FYI

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Memorandum for Record

Subject: The M16A2 Rifle

PURPOSE

This memorandum for record updates previous papers developed on the above subject. Similar papers were dated 25 February 1980; 16 November 1981; 15 July 1982, and 22 October 1982.

The features of the new rifle developed by the Marine Corps are discussed and the contrasting marksmanship training philosophies employed by the Army and the Marine Corps are outlined as they relate to rifle features. Army requirements are discussed in detail from a training developer's prospective, and rifle improvements considered optimum for Army use while meeting Marine Corps requirements are combined into a recommended rifle.

BACKGROUND

During the past five years, the Army Research Institute (ARI) Fort Benning Field Unit, Fort Benning, Georgia, has been conducting an ongoing program of research directed towards development of cost effective methods for individual and collective training in M16 rifle marksmanship. The research includes all aspects of training inquiry from problem assessment through instructional improvement to consideration of appropriate ranges, weapons, training aids, and devices. The research effort has been augmented by a resident contractor, Litton Mellonics, and has involved coordination with the Infantry School, Infantry Board, Army Marksmanship Unit, Army Training Centers, and Forces Command.

During this period, some 25 marksmanship research products have been produced by ARI/Litton. Those most relevant to the current subject include: the Basic Rifle Marksmanship (BRM) program used by all Army Training Centers (ATC) conducting Initial Entry Training (IET), the Basic Rifle Marksmanship Trainer's Guide currently available Army-wide, the Advanced Rifle Marksmanship (ARM) program used by the ATC at Fort Benning, the Unit Rifle Marksmanship Training Guide currently in draft, Infantry Magazine article (The M16 Rifle--Bad Reputation, Good Performance), and ARI Research Report 1265 Adequacy of M16A1 Performance and Its Implications for Marksmanship Training.

Since its adoption as the standard service rifle, the M16 has been subjected to considerable criticism concerning its reliability and performance capabilities. Early in the research effort, it became obvious that

a serious detriment to an effective rifle marksmanship program was a general lack of confidence in the M16A1 rifle. Therefore, a detailed evaluation of M16A1 performance was conducted to determine adequacy, peculiarities, etc. The findings clearly indicated that the M16A1 was an adequate combat rifle. Accordingly, to build necessary soldier confidence in the rifle, the positive aspects of the rifle were emphasized and training procedures were adjusted to minimize the negative characteristics. The Infantry article mentioned above was written to help develop soldier confidence in the rifle. At the same time, it was clearly indicated that the M16A1 was not the best rifle that could be in the hands of the American soldier. Many shortcomings were identified that should be addressed in any rifle Product Improvement Program (PIP).

In September 1979, a Strategy Meeting was held at Headquarters, Marine Corps to review possible solutions to infantry weapons problems, including a product improvement proposal for a short-term solution to correct identified M16A1 deficiencies. Negotiations were initiated with Colt Industries, and in January 1980, a unilateral program was initiated by the Marine Corps which resulted in the testing of three improved M16s. In February 1980, a Joint Service Small Arms Program (JSSAP) meeting was held, and it was determined that enough interest existed to initiate a joint service program. Accordingly, the JSSAP management committee approved a plan to have Colt Industries build fifty M16 prototype rifles. The rifles were delivered in November 1981 and a Modified Operational Test (MOT) was conducted by the Marine Corps from 23 November 1981 to 11 December 1981. The MOT was conducted using thirty M16A1 rifles and thirty Product Improvement Program (PIP) rifles, designated M16A1E1 for testing. Test troops consisted of 20 marines and 10 soldiers from the 197th Infantry Brigade, Fort Benning, Georgia.

The PIP rifle, type classified in September 1982, and designated the M16A2, is currently being produced by Colt Industries for the Marine Corps. The Marines plan to purchase an average of approximately 40,000 M16A2 rifles per year for the next five years, with the total purchase projected at 264,000 rifles.

## THE M16A2

The M16A2 is the result of a Product Improvement Program (PIP); however, it is, for all intents and purposes, a different weapon. The changes are:

- A new barrel--changed from 1:12 twist to 1:7 twist and somewhat heavier at the muzzle.
- A new muzzle compensated flash suppressor.
- A square front sight post for elevation adjustment.
- A differently shaped handguard of more durable material.
- A strengthened upper receiver, including a brass deflector rib, which supports a new rear sight. The rear sight has a horizontal wheel which is adjustable for ranges of 300 to

800 meters, using a 1-3/4mm aperture. While the sight is set for 300 meters, pushing the flip-type sight forward provides a 5-mm aperture for ranges of 0 to 200 meters. A drum-type knob is used for windage adjustment.

- The "automatic" firing mode has been replaced with a "burst" mode which fires a maximum of 3 rounds for each trigger pull.

- The pistol grip has been remolded to provide for finger grooves and is constructed of a more durable material.

- The butt stock has been lengthened by 5/8 inch and is constructed of a more durable material. The butt plate is made of tougher material and designed to minimize slippage.

MARINE TEST FINDINGS

The Marine Corps test results (M16A1E1 Test Results and Final Report, dated 21 May 1982) stated the following advantages for the PIP rifle:

- Ease of training (handling and ease of sight movement).

- Improved safety (no hazard when adjusting elevation on the rear sight even with loaded weapon).

- Increased effectiveness at long ranges (more hits, better accuracy, and greater penetration).

- Improved handling characteristics and durability in hand-to-hand close combat.

- Reduced barrel jump and muzzle climb during automatic and rapid fire.

- Increased contrast and less glare with square front sight post.

- Stronger, more durable and improved grasping characteristics of front handguard.

- Stronger barrel with quicker twist to take advantage of increased effectiveness provided by new ammunition.

- Improved sighting characteristics providing quick target acquisition for moving targets and better detection of targets in low level light conditions at close ranges, and more accurate long range fire by use of two modified rear sight apertures.

- Increased ammunition conservation and more effective use of ammunition with burst control device.

- Conformity to human factors standards by lengthening stock (alleviating bruised eyebrows, noses, and lips).

- Stronger, more durable stock.

- Stronger, more durable buttcap which also reduces slipping on the shoulder during firing.

- More controllable and comfortable pistol grip contoured to the shape of the hand.

- Improved brass deflector which protects left handed shooters from hot ejected brass casings.

- Can use NATO type improved ammunition (XM855) which provides increased performance and penetration at long ranges.

The above list of advantages is very impressive. It appears that the rifle meets the primary requirements stated by the Marines:

- A sight adjustable to 800 meters.

- A bullet with better accuracy at 800 meters and the capability to penetrate all known helmets and body armor at ranges of 800 meters.

- A rifle with more durable plastic parts and barrel which will take a beating during bayonet training and extended field exercises.

- The replacement of the full automatic capability with a burst mode which fires a maximum of three rounds with each pull of the trigger.

The list, however, represents the objective and subjective evaluation of Marine Corps personnel who are emphasizing only the most positive aspects of rifle characteristics as they pertain to envisioned Marine Corps requirements.

To provide a balanced view, an additional analysis has been conducted from the point of view of Army trainers. It is not surprising that a different list of findings emerged. In fact, most findings are in the form of a disadvantage or shortcoming as the test results and rifle features relate to Army training and combat requirements. Also interesting to note is that there is very little direct conflict between items on the above list and the items listed below.

- The M16A2 does not have a sight setting for firing at 25 meters, where zeroing and most practice firing occurs. (Discussed on p. 13).

- The M16A2 does not have a setting for battlesight zero, i.e., 250 meters. (Discussed on p. 14).

- The M16A2 probably does not have an aperture suitable for the battlesight, e.g., the single aperture used for shooting the record fire course, the IRETS course, the primary aperture

for combat, etc. The 5mm aperture used for 0-200 meters is probably too large and the 1-3/4mm aperture used for 300-800 meters is probably too small. (Discussed on p. 13).

- The M16A2 sighting system is too complex, i.e., elevation is changed three different ways, leaving too much room for soldier error. (Discussed on p. 11 & 12).

- Sight movements on the M16A2 result in changing bullet strike by different amounts; .5, 1, 1.4, and 3 minutes of angle (MOA)*. The sights intended for zeroing, .5 and 1.4 MOA, are not compatible with old Army zero targets or the new targets being fielded. (Discussed on p. 12).

- The M16A2 does not have a sighting system which allows for easy recording of rifle zero. Also, the zero cannot be confirmed by visual inspection.

- The M16A2 does not have a reliable procedure for setting an indivdual's zero after changing sights for any reason, e.g., using MILES or .22 rim fire adaptors.

- The M16A2 does not have a night sight.

- The M16A2 has not been designed to aid firing while wearing a protective mask.

- The M16A2 sight has not been designed to aid in the estimation of range.

- The M16A2 sight has not been designed to aid in the engagement of moving targets.

- The M16A2 front sight is subject to bending, causing various amounts of change to windage adjustments when elevation adjustments are made.

- The M16A2 rear sight is subject to binding and must be kept clean and well lubricated.

- The new ammunition (XM855) cannot be fired in the current rifle (M16A1).

- The M16A2 is less accurate out to ranges of 500 meters. Independent testing conducted by the National Rifle Association, firing five groups of five rounds each at a range of 200 yards, resulted in the following average group sizes:

  M16A1/M193 - 3.82"

  M16A2/XM855 - 5.38"

*MOA is equal to 1 inch at 100 yards.

The primary Marine test consisted of firing at ranges of 200, 300, 500, 600, 700, and 800 yards. The sum of extreme spreads at 200, 300, and 500 yards resulted in 50.3" for M193 ammunition and 55.8" for XM855 ammunition. While there are only small differences in accuracy to 500 meters, the sum of all firing data clearly indicates that the M16A1 firing M193 ammunition (current system) is more accurate than the M16A2 firing XM855 ammunition (new system). The test subjects who were qualified "expert" preferred the M16A1 due to its superior accuracy. The accuracy advantage of the new system has only been shown at 600, 700, and 800 meters.

The following data from the Marine endurance and accuracy testing conducted with three rifles of each type from a distance of 200 meters shows the average extreme spread of shot groups measured at the start of the endurance test, after 3600 rounds had been fired through each rifle, and after 6000 rounds had been fired through each rifle.

| | Start | 3600 rounds | 6000 rounds |
|---|---|---|---|
| M16A1 (M193) | 19.03-cm | 18.73-cm | 17.73-cm |
| M16A2 (XM855) | 27.43-cm | 31.23-cm | 62.23-cm |

These data represent the only endurance firing conducted with the M16A2 and XM855 ammunition during the MOT, but many positive actions have been taken to discover the problems, and it is believed that bad ammunition was a major cause of this unsatisfactory performance. However, the fact remains that the system (rifle and ammunition) has not met minimum endurance and accuracy standards.

The M16A2 is less reliable. The primary Marine test resulted in the following firing failures:

Thirty M16A1 rifles firing 26,010 rounds of M193

Failures to fire - none

Failures to feed - 3
(Not locking magazine in place)

Thirty M16A2 rifles firing 26,010 rounds of XM855

Failures to fire - 52
(27 - bad ammunition)
(25 - mechnanical malfunctions)

Failures to feed - 3
(Improperly loaded magazines)

Upon completion of the primary test, the straightness guage, (to indicate barrel bend) would not pass through 1 of 30 M16A1 rifles

and would not pass through 14 of 30 M16A2 rifles. An investigation of this condition found that the barrels were not bent but that barrels contained metal foulings. It was suspected that jacket hardness, powder fouling and the fast twist probably worked together as contributing factors.

During the cold weather test, the following failures were reported:

Five M16A1 rifles firing 30,000 rounds of M193

Failures to fire - 4

Weapon failures - None

Five M16A2 rifles firing 30,000 rounds of XM855

Failures to fire - 159

Weapon failures - 2

Again, many of these failures have been blamed on bad ammunition and new parts associated with the burst control. However, the reliability of the new system has not been demonstrated.

The M16A2 has less combat capability due to the elimination of full automatic fire. Full automatic fire enhances the ability of Army units to clear and defend buildings, to conduct final assaults on enemy positions, to defend against an enemy final assault, to conduct an ambush, to react to an enemy ambush, to engage an enemy helicopter or fast moving vehicle, etc. While the Marines claim greater accuracy and conservation of ammunition for the 3-round burst control, no data were generated during the test to support these contentions and no supportative data are known to exist. Also, it should be noted that room-to-room fighting was conducted with blanks, no close-in firing was conducted, no firing with short time limits was conducted, no firing at aircraft was conducted, etc. In other words, for all of the automatic/burst firing conducted during the test, a semi-automatic mode of fire would have probably resulted in a greater number of target hits. Finally, to be given very serious consideration, is the fact that the burst control requires nine (9) new parts in the lower receiver, evidently contributing to the large number of weapon malfunctions during testing of the M16A2. (Discussed on p. 14).

The M16A2 "heavy barrel" is heavy in the wrong place. The problem with the M16A1 is a temporary bending of the barrel which occurs from the stress of various firing positions causing bullet strike to vary, e.g., the difference between a bipod firing position, and a position using a hasty sling will change the strike of the bullet at 300 meters by three to four feet or more. The "bending" takes place between the receiver and the sling swivel/bayonet stud. The M16A2 barrel is "heavy" only from

the sling swivel to the muzzle--where it can have no effect on the bending problem. The Marines are currently testing a new barrel which may correct this problem. (Discussed on p. 18).

