3.5 x 30 mm, 100 - 1,000 meter reticle with quick ranging feature and close range Ruggedized Miniature Reflex (RMR)
Rail system	1-piece quad (M1913 Picatinny) Free Floating Rail System / 11" length
Buttstock	6-position adjustable with storage space
Operation	Air-cooled, gas operated, short stroke piston driven operating rod, firing from a closed bolt
Selector	Safe, Semi, Automatic / Ambidextrous
Magazine	30-round U.S. government magazines (HK magazines optional)
Muzzle velocity	Approximately 2,900 FPS (with M855 ammunition)
Rates of Fire	Cyclic: Approximately 700-900 RPM
	Sustained: Approximately 36+ RPM
	Semi: Approximately 45 RPM
	Automatic: Approximately 90+ RPM (3-5 round burst)
Accuracy	Test guns with 15,000 rounds have fired 2 MOA with M855 ammunition
Single fire	Single fire: Less than 4 MOA (averages 2.5 MOA with M855 ammunition)
Automatic fire	Less than 8 MOA with 5-round burst (averages 5.5 MOA with M855 ammunition)
Graduated Range	Iron sight graduated effective range: 600 meters Optic graduated effective range: 1000 meters
Maximum range	Approximately 3,545 meters
Barrel life	15,000 rounds minimum
Parts life	10,000 rounds minimum
Other	Equipped with "Over the beach (O.T.B.)" features and other enhancements

Military and Federal Law Enforcement Sales • 19980 Highland Vista Drive, Suite 190 • Ashburn, VA 20147 • TEL: (703) 450-1900
Commercial and Law Enforcement Sales • 5675 Transport Boulevard • Columbus, GA 31907 • TEL: (706) 568-1906
Global: www.heckler-koch.com • USA: www.hk-usa.com

HECKLER & KOCH