- The M16A2 barrel has a 1:7 twist (the bullet rotates once every seven inches) which was found to be appropriate for the squad automatic weapon (SAW). Available data indicate that a 1:9 twist would be more appropriate for the M16 rifle, improving accuracy and reliability. (Discussed at p. 18).

- The M16A2 stock is too long for Army use. The decision to lengthen the stock was made after all portability tests (entering and exiting aircraft/vehicles/buildings, etc.) had been completed and without consideration for body armor, field jacket with liner, load bearing equipment, etc. This change results in the M16 trigger to butt plate length being a full inch longer than the Springfield, M1, or M14. The Army problem was that the existing stock was already too long for many soldiers (mostly females). (Discussed on p. 19).

- The M16A2 may not be able to accommodate the .22 rim fire adapter. The .22 long rifle bullet is designed to be fired in a 1:16 twist barrel. While there are many problems associated with firing the .22 bullet through the M16A1 barrel, fouling being one of them, it is an acceptable training alternative. It may not be possible to fire the .22 long rifle cartridge through the M16A2 barrel without excessive loss of accuracy or excessive fouling. The relatively soft body of a .22 bullet is approximately the same size as a 5.56 bullet, and it fits into the grooves of the rifle bore in a similar manner; therefore, since metal fouling is a problem with the hard military bullet, the .22 rim fire adapter should be tested for compatability with a 1:7 twist barrel.

- The M16A2 also does not include several needed features: improved serviceability checks, improved magazines, improved trigger or a system for obtaining a mechanical zero. (Discussed at pages 20 to 21).

## MARINE REQUIREMENTS VERSUS ARMY REQUIREMENTS

More than 20 years ago the Army converted from Known Distance (KD) type ranges, firing at large bulls-eye targets at distances of 200, 300, and 500 yards, to Trainfire ranges, firing at pop-up silhouettes at distances of 25 to 300 meters. The Marine Corps retained KD ranges for their primary marksmanship training and have continued to emphasize long range precision shooting. The Marine and Army marksmanship programs can each be justified based on uniquely different training considerations. However, this vast difference in training philosophy and expected combat employment dictates that rifle requirements may be quite different.

The Marines are training a "few good men". They dedicate resources to this effort in the form of firing ranges which provide precise bullet location

(essential for teaching shooting fundamentals) and a large number of highly trained instructor personnel. The ratio of trainers to recruits is seldom more than 1:2 on the firing line. They do an excellent job. The Army is training masses of men and women on ranges which provide at best only hit/miss feedback with a limited number of untrained instructors (The Army is the only service without a marksmanship instructor training program). The typical soldier receives no assistance during live fire. He shoots at the 300 meter target 10 times, and at least seven times the bullet goes some place else. He does not know where. We should not be surprised that little learning occurs.

One reason for drawing the above distinction is to make the point that the Marines can cope with a more complex requirement, e.g., sighting system, than can the Army.

The Marines have clearly given priority to expected rifle targets in the 300 to 800 meter range band (the primary aperture on the A2 is designed for use only from 300 to 800 meters), and the Army has clearly demonstrated through current and planned range requirements that it is interested primarily in the range band of 15 to 300 meters. The Marines focus their marksmanship program on long range Known Distance (KD) type firing and the Army directs its marksmanship efforts to close-range, pop-up targets.

While attending the Marine Corps Command and Staff College, Major Rex Wigney, Royal Australian Regiment, conducted marksmanship research. His report, dated May 1982, titled Small Arms Weapons Training: An Examination of Selected Countries Training Systems* is a survey of rifle marksmanship in the U.S. Army, U.S. Marine Corps, United Kingdom, Canada, New Zealand, Federal Republic of Germany, Australia, Soviet Union, Israel, and Austria. The U.S. Marine Corps program is unique in that it is the only program surveyed that requires individual riflemen to engage targets beyond 300 meters and is the only program which conducts sight changes on the firing line to allow for wind and gravity (all other programs use hold-off). Major Wigney states that the requirement to shoot at long range does not appear to have a doctrinal base, in that the Marine Corps official publication FMFM 1-3 states: "In the majority of cases, the range at which individual combat targets can be detected and effectively engaged will be less than 300 meters." He goes on to say that the requirement to shoot at 500 yards appears to have arisen from one of three possible sources: a competitive shooting background, the desire to exploit the ability to engage targets up to maximum effective range, or simply to build the Marine's confidence in his ability with his rifle.

The Marines are different, but they are not wrong. The Marines do an excellent job of teaching basic shooting skills. They also make the valid point that if they can teach soldiers to hit long-range targets, hitting short-range targets will be easy. There is also a well recognized requirement to engage some combat targets at long range with rifle fire. But the Marine program may not be appropriate for the Army, and the Army should take a close look at the Marine developed rifle to be sure it fits Army requirements.

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*The information presented is the opinion of Major Wigney and does not necessarily represent the views of the Marine Corps.

DISCUSSION

The Marines may be able to justify an 800-meter setting on the rifle. The Army should not oppose an 800-meter setting on the rifle sights, but it should be considered in the proper perspective. Given that the typical soldier cannot hit a 300-meter stationary target under no wind conditions, a sight capable of being set on 800 meters may not be very useful. Assuming a soldier can properly hold on an 800-meter stationary target and get off a perfect shot, a 100-meter error in estimating range would cause the target to be missed by five feet. To compound things further, a walking target would move eight feet between the time the new rifle is fired and the bullet arrives, and a 10 MPH crosswind would blow the new bullet more than eight feet off target. The point is that teaching effective engagement of extended range targets for all soldiers is a very complex and difficult task and one that would take a major commitment of resources in the form of personnel, ranges, and target systems.

The M16A1 with standard sights can be effectively aimed at personnel targets to a range of 500 meters. All things considered, it is at least as effective as the M16A2 to that range. However, most combat units have equiped their rifles with the Low Light Level Sight System (LLLSS), which limits effective aiming to a maximum of 350 meters. All available test data and our own testing indicate the LLLSS degrades a unit's overall ability to hit targets. Accordingly, we have recommended that the use of the LLLSS be discontinued and that standard sights be installed on all rifles. This action would immediately add 43% to the range at which all soldiers can aim at targets.

The "sniper type" position which is part of the Division 86 organization is expected to utilize a low power telescopic sight, so this "master rifleman" will not have to rely on the standard sights.

The requirement to engage long-range targets with rifle fire has been emphasized in the after-action reports from training exercises in the Mid-East. While the opportunity to engage targets out to 800 meters appears to exist in training exercises, there is doubt that many opportunities will exist in combat when it will be appropriate for riflemen to engage targets at such extended ranges. Given an extremely low hit probability, it is doubtful that a rifleman's contribution to the generation of combat power would be sufficient to compensate for his reduced survivability. A rifleman who participates in the exchange of direct fire from 800 meters while being subject to massive amounts of indirect fire, does not have a high probability of surviving the encounter. It may be advisable to keep the rifleman in a protected posture until the enemy is at a range which will allow his fire to be relatively effective.

The tactical employment of a rifle capable of firing to 800 meters should also be considered in light of current doctrine, i.e., a rifleman's primary sector of fire is approximately 45 degrees from his front, which means the majority of an 800-meter range band would be fired in front of adjacent units.

To be given some consideration is the fact that combat infantry units, those units which have the highest probability of being in position to employ

long-range small arms fire, have very few dedicated riflemen. A larger number of rifles may be employed by combat support and combat service support units.

After reviewing the state of Army marksmanship training, our training goals have been to improve hit probability on close range targets, developing soldier confidence that all life-threatening enemy targets can be hit. The marksmanship problems are basic--we need to focus on good shooting fundamentals and make every effort at simplification.

The intent of this long discussion on the relative importance of shooting to 800 meters is to make a case for not giving up too much in the zero to 300 meter range band. Accuracy, terminal ballistics, reliability, endurance, and system simplicity are at stake. The current sight on the M16A2 can be adjusted from 300 to 800 meters or from 200 to 700 meters, but not both. Currently, insistence on an 800 meter setting is preventing a 250 meter setting for battlesight zero.

A reasonable measure of a unit marksmanship program may be to check to see that every soldier has his rifle zeroed. There are several methods for recording zeroes; unfortunately, none of them work for the M16A1. The only positive way to check the zero is to move to a range and fire a shot group. Checking the first shot group fired by each soldier will indicate that major sight changes are required unless it is an exceptional unit. Why are soldiers not zeroed? A lack of training can always be blamed, but complexity in rifle design can also be a major factor. When the soldier goes down range today to inspect his zero target and finds he needs to make an elevation change, depending upon which sight/target combination is being used, one click of the front sight will move the bullet 1/2 square, 3/5 square, 3/4 square, 1 square, or 1-1/4 squares on the zero target, and when he turns the sight "up", it goes "down" to move the bullet strike "up", and all of this is dependent upon the availability of an 8-penny nail. It is impossible for most soldiers to keep track of the positive and negative numbers of sight changes, even if they do not lose count of clicks, which are made from some unknown point--unless fingernail polish is used to mark a flush starting position--in which case, the real zero must be taken off to verify it. And the zero needs to be checked because the sight has to be changed to align the sights with the MILES laser, to clean the front sight for inspection, to use .22 Rim Fire Adapter, etc. The point is that a simple weapon design can contribute greatly to combat readiness. Things are already too complex. In its current form, the M16A2 will add to the problem. In the above example of changing a front sight (standard or LLLSS) with any of three zero targets currently in the field, the M16A2 would add 1-2/5, 1-1/8, and something less than 3/4 to the possible combinations. The new targets being fielded and our recommended sights will result in all sight movements of one click moving the bullet one square on the zero target or one inch at 100 yards.

## Our Proposed Rifle

The Table at Inclosure 1 (page 25) provides a brief comparison of features among the M16A1, the M16A2, and our recommended Army rifle. The recommendations reflect our best attempt to combine training and development considerations, making tradeoffs which seem to have the highest probability of resulting in optimum combat performance. The recommended features are discussed in some detail in the following paragraphs.

## THE SIGHTING SYSTEM

Front Sight. The adjustable front sight is the source of many problems. It should be a fixed blade, .090 inches wide. The width of this recommended sight is somewhat large for optimum long range shooting, but it is smaller than the current sight (LLLSS) used by most units, and it serves two useful training/combat purposes: range estimation and engagement of moving targets.

- Range Estimation. As a guide to assisting in the difficult task of estimating range, when a man appears to be the same width as 1/2 the sight post width, i.e., when the sight post will cover two men, you are at your zero range of 250 meters; when it appears that the target is larger than one-half the sight width, it means the target is closer than 250 meters, and when the target appears smaller than one-half the sight width, it is at a greater range. The sight covers one man at 125 meters, two men at 250 meters, and three men at 375 meters. This sight/target relationship is shown in Inclosure 2 (Page 28).

- Moving Targets. Current plans call for the world-wide installation of moving target ranges within the next few years. These Infantry Remoted Target System (IRETS) ranges, including an overwhelming scenario of moving and stationary targets, were initially planned to be used for BRM qualification and annual qualification for all soldiers. While final decisions have not been made concerning the use of IRETS ranges, it is clear that simplified training procedures must be developed. The current lead rules are too complex: For a walking target 0 to 300 meters or for a running target 0 to 100 meters, split the front sight post with the leading edge of the target. For a running target 100 to 200 meters, place the trailing edge of the front sight post against the leading edge of the target. If the target is running at a distance of 200 to 300 meters, lead the target the same distance as the perceived width of the front sight post. This sight/target relationship is shown in Inclosure 3 (Pages 29 to 30). This is too much for a soldier to remember and may be the reason that some of our moving target training results in decreased performance.

  The recommended sight post will allow the teaching of one sight rule for all laterally moving targets at all ranges, walking or running, with no decrease in hit probability: Place the trailing edge of the sight at target center. This rule is shown in Inclosure 4 (Page 31). This rule causes lead to automatically increase as range to target increases. The perceived width of the target at various ranges provides for proper lead, e.g., at 15 meters, the center of the sight is one inch in front of target center, and at 150 meters, it is 11 inches in front, providing for good hits on most moving targets. This sight/target relationship is shown in Inclosure 5 (Page 32).

Rear Sight. Windage and elevation adjustments should be made with friction drums on the rear sight with numbers clearly indicated so the weapon's zero can be visually verified. Each click for windage or elevation should equal one minute of angle. When adjusting sights from the rear of a weapon, both windage and elevation adjustments are made in the direction of desired bullet strike. This sight, shown in Inclosure 6 (Page 33), will

greatly simplify the zeroing process. To move the bullet left, the windage knob is turned left, moving the sight and the bullet strike left. To move the bullet up, the elevation knob is turned up, moving the sight and bullet strike up. Upon completion of zeroing, a tool is used to align the windage knob on "Ø" and the elevation knob on "25". Following this adjustment, the elevation is set at 250 meters, and all subsequent sight changes are made simply by clicking the knobs, e.g., when the MILES laser is used, the windage and elevation knobs are turned to align rifle sights with the laser beam and at the completion of MILES training, the individual is assured of having the correct zero on his rifle by turning the windage knob back to zero and the elevation knob back to 250.

Peep Size. The Marines plan to use a 5mm peep sight from zero to 200 meters, and a 1-3/4mm peep sight for ranges from 300 to 800 meters. The proposed sighting system uses a single peep sight and retains the 2mm aperture used on the M16A1. It is significant that the Army and Marines teach different uses of the peep sight. The Marines align the front sight within the aperture. The Army looks through the aperture at the front sight, relying on the natural centering ability of the eye for alignment. Our tests determined that the 2-mm aperture provides an adequate field of view and good accuracy under a broad range of light conditions.

25 Meter Setting. While the Marines conduct limited training at 25-meters, the only primary Army ranges which provide precise feedback of bullet location are 25 meter ranges, and many targets have been developed and proven training-effective which allow for point-of-aim/point-of-impact at 25 meters for purposes of zeroing, skill practice, scaled silhouette firing, etc.

The old and new zero targets are shown in Inclosure 7 (Page 34). The old zero target was confusing, difficult to use, and provided no indication of downrange performance. Throughout the research effort on marksmanship, the complexity of information presented to the trainee was of concern. Using the Canadian bull zeroing target required that sights be adjusted so bullets would hit 2.4cm below point of aim at 25 meters. Many soldiers were confused by this procedure. Some confusion could obviously be eliminated if the initial firings were conducted so that bullet impact was the same as point of aim. It was quite by accident that we discovered that using the M16 long-range sight at 25 meters, and adjusting the bullet impact to coincide with point of aim, would produce a good 250 meter battlesight zero with the regular sight. The sketch in Inclosure 8 (Page 35) depicts the bullet trajectory.

The ability to shoot at scaled silhouette targets and hit where the rifle is aimed has an important training implication. The use of the new target allows the role of the 25 meter range to be expanded beyond that of merely providing for the zeroing of weapons. Additional exercises are included based on scaled silhouette targets, which are designed to provide the same visual perception when viewed at 25 meters as actual targets viewed at actual range. Samples of these targets are shown in Inclosure 9 (Page 36). For example, the six-silhouette target represents targets at ranges of 75, 175, and 300 meters. It is used on the 25-meter range in a transitional role prior to subsequent field firing where only hit/miss feedback is available. It is also a valuable diagnostic tool at this stage of training. If a soldier cannot hit scaled

silhouettes at 25 meters, additional training is indicated rather than advancing to the limited feedback environment of field firing. The silhouette targets can be used without the point of aim/point of impact capability, but the inherent confusion can be seen in the targets at Inclosure 10 (Page 37), which were developed for use with the Low Light Level Sight System (LLLSS).

A capability is needed on the rear sight which allows for obtaining a zero by firing point-of-aim/point-of-impact at 25 meters. The recommended sighting system does this by providing a 25 meter setting on the elevation knob. When firing on a 25 meter range, turning the knob to the 25 meter setting (after zeroing) will provide for simple and effective skill practice training--the bullet will hit where the rifle is aimed.

15-Meter Setting. Many Reserve and some Active Component units use the standard 50 feet indoor range for marksmanship training. The recommended sight provides a 15-meter setting (approximate 11 clicks from the battlesight zero) which allows for point-of-aim/point-of-impact training on the indoor range and a positive return to the battlesight zero.

Battlesight Zero. The Army has a requirement for a battlesight zero setting on the rear sight, i.e., a setting which provides a high probability of target hit with center-of-mass aiming out to the maximum allowable range, a zero of 250 meters, which will allow for the engagement of targets out to 300 meters with minimum adjustment of the aiming point. The recommended rifle has a clearly marked battlesight setting—the setting which will always be on the rifle unless a special target is being engaged. The idea of making numerous sight changes during the course of a battle has no support from available data.

Night Sight. An effective night sight should be developed concurrently with the new rifle. Peepsights are inappropriate for use at night (5mm or 7mm) and luminous sights which must be placed on the target (LLLSS) tend to obscure the target. A system which provides for luminous dots on the front sight guards can be used to align the front of the rifle with the target (Fort Leonard Wood has recently demonstrated that this greatly improves hit probability) and luminous dots on the rear of the rifle (See Inclosure 6) can be used to align with the front dots, bringing the rifle into proper alignment while keeping line of sight between the eye and the target completely clear of sighting devices or luminious material. A sight picture is shown in Inclosure 11 (page 38). Another version of this night sight under investigation uses one dot for rear alignment, placed high at the forward portion of the receiver and flipped-up for use. It may also prove useful when wearing a protective mask, eliminating some or all of the parallax caused by rifle cant.

## AUTOMATIC FIRE

One of the reasons we acquired the M16 was because soldiers in combat felt they were being outgunned by an enemy armed with a full automatic AK47. Many times it is a very close call as to which side has fire superiority. The psychological impact of full automatic fire can often make the difference in the unit's perception of how effective their fire is. There are also some

data to suggest that a soldier is more willing to expose himself and return fire if he has a full automatic weapon, as opposed to a more controlled way of delivering fire. It has been well established that, during World War II and Korea, up to 85% of soldiers failed to fire their semi-automatic weapons during some enemy contacts. In Vietnam, armed with a full automatic weapon, almost all soldiers returned fire. While much of the Vietnam firing was "wasted", i.e., it didn't hit anybody, it was a rare exception when individuals or units got into trouble because they had expended all of their available ammunition.

Reliability is perhaps the most important feature of a combat rifle. The "problem" with the M16 in Vietnam was reliability--it would not shoot every time the trigger was pulled. There should be a very careful analysis conducted to determine just what the issues are. There are several means of delivering fire on an enemy; mortars, artillery, small arms, TAC air, etc. We must plan to inflict the majority of enemy casualties through means other than small arms. However, when combat actions involve the exchange of small arms fire, that is certainly the cheapest way of killing the enemy. In other words, there is nothing wrong with firing a lot of bullets if ammunition stocks are retained at safe levels. Considerable ammunition is conserved when 85% of a unit fails to fire their weapons, and considerable ammunition is expended when all unit members engage targets with full automatic fire. While we hope that good training and good leadership would keep us between these two historical extremes, the question of which alternative is perferred should be addressed.

The soldiers in Vietnam, including leaders, were not trained to employ rifle fire effectively. But it was not a one-bullet-for-one-kill environment. Most firing was directed at unseen targets, and in small unit rifle versus rifle contacts, the full automatic rifle may be what gave our soldiers the edge. Whether or not the full automatic rifle really made any difference, soldiers thought it did. And accordingly, they went into fire-fights with full confidence that they would prevail, and they did. We must also carefully consider the fact that all potential enemies we will face have individual weapons with full automatic capabilities.

We have conducted an extensive analysis of the Infantry and Mechanized Infantry ARTEP's to determine rifle requirements associated with each task within each ARTEP mission. There are numerous situations identified within the ARTEP and within the doctrinal manuals where full automatic fire would seem to be the most appropriate and effective mode of fire--clearing buildings and defending buildings in MOUT environments, final stages of an assault on an enemy position, the enemy's final assault on friendly positions, ambush requirements, reaction to ambush, engagement of aircraft, placing effective suppressive fire on enemy ATGM gunners, placing effective fire on exposed masses of troops (when the first burst will disperse the target), placing effective fire on exposed vehicle drivers/commanders when they are moving rapidly and visible for brief periods, etc.

During the limited research we have conducted in automatic fire--experimenting with burst size, various holding positions, etc.--we are finding that three-round bursts may not be the optimum burst size. In the

majority of bipod-supported automatic fire holding positions, firing up to five and ten round bursts, the third round will many times find the limit of the group size with subsequent rounds moving back in toward and around the initial aiming point (see Inclosure 12, p. 39). Therefore, an increased hit probability may occur with a five or six round burst on target, as opposed to two three-round bursts. Also, some targets do not stay around for a second burst, and sometimes the firer is not around for a second burst.

Heckler & Koch, Inc. has recently developed a new rifle which fires caseless ammunition, designated the G-11. This rifle incorporates a three-round burst control which appears to accomplish the intended purpose of a three-round burst control, i.e., it distributes three rounds into a man-sized area, which may compensate for aiming error and may result in higher hit probability for three rounds on a given target than for three single rounds. This is accomplished because the rifle has very low recoil and a cyclic rate of 2000 rounds per minute that has been timed to the recoil pattern to provide optimum dispersion of three rounds in a single burst. Because this works on the G-11, it is no indication that it works on the M16 which has much more recoil and a much slower cyclic rate of fire. Also of some significance is that the G-11 has a full automatic setting.

It also is important to note that the proposed three-round burst control on the M16A2 does not recycle, i.e., if one or two rounds are fired because the trigger is not held long enough, a magazine change is required, or in the event of a stoppage for any other reason, the next pull of the trigger will not result in a three-round burst, but will result in one or two shots being fired. In other words, even when the burst control is properly working, it may result in the firing of one, two, or three shots. This is a frightening consideration for the soldier who must burst through a doorway to face a couple of waiting enemy soldiers.

There are two primary arguments for the three-round burst control--it is more accurate and it conserves ammunition. The first claim (more accurate) is not true. The second claim (conserve ammunition) is not supported by data. Using the assumed rationale, a two round burst would always be more accurate and conserve more ammunition than a three-round burst and firing single rounds would be a significant improvement in accuracy and conservation of ammunition. Accuracy and conservation of ammunition should be discussed as separate issues. If a three-round burst is more accurate than a five-round burst, that must mean that there is a higher probability of hitting a given target with a three-round burst than with a five-round burst. Of course, that is not true, because, all things being equal, the first three rounds of a five-round burst will strike the same place as the rounds from a three-round burst--since the third round departs the barrel before the fourth round is fired. As for conserving ammunition, a thirty-round burst will result in the expenditure of thirty rounds in a little less than 2 1/2 seconds, and ten 3-round bursts can result in the expenditure of thirty rounds in five seconds. The time difference in these two modes of fire is very small, resulting in the expenditure of a similar amount of ammunition for a given engagement. This assumes that a soldier who would hold the trigger for the duration of a thirty-round magazine (full automatic) would also fire a full magazine (burst control) as fast as he could pull the trigger. As discussed previously, this may not be a valid assumption because the soldier may elect

not to expose himself and/or his position to fire one, two, or either three rounds per trigger pull. While ammunition expenditure in each mode of fire may be similar for a given engagement, there may be a vast difference in the effectiveness of the fire. During close-in fighting, full automatic fire can be used as a very effective means of walking fire into a target or to quickly saturate an area with fire. The burst control can serve to reduce both speed and accuracy. For example, it is generally assumed that the firing port weapon on the fighting vehicle would not be as effective if it could only be fired in three-round bursts.

It is the responsibility of the combat leader to control burst size and conserve ammunition, and that responsibility cannot be delegated to a mechanism in the rifle. When troops are frightened and are convinced that fully automatic or burst fire will offer them greater protection, they can expend a thirty-round magazine every few seconds. Additionally, if the three-round burst control causes the commander to be less diligent in his responsbilities, then actually more ammunition could be expended. Improved training in the employment of fire is probably a better solution.

In May/June 1982, an experimental Advanced Rifle Marksmanship (ARM) program was implemented at Fort Benning for the Infantryman in OSUT training. Primary additions to the program include these periods: Rapid Semi-Automatic Fire, Suppressive Fire, Quick Fire, and Engagement of Moving Targets. A principle focus of ARM is to improve skills beyond the BRM level in the rapid application of basic shooting fundamentals, to allow an aimed shot to be placed in a target area every one or two seconds--resulting in a large volume of very accurate fire with maximum conservation of ammunition. Supppressive fire is taught on a scaled landscape target to begin teaching how to shoot at unseen targets, e.g., when enemy fire is being received but no enemy can be seen and fires must be directed at a fence line, wood line, building, puff of smoke, etc. Automatic fire is used on one target fired in three-round bursts to demonstrate the superior accuracy of rapid semi-automatic fire. The intent is not to show that automatic fire is ineffective, but to develop an appreciation for the relative accuracy of various types of fire. When the soldier's life is threatened and he believes that deliberately aiming each shot or that rapid semi-automatic fire is the optimum way to expend available ammunition, the combat leader will have a manageable job of controlling fires and conserving ammunition. On the other hand, there are special situations when a five- or ten-round burst will save the soldier's life and assist in unit mission accomplishment.

Our mis-utilization of automatic rifle fire is reflected in every qualification course. To improve scores, just flip the selector to semi. It appears logical that if we were properly employing automatic fire in a realistic setting, automatic fire would result in a higher score than semi-automatic fire. We are currently developing such a course. Currently, all rifle training is designated as automatic or semi-automatic and the soldier is not required to select a mode of fire to fit the situation. We are considering the development of a rifle course of fire which will vary the nature of targets, tactical situations, ammunition availability, etc., and will result in the highest possible score being obtained when the most effective firing techniques are employed, e.g., well aimed shots, rapid semi-automatic fire, quick fire, or automatic fire.

The issues associated with automatic fire are complex. The collection of valid data is complicated due to a void of information concerning automatic fire feedback. The Army does not have adequate feedback capabilities for semi-automatic or automatic fire. The Marines have excellent facilities for semi-automatic fire but no capability for recording automatic fire. Projectile location equipment which shows the precise location of each round and the sequence of each round in a burst would provide a basis for making more valid decisions concerning automatic fire. Adding to the information void is that no alternatives were evaluated for the M16A2; one muzzle compensated flash suppressor was coupled with a three-round burst control and the majority of rounds fired were lost. In the absence of objective data, it may be appropriate to survey combat veterans as to which they would prefer for their personal defense weapon during close combat--automatic or burst control (none of the thirty Marine test subjects had combat experience).

The results of a combat veteran survey coupled with the existing data (the burst control adds no capability to the rifle, the burst control requires nine new parts, the burst control requires additional training, and the burst control was the cause of several weapon malfunctions during testing), and a test which could not be won with semi-automatic fire would probably result in retaining the M16A1 lower receiver which has been refined into a dependable and reliable system during 15 years of combat and training.

## THE BARREL

Heavy Barrel. The light-weight barrel of the M16A1 is prone to external pressure, and our firing tests have revealed large differences in bullet strikes based on these stress extremes, i.e., a hasty sling as opposed to a bipod position with downward pressure (see Inclosure 13, p. 40). It is proposed that only sufficient weight be added to the barrel at the receiver and mid-barrel to help the barrel bend problem and that this be tuned with a more securely fastened handguard to help provide rigidity while retaining light weight. The Marines are currently testing a heavy barrel and plan to incorporate it as a preplanned product improvement if it proves to be adequate; however, the goal is not a heavy barrel, but the elimination of serious bullet displacement resulting from various holding positions. Another consideration must be to retain sufficient cooling air space, already reduced, between the barrel and the handguard.

Barrel Twist. The SAW has a 1:7 twist, because it was reported that this amount of twist was required to stabilize the tracer round at extended ranges. No alternative to a 1:7 twist has been tested for the rifle. The general rule seems to be that, for bullets of the same diameter, more twist is required to stabilize a round in flight as the length of the round increases. Our measurements indicate the following lengths:

- Current ball (M193) - 19-mm
- Current tracer (M196) - 22 1/2-mm
- New ball (XM855) - 23-mm
- New tracer (XM856) - 29 1/4-mm

While any alternative must be tested, previous firing tests have confirmed that a 1:9 twist will provide for stability of a bullet similar to the new ball round. Reducing barrel twist to 1:9 will result in less stress on the bullet, barrel life may be improved, and barrel fouling will be reduced. While this twist may not fully stabilize the tracer round to maximum range, the rifle tracer is normally used as a marking round at extended ranges and precise accuracy is not required.

A more important consideration is that reducing twist to 1:9 will probably improve accuracy at all ranges, particularly at 25 meters and in the primary range band out to 300 meters. A general rule is that minimum twist should be used to stablilize the round. Any additional twist will increase variability, causing the bullet to move in a corkscrew-type pattern at closer ranges. With the Army dependence on 25-meter ranges, this factor is much more important to the Army than the Marine Corps. An example of appropriate twist may be seen in the Army marksmanship unit rifles which have a 1:10 twist for firing at ranges up to 1000 yards. When the same type rifle and ammunition is used for 300-meter competition, the twist is reduced from 1:10 to 1:14 to obtain greater accuracy. From reviewing available firing data and giving consideration to terminal ballistics, employment ranges, barrel fouling, accuracy, and compatibility with M193 ammunition, a 1:9 twist appears optimum for the Army rifle.

Tapered Slip Ring. The tapered slip ring has been designed to allow easy removal of handguards; however, M16 rifles could probably go through a complete war without handguards being removed and weapons reliability and accuracy would not be affected. It does appear that a very secure slip ring, perhaps even one that screws securely and tightly into position, could assist in providing some rigidity to the barrel, eliminating some of the sensitivity to stress while retaining light weight. In other words, we should increase shooting accuracy at the expense of easily removed handguards.

Muzzle Compensator. The muzzle compensator was developed to allow for more effective automatic firing; however, no variations have been tested and the muzzle compensator has been used only for firing three-round bursts. It would appear logical to determine the type of fire to be employed and the primary firing positions to be used and then modify the muzzle compensator for optimum results. Also a close look at the effectiveness of flash suppression is warranted, because a portion of the suppressor has been closed.

## STOCK LENGTH

The stock should not be increased in length. Many smaller soldiers, mostly female, cannot comfortably position their eyes close enough to the rear sight now. The longer stock is appropriate for males on the KD firing range. However with consideration for normal soldier activities associated with personnel carriers, fighting vehicles, helicopters, and fighting in cities, the current length should be retained, with consideration for an adjustable option.

The stock length issue involves an important difference in how the Army and Marines teach aiming. The Marines place emphasis on the precise alignment of three items; the target, the front sight, and the rear sight. The Army

teaches a simplified aiming procedure which is faster and more accurate for close-in, short-exposure, pop-up targets; alignment of only two items--the front sight and the target. With the eye focused on the tip of the front sight, the natural and instinctive ability of the eye to center objects and to seek the point of greatest light (which is the center of the aperture) will result in correct sight alignment. But for this simple aiming procedure to work, the eye must be placed close to the rear sight.

UNIFORM CONSTRUCTION

A problem with the M16A1 is that variability among weapons makes it impractical to have a common starting point from which to zero weapons. Accordingly, all soldiers (trainees especially) start firing with a weapon which may not hit the zero target, even if sights are properly aligned and proper firing techniques are employed. Therefore, target misses normally result in the rotating of difficult to move sights. In effect, we are forced to have the new soldier zero the rifle before we teach him how to shoot--resulting in wasted ammunition, lack of confidence, and a frustrating training experience.

To overcome this, we have experimented with various collimator devices which would allow a mechanical zero (alignment of the sights to the bore) to be placed on the rifle prior to rifle training, but we have not found one accurate enough for use on the M16. More uniform construction of weapons would assist the zeroing problem and the zeroing of starlight scopes, but a requirement should be established to produce a collimator, improving weapon construction as necessary to obtain necessary accuracy. This capability would allow initial marksmanship training to focus on the teaching of shooting fundamentals, with refinement of individual zeroes undertaken after shooting skills have been developed.

The advantage of going to the range (or combat) with a mechanical zero on the rifle was demonstrated during a recent experiment involving twenty subjects firing on the Weaponeer, the Multi-Purpose Arcade Combat Simulator (MACS), and firing live bullets at a 200-meter silhouette target. Of the twenty subjects, thirteen had little or no shooting experience, five were experienced shooters, and two were world-class shooters. The same M16A1 rifle with the same sight setting was used for all shooters. Ten shooters received precise feedback, using Locaton of Miss and Hit (LOMAH) equipment, for each of the first ten rounds fired. This allowed them to adjust their aiming point after the first round, therefore, only the first round each person fired from the rifle is shown in Inclosure 14 (p. 41). It is interesting to note that every person hit the 200-meter target with the first round fired, and the average of the ten shots is very close to target center.

The other ten shooters received only hit/miss feedback for their first ten shots; therefore, they had no reason to adjust point of aim unless they missed the target. Their targets are shown in Inclosure 15 (p. 42). It should be noted that only 13% of the bullets missed the 200-meter target, and the shot groups indicated no sight change necessary for at least seven of the ten shooters. The capability to align all new or newly issued rifles to closely match the rifle used in this test has important training implications. For example, a major problem at all Army Training Centers (ATC) is

getting trainees zeroed. Too many soldiers fire fifty to sixty rounds and still cannot zero. For an individual who has learned basic shooting fundamentals, the zeroing process is fast and simple, requiring only a few rounds of ammunition. For an individual who has not acquired basic shooting skills, who cannot shoot tight shot groups, and cannot place shot groups in a consistent location, zeroing is impossible, e.g., trainees who cannot zero with eighteen rounds. It is also illogical that we require the soldier to perform the most difficult shooting task within the BRM Program (the zero requirement equates to hitting a 300-meter target every time) as the first shooting task. Some soldiers arrive on the record fire range without having a good zero. A rifle which can be mechanically zeroed has potential for making significant improvements to the marksmanship program. It would allow learning to occur in a logical sequence--learning how to shoot and then zeroing.

OTHER FEATURES

Magazines. Numerous weapon malfunctions occur because of bad magazines. There is no effective procedure for getting bad magazines out of the system, or to be certain that a magazine has been the cause of the problem. Consideration should be given to building a sturdier magazine, a more positive operating magazine, and/or one that fits more securely into the magazine well. This appears to be a very serious problem, and it deserves attention during the development and testing of the new rifle.

Trigger. Trigger pull can be improved. Many M16 rifles have been observed to have a hard, creepy trigger pull. The trigger should maintain a clean, crisp break during its useful life.

Serviceability Checks. Available serviceability checks for the M16A1 will eliminate unserviceable rifles; however, the passing of all serviceability checks is no indication of rifle shooting quality (see Inclosure 16, p. 43). Development efforts for the new rifle should include built-in serviceability checks which will ensure that accurately firing weapons can be turned out of the maintenance units.

Weapon Protection. Consideration should be given to providing necessary items to prevent dirt and sand from entering the weapon. For safety reasons, the weapons many times are carried with dust covers open, bolts to the rear, magazines removed, and without a muzzle cover. Features should be considered such as: a dust cover which is spring loaded to stay closed except for ejection, rubber plugs or bands to protect the magazine well and other potential entry points from dirt and grime, etc.

Additional Items. Additional items that should be checked during the test and evaluation for the new rifle are: use of MILES equipment, use of .22 rimfire adapter, and firing while wearing a protective mask.

BRIEFING OF M16A2

To our knowledge, all briefings concerning the M16A2 have been presented in a very positive light. While we would not expect all of our concerns to be presented, it is doubtful that decision makers have been given sufficient information to make educated decisions.

- For example, it seems important to know that the new ammunition (XM855) will not shoot in the current rifle. The results of a short test conducted with SS109 ammunition is shown in Inclosure 17 (Page 44). This test is very close to numerous firings conducted by the Marines with XM855 ammunition.

- The chart at Inclosure 18 (Page 45) puts the serious nature of the test results in perspective for Army personnel. It seems appropriate to show the actual data and then explain that bad ammunition may have been the cause.

- The charts at Inclosures 19 and 20 (Pages 46 and 47) should be shown because reliability is critical for a combat rifle. The causes of this difference in performance should be explained, but the decision makers should clearly understand that the system (M16A2 rifle and XM855 ammunition) has not yet undergone successful testing.

CONSIDERATION OF ALTERNATIVES

The rifle which has been type classified and designated the M16A2 is described in the front of this paper. We believe this rifle is unsuitable for Army use and should not be purchased under any circumstances.

A conference was conducted at the Infantry School on 5 October 1982, to discuss the M16 sighting system. The bottom line of this conference was that action should continue to procure the M16A2 for Army use. It was agreed that the following changes may be incorporated into the Marine rifle providing there is neither a cost increase nor production delay and if Headquarters Marine Corps concurs:

- 25-Meter sight setting

- 250-Meter battlesight setting

- Change windage clicks from .4 MOA to 1 MOA

- Change front sight elevation clicks from 1.4 MOA to 1 MOA

Subsequent coordination with Colt indicated they had sub-contracted for some production items prior to the 5 October Conference, and that they could not incorporate the 250-meter battlesight zero because the Infantry School had insisted on an 800-meter sight setting. The range on the existing M16A2 rear sight can be adjusted from 200 to 700 meters or from 300 to 800 meters, but cannot be adjusted from 250 to 800 meters. Therefore, Colt suggested that the Army change its battlesight zero from 250 to 300 meters. We could not agree to that because there is too much difference in the trajectory. For example, using M193 ammunition and firing at a 175-meter target, the bullet is 3" above line of sight with a 250-meter zero and 6" above line of sight with a 300-meter zero. Colt indicated that the windage clicks would be changed from .4MOA to .5MOA.

If all of the changes discussed at the 5 October Confernece were incorporated into the rifle, it would improve the rifle for Army use, but the rifle

would still not meet Army requirements as we see them. In fact, it appears that none of these changes may be made and the Army continues to be on record supporting the M16A2 in its current configuration.

There appears to have been a verbal agreement with personnel of ARRADCOM to initiate a product improvement proposal to improve only the sights at a later time.

There does not appear to be a firm requirement that Marine and Army rifles be exactly the same. One alternative may be to develop an Army rifle which will fire the new bullet, with a minimum number of different parts and all major parts interchangeable with the Marine rifle.

If a requirement exists to purchase new rifles now, the only low-risk alternative is to purchase M16A1 rifles. This would also allow time for the development of the rifle we recommend, time to develop appropriate targets, appropriate training literature, and time to develop ranges to take advantage of an extended range rifle. Currently, there are no firm Army plans for suitable feedback ranges beyond 25 meters--certainly not adequate for teaching target engagement to ranges of 800 meters.

New M16A1 rifles could be ordered with the new plastic parts, and new plastic parts could be purchased as replacement items. This would solve the parts breakage problem while the ammunition, sights, and barrel are being developed. We believe that refinements to the sighting system can only be made after the ammunition has been developed and theoretical ballistic information has been confirmed through actual firing.

An immediate decision to eliminate the Low Light Level Sighting System (LLLSS) would increase the effective aiming range of most combat rifles by 43% (from 350 to 500 meters). The addition of a scope on selected M16A1 rifles would greatly improve long-range potential. Adding sniper positions to combat units would provide an immediate long-range rifle capability.

Time has been a major factor with the Marine development effort. They were short a large number of rifles and had to purchase new rifles. It did not make sense to puchase old rifles when new rifles were ready for testing. Therefore, they decided to purchase new rifles and stepped up the tempo of testing activities accordingly, taking what Colt had available on-the-shelf and conducting a quick Modified Operational Test (MOT). When the system (M16A2 firing XM855 ammunition) failed to meet requirements for major portions of the test, it would seem appropriate to have delayed testing and new weapon purchases until the system could undergo successful operational testing. But under time pressure, the Marines have ordered combat rifles which failed to meet minimum standards for accuracy, durability, or reliability. Of course, the Marines have made a clear statement that all of these problems will be corrected prior to fielding.

Some consideration must be given, however remote, to the possibility that the M16A2/XM855 system will never undergo successful testing or cannot be developed in time to meet mobilization requirements.

Some consideration should also be given to the fact that American soldiers were sent to Vietnam with a rifle/ammunition system which did not work.

Concurrent with service rifle decisions, firing tests should be conducted using the firing port weapons (M231), the short version of the M16 (M177, commonly called CAR15), and any other planned 5.56mm weapon systems to insure that M855 ball and M856 tracer ammunition can be used in all 5.56mm weapons.

An important consideration must be to look at loss of rifle capability resulting from a delayed purchase of M16A2 rifles. If the majority of combat rifle fire will be employed against personnel at ranges from zero to 500 meters, there is little real advantage of the M16A2 over the M16A1. While common ammunition is certainly an advantage, the squad automatic weapon (SAW) ammunition will be issued in belts and rifle ammunition will be issued in clips. The SAW can effectively fire current rifle ammunition (M193), with degraded performance only at ranges of 600 to 800 meters. The current rifle can also fire SAW ammunition (M855) during close-in emergency situations.

CONCLUSION

The recommended rifle features in Inclosure 1 reflect Army training and combat requirements. They have been developed with a view toward overall combat effectiveness, without the normal organizational limitations which focus efforts into confined areas of responsibility. A study of training standards and tactical doctrine, coupled with five years of field research and contact with the majority of Active and Reserve Component units, has provided a unique perspective from which to evaluate the relative importance of various rifle features. The rifle that we recommend takes advantage of the new 5.56-mm bullet while minimizing the problems to be expected with a new system. It is compatible with current rifles, ammunition, and new targets which are being fielded. It provides for optimum trade-offs which results in a reliable rifle capable of effectively engaging long-range stationary targets or close-in moving targets under all light conditions. While meeting all Army training and combat requirements, it exceeds all stated requirements of the Marine Corps.

Art Osborne

Art Osborne
Research Consultant

20 Inclosures

| ITEM | M16A1 | M16A2 | RECOMMENDED |
|---|---|---|---|
| Front Sight (Standard) | Adjustable round post .065 wide. 1 click = 1 MOA. | Adjustable square post .070" wide. 1 click = 1.4 MOA. | Fixed blade .090" wide. |
| Front Sight (Low Light Level) | Adjustable round post .095" wide with liminous vial in center of post. 1 click = 1.25 MOA. Must be turned 2 clicks for vial to show = 2.5 MOA. | None. | A luminous dot on each sightguard. |
| Rear Sight (Standard) | Flip-type peep. Back is 2-mm peep used for 250M zero. Forward marked L, is 2mm used for 25-meter firing (zeroing with point-of-aim/point-of-impact) and a zero for 375 meters. Windage adjustment is made with a flat slotted wheel, 1 MOA per click. | Flip-type peep. Elevation drum built into carrying handle has 25 clicks (1 MOA ea.) of elevation adjustment and markings for 3, 4, 5, 6, 7, and 800 meters. Back flip sight is 1-3/4mm and used for 300 through 800 meter firing. The forward flip is 5mm and is used from 0 to 200 meters, with the drum set for 300 meters, and for moving targets, close combat and reduced light. Windage adjustments are with a drum-type knob,.5 MOA per click. | A single 2mm peep. A single elevation knob marked for 200, 250, 300, 25, 400, 500, 15, 600, 700, and 800 meters. Windage knob at rear. Each click equal to 1 MOA. |
| Rear Sight (Low Light Level) | Flip type peep. Back is 7mm peep used for low light level firing. Forward is 2mm peep marked L, which is the regular sight for 250 Meter zero. Windage adjustment is made with a flat slotted wheel, 1 MOA per click. | None. | Two luminous dots on upper portion of receiver are aligned with front dots for shooting at night. |

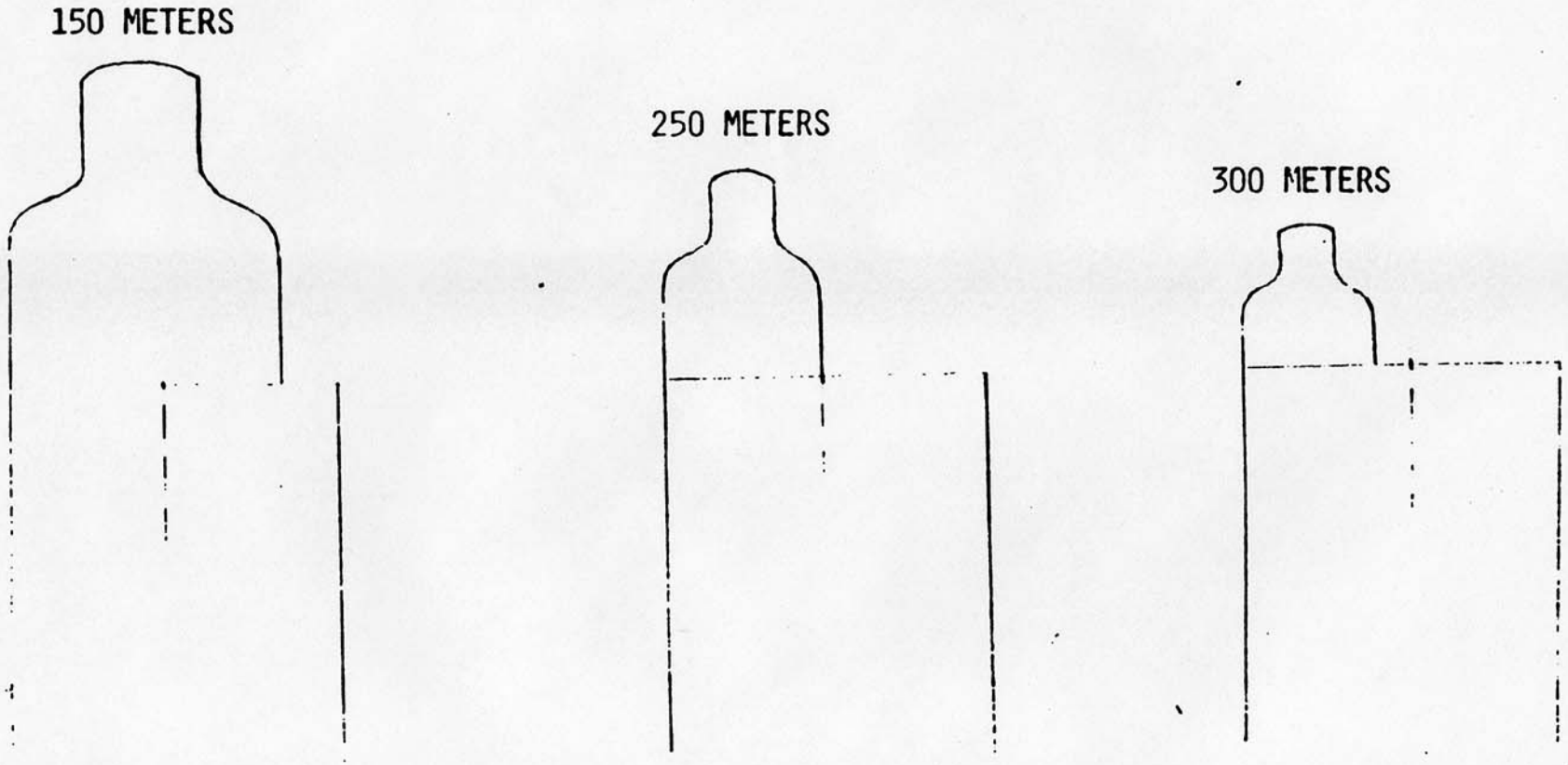
*A minute of angle (MOA) is equal to one inch at 100 yards or .7cm at 25 meters.

| ITEM | M16A1 | M16A2 | RECOMMENDED |
|---|---|---|---|
| Recording of Zero | Almost impossible. | Very difficult. | Simple. |
| Visual inspection of Zero | Impossible. | Impossible. | Simple. |
| 25 M Setting (Standard Sights) | Not by design. | None. | Yes. |
| 25 M Setting (Low Light Level Sights) | None. | N/A | Yes. |
| Mechanical zero can be placed on the rifle. | No. | No. | Yes. |
| Battlesight (A sight setting for 250 Meters) | Yes | No. | Yes. |

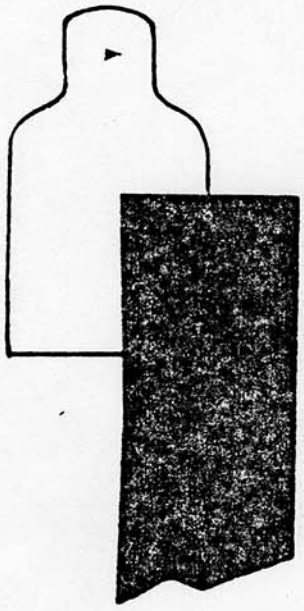
| ITEM | M16A1 | M16A2 | RECOMMENDED |
|---|---|---|---|
| Firing Mode | Semi and Auto | Semi and 3 round burst | Semi and Auto |
| Barrel | Light weight 1:12 twist. | Heavy at muzzle end. Light weight at receiver and mid-barrel. 1:7 twist. (Heavy barrel currently being tested.) | Slightly heavier at receiver and mid-barrel. 1:9 twist. |
| Handguard | Triangular in shape. Left and right sections different. Held in place with a difficult to move slip ring. | Round in shape and constructed of more durable material. Upper and lower sections identical. Held in place by an easy to move slip ring. | Same as M16A2 except held in place with a securely fastened ring nut to provide rigidity. |
| Butt Stock | Standard | Constructed of more durable material. 5/8" longer. | Same material as M16A2. Same length as M16A1. Option for adjustable length. |

## FRONT SIGHT BLADE AS A RANGE ESTIMATION AID

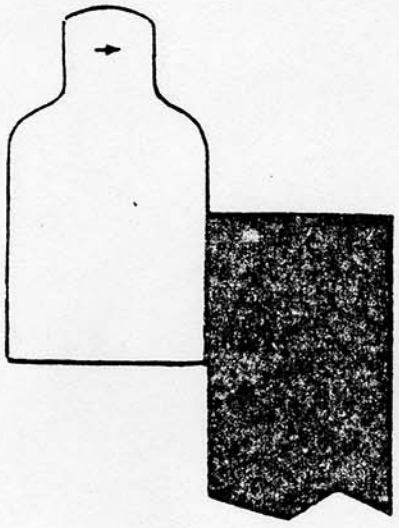
- TARGET LARGER THAN ½ BLADE WIDTH - CLOSER THAN 250 METERS
- TARGET EQUALS ½ BLADE WIDTH - TARGET AT 250 METERS
- TARGET SMALLER THAN ½ BLADE WIDTH - FARTHER THAN 250 METERS



## AIMING RULES FOR MOVING TARGETS

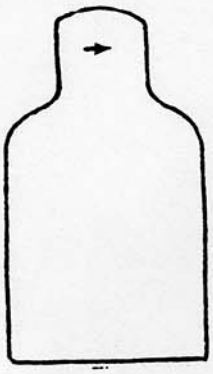


TARGET RUNNING AT A DISTANCE OF 0-100 METERS OR WALKING AT A DISTANCE OF 0-300 METERS. SPLIT THE FRONT SIGHT ON THE LEADING EDGE OF THE TARGET. (SLOW LATERAL SPEED OR CLOSE)

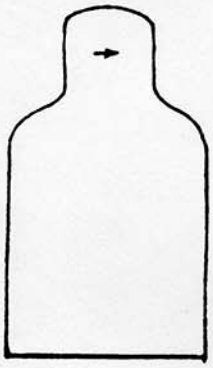


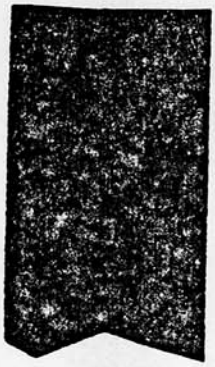
TARGET RUNNING AT A DISTANCE OF 100-200 METERS. PLACE TRAILING EDGE OF FRONT SIGHT AGAINST THE LEADING EDGE OF THE TARGET. (MODERATE LATERAL SPEED)

# AIMING RULES FOR MOVING TARGETS



(FAST LATERAL SPEED)
LEAD THE LEADING EDGE OF THE TARGET WITH THE TRAILING EDGE OF THE FRONT SIGHT BY ONE HALF THE PERCEIVED WIDTH OF THE FRONT SIGHT.



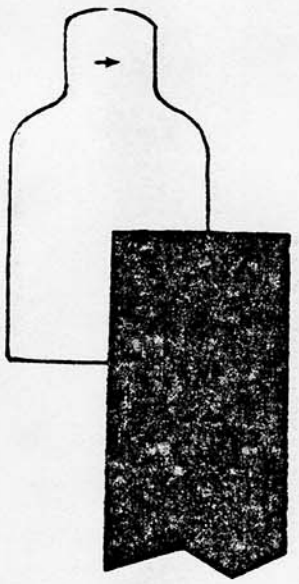


TARGET RUNNING AT A DISTANCE OF 200-300 METERS. LEAD THE LEADING EDGE OF THE TARGET WITH THE TRAILING EDGE OF THE FRONT SIGHT THE SAME DISTANCE AS THE PERCEIVED WIDTH OF THE FRONT SIGHT.

Incl. 3-2

## SINGLE AIMING RULE FOR MOVING TARGETS

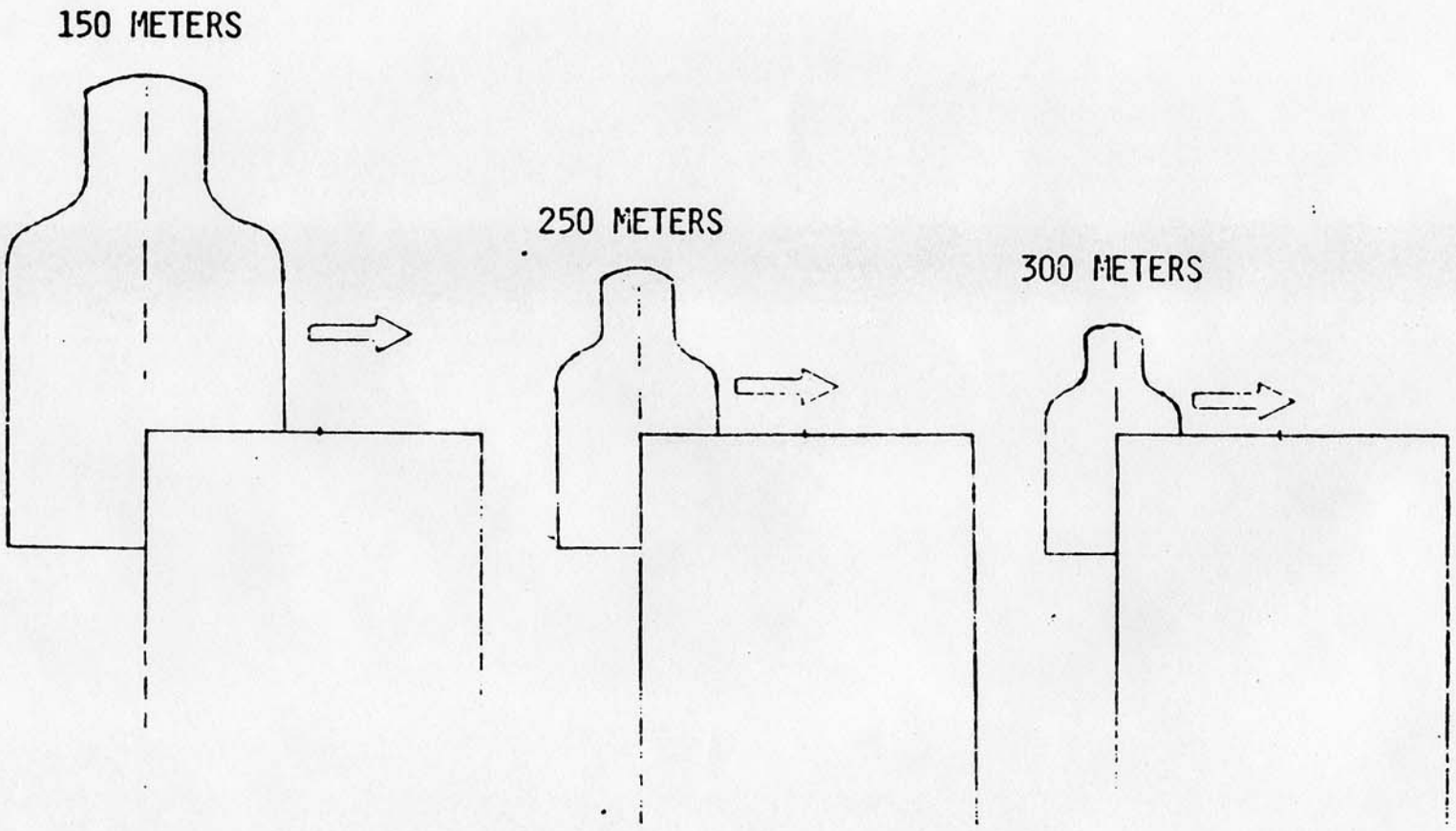
PLACE THE TRAILING EDGE OF THE FRONT SIGHT AT TARGET CENTER.
(WIDTH OF FRONT SIGHT .090")



Incl. 4

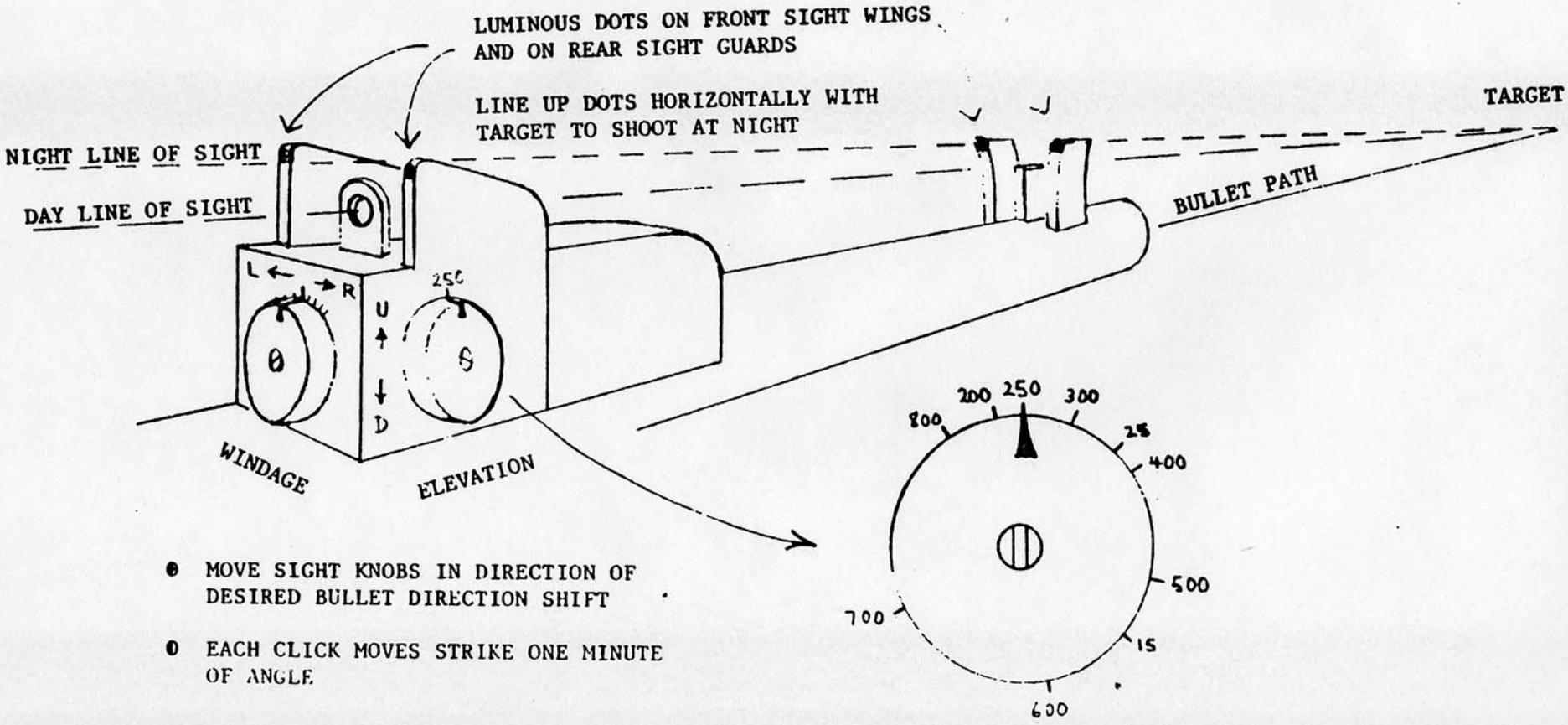
## MOVING TARGET LEAD RULE

- TRAILING EDGE OF SIGHT BLADE ON MIDLINE OF TARGET
- LEAD AUTOMATICALLY INCREASES AS RANGE INCREASES



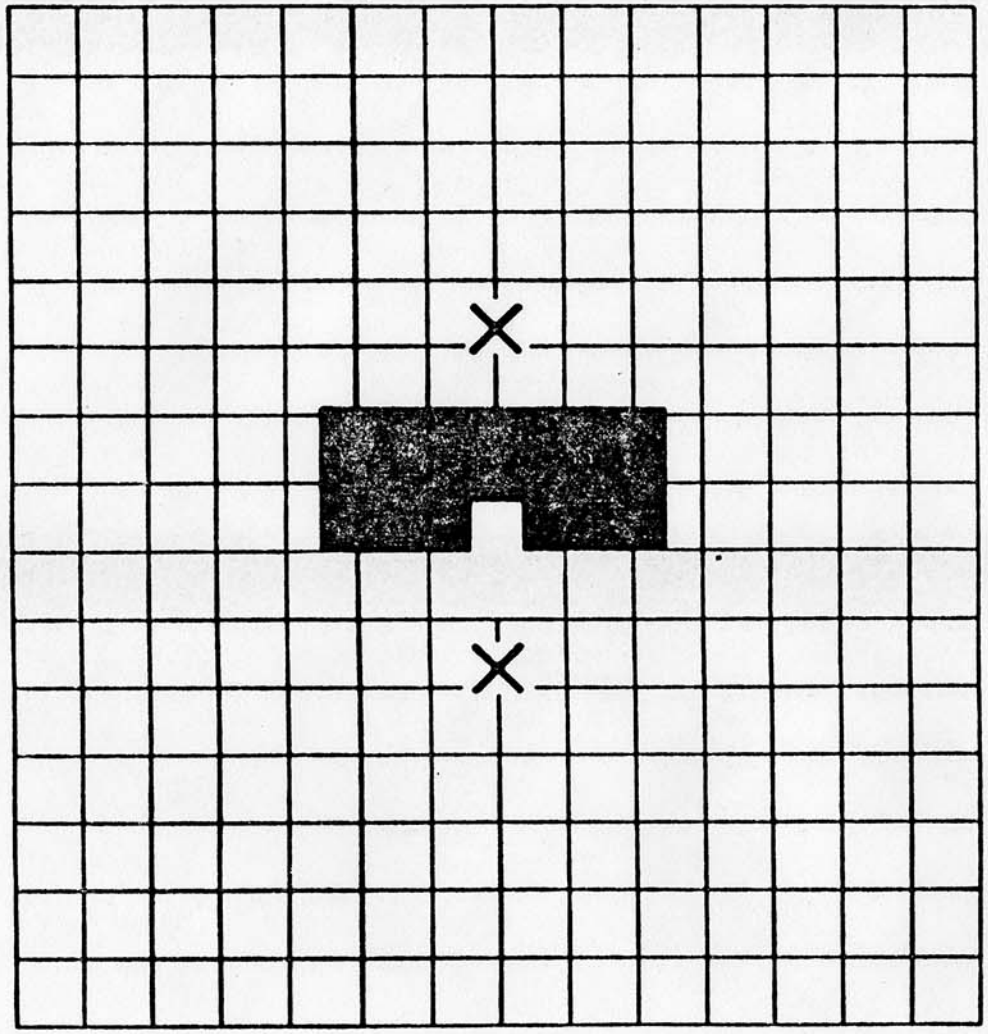
# SMITH - OSBORNE INTEGRATED SIGHT SYSTEM

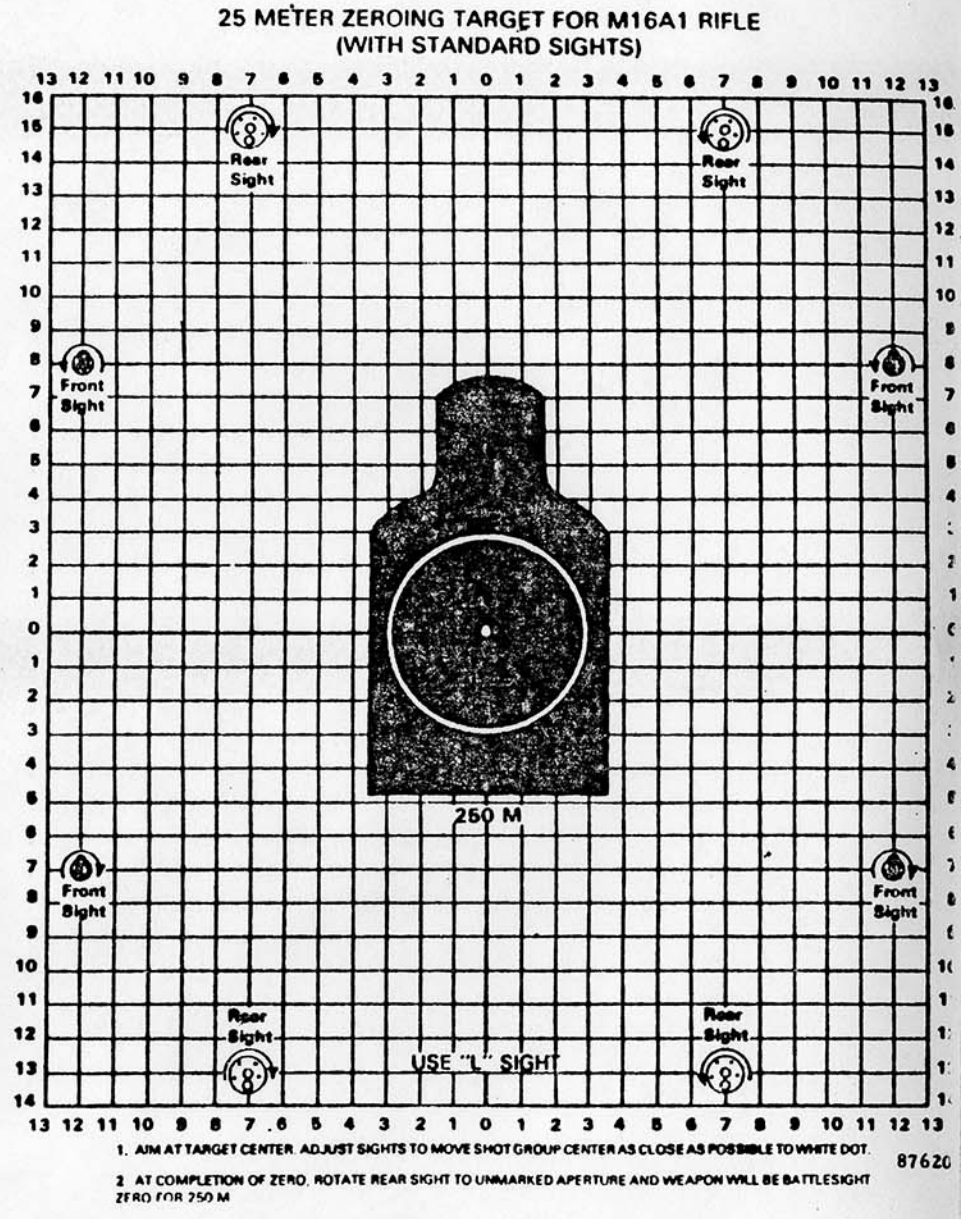
- DAY SIGHT - ADJUSTABLE FOR SEVERAL RANGES INCLUDING 25 AND 250 METERS
  - POSITIVE RETURN TO ZERO
  - FULLY COMPATIBLE CONTROL/DISPLAY MOVEMENTS
- NIGHT SIGHTS
- FRONT SIGHT BLADE - A RANGING AND MOVING TARGET LEAD AID
- FEWER CHANCES FOR ERRONEOUS SETTINGS




- MOVE SIGHT KNOBS IN DIRECTION OF DESIRED BULLET DIRECTION SHIFT
- EACH CLICK MOVES STRIKE ONE MINUTE OF ANGLE

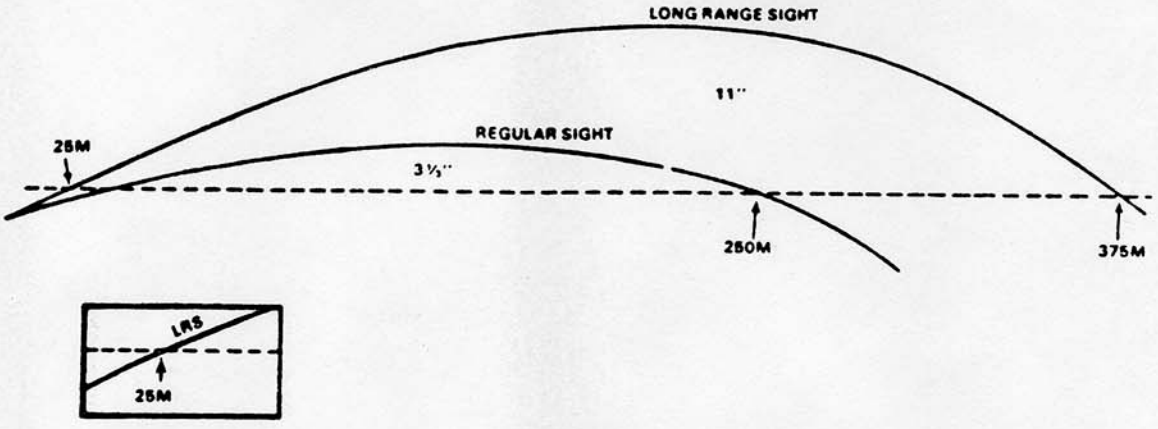
# 25 METER (1000 INCH) TARGET





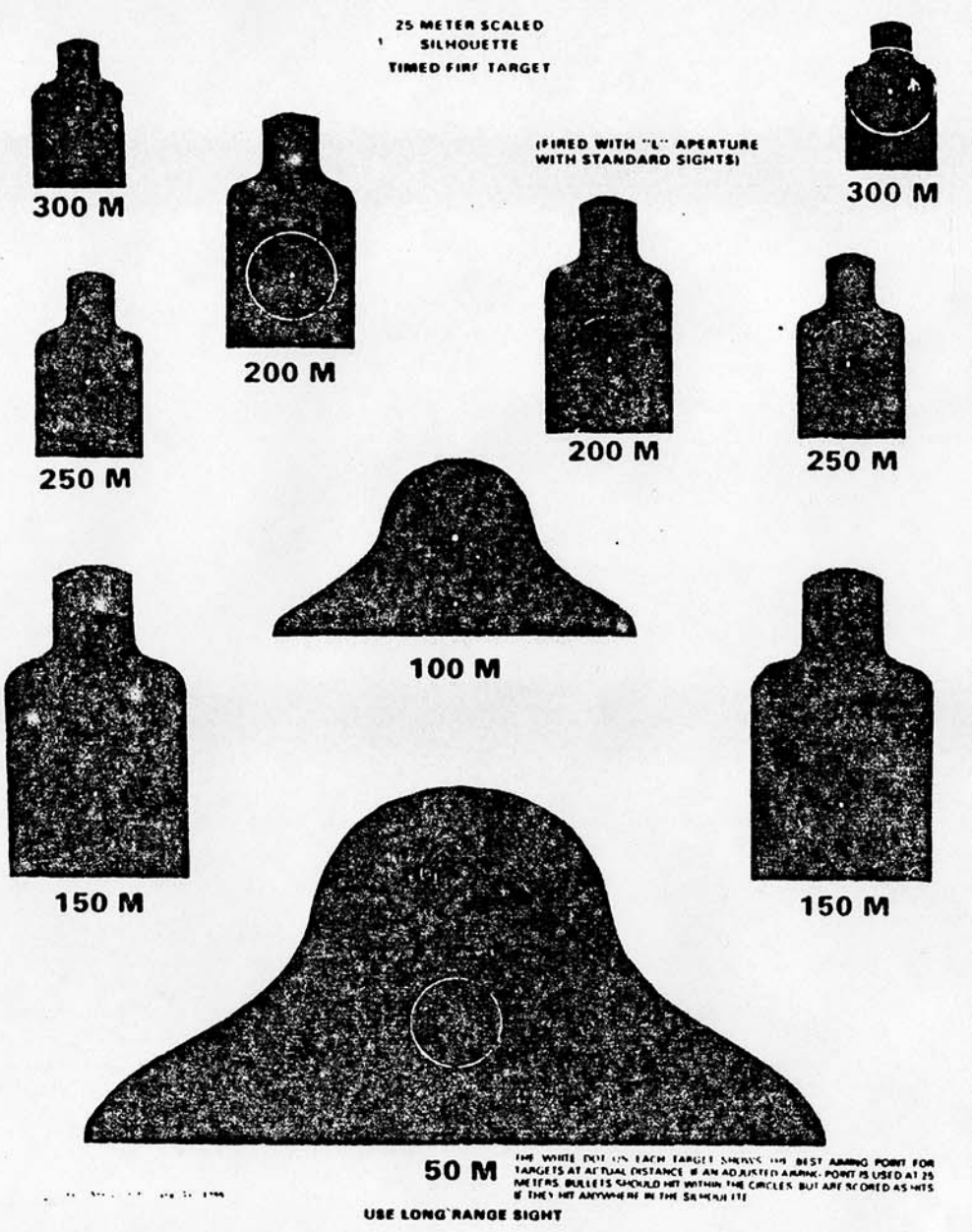

The Canadian bull zeroing target on the left, which required aiming at the bottom of the Canadian bull, and adjusting bullet strike to the lower "X," has been replaced with the scaled silhouette zeroing target on the right. The soldier aims at center-of-mass and makes sight adjustments until bullets hit center-of-mass.

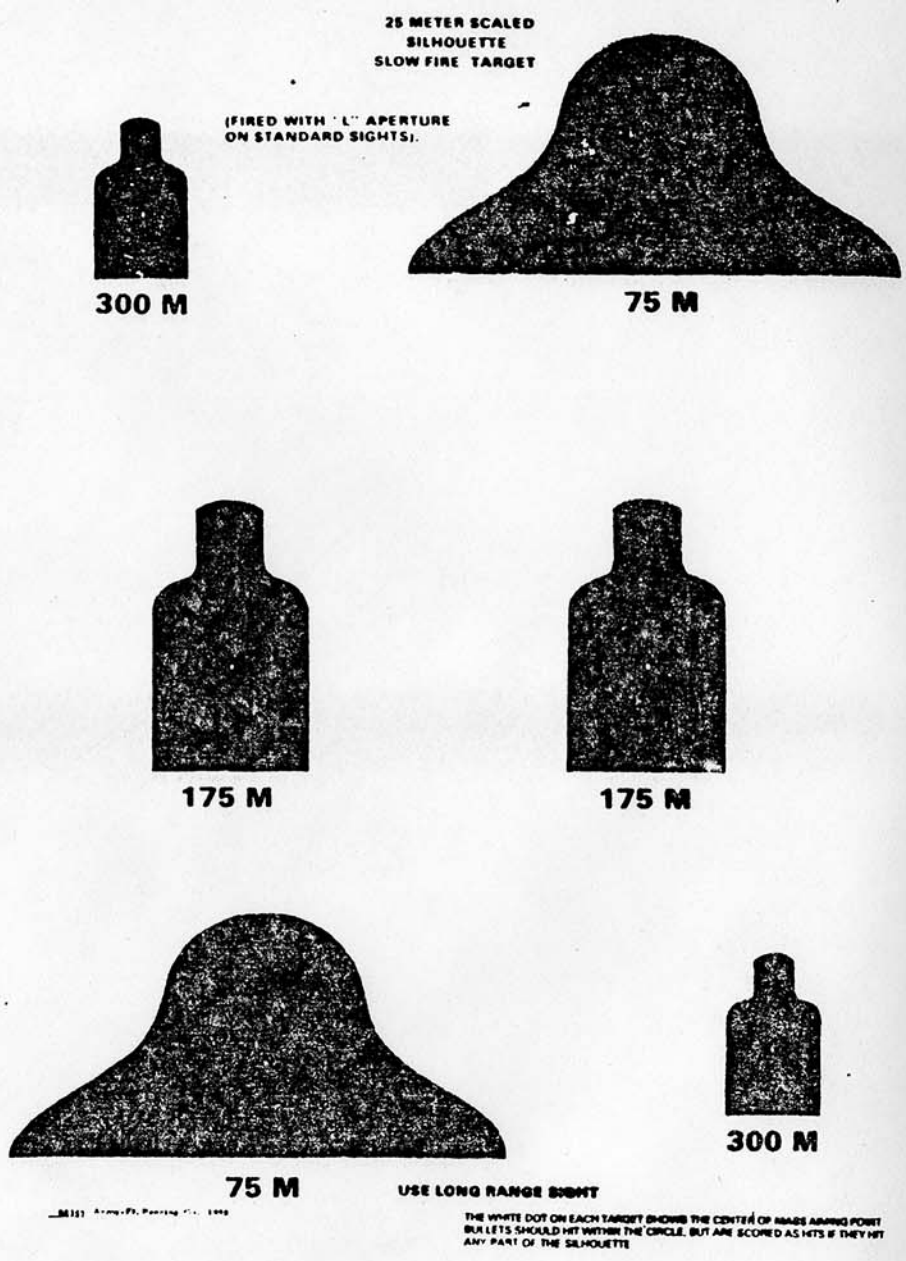
Incl. 7




The procedure of aiming one place and adjusting bullets to hit another place has been confusing to many soldiers. Marksmanship research revealed that using the long-range sight and adjusting bullet strike to coincide with point of aim at 25 meters would produce a good 250-meter zero when the sight was flipped back to the regular aperture. The standard rear sight of the M16A1 consists of two apertures. When the unmarked aperture (regular sight) has been zeroed for 250 meters, flipping to the aperture marked "L" automatically provides a zero fo 375 meters. The above sketch shows the difference in bullet trajectory between the regular and long-range sights. In theory, the rifle may be zeroed at any point along the trajectory curve produced by the regular or long-range sight. Therefore, by flipping to the long-range sight and adjusting bullet impact to coincide with point of aim at 25 meters produces a 375-meter zero on the long-range sight, or a 250-meter zero when the sight is flipped back to the regular aperture.

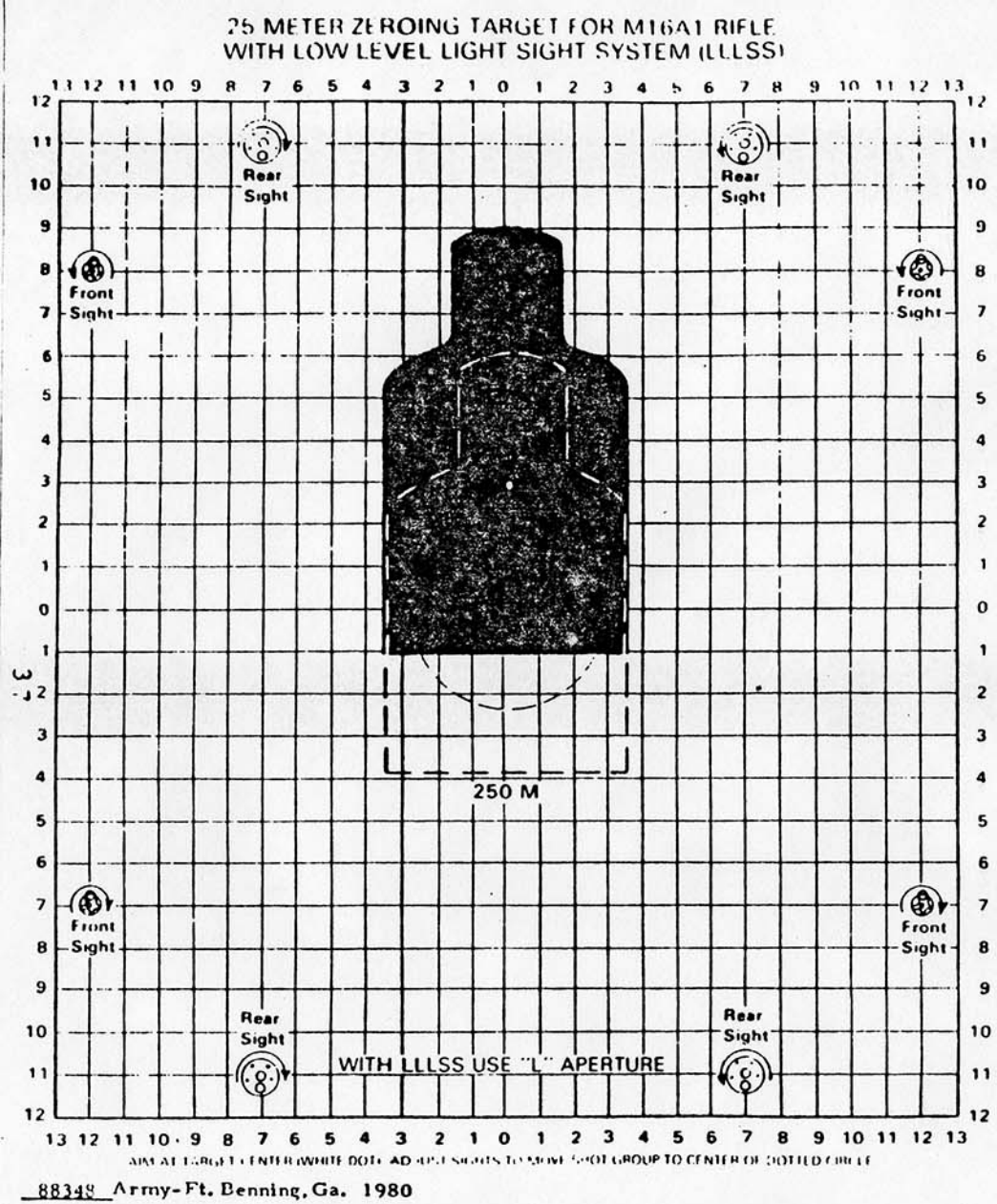
The recommended M16A2 sight is marked for 25 meters at the range location on the elevation drum which results in the M855 bullet crossing line of sight at 25 meters and again at some greater range.

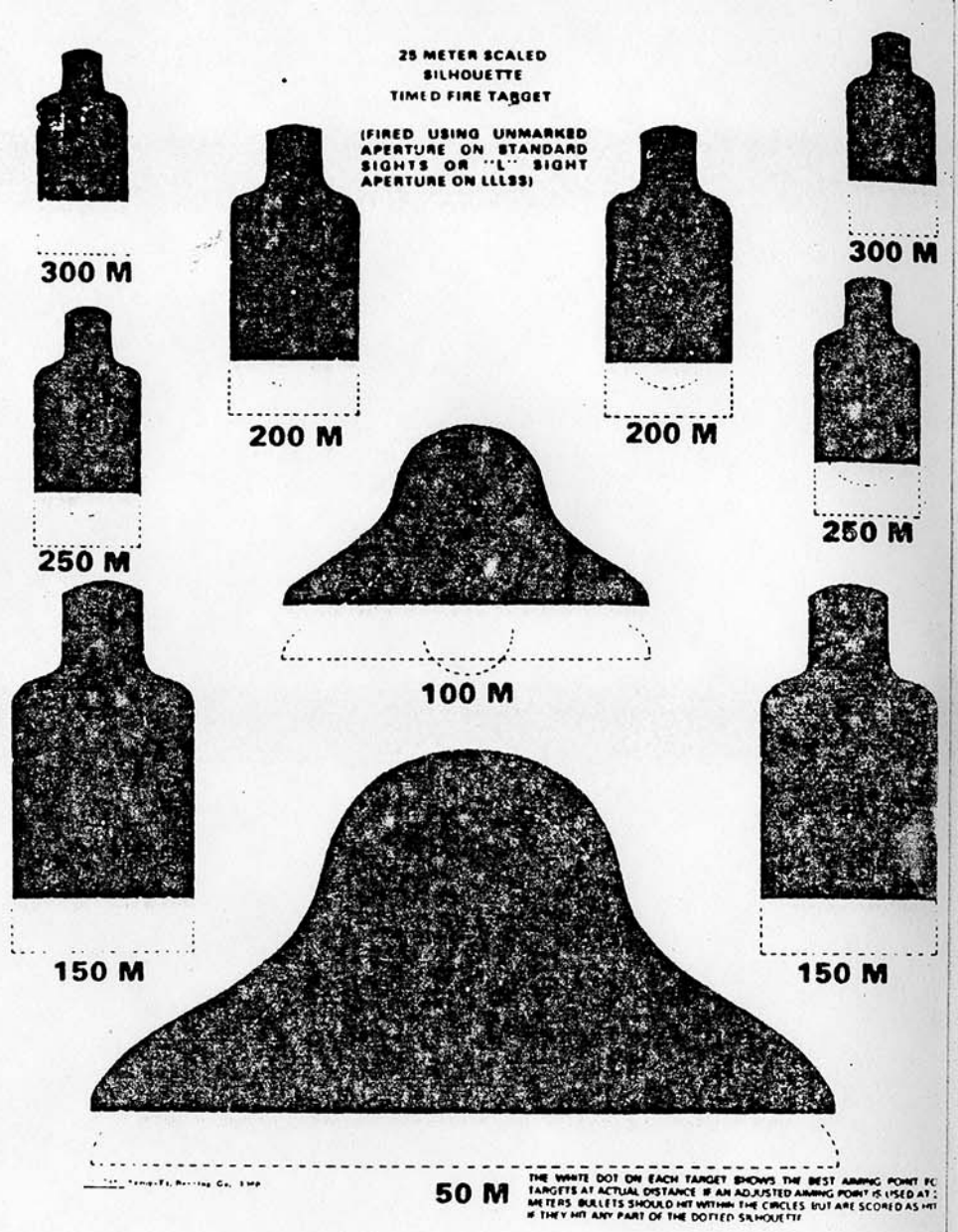



Incl. 9

The scaled silhouette target on the right (actual target size is 18 x 23") was designed to assist in the transition from firing at 25-meter zeroing targets to engaging pop-up targets on the field fire range. The left target emphasizes the task requirements of rapid target engagement under time pressure. The soldier completes the exercise with some understanding of what will be required during record fire.



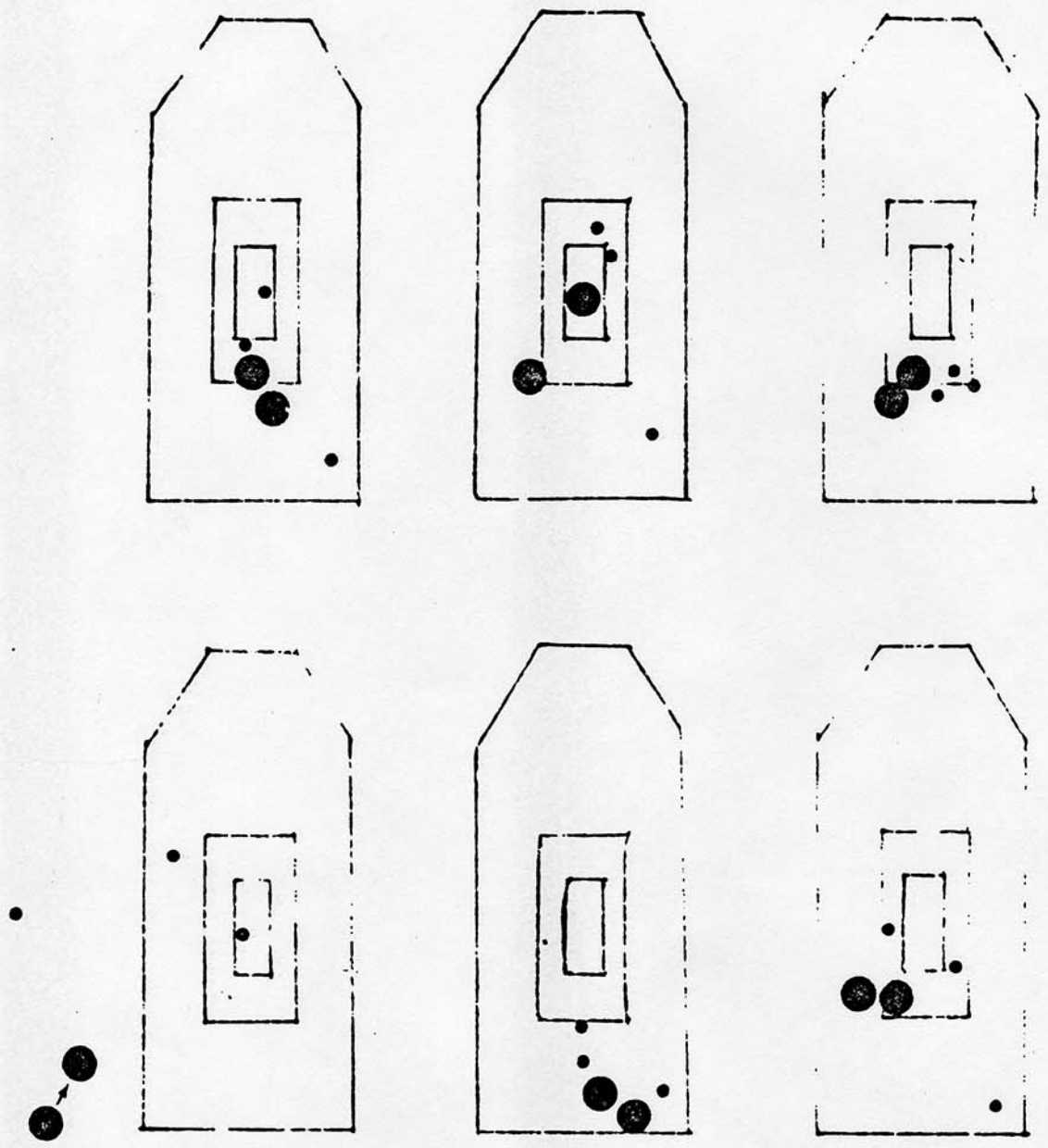




These targets were designed for rifles without a point of aim/point of impact capability. Bullet strike is measured 2.4cm below point of aim.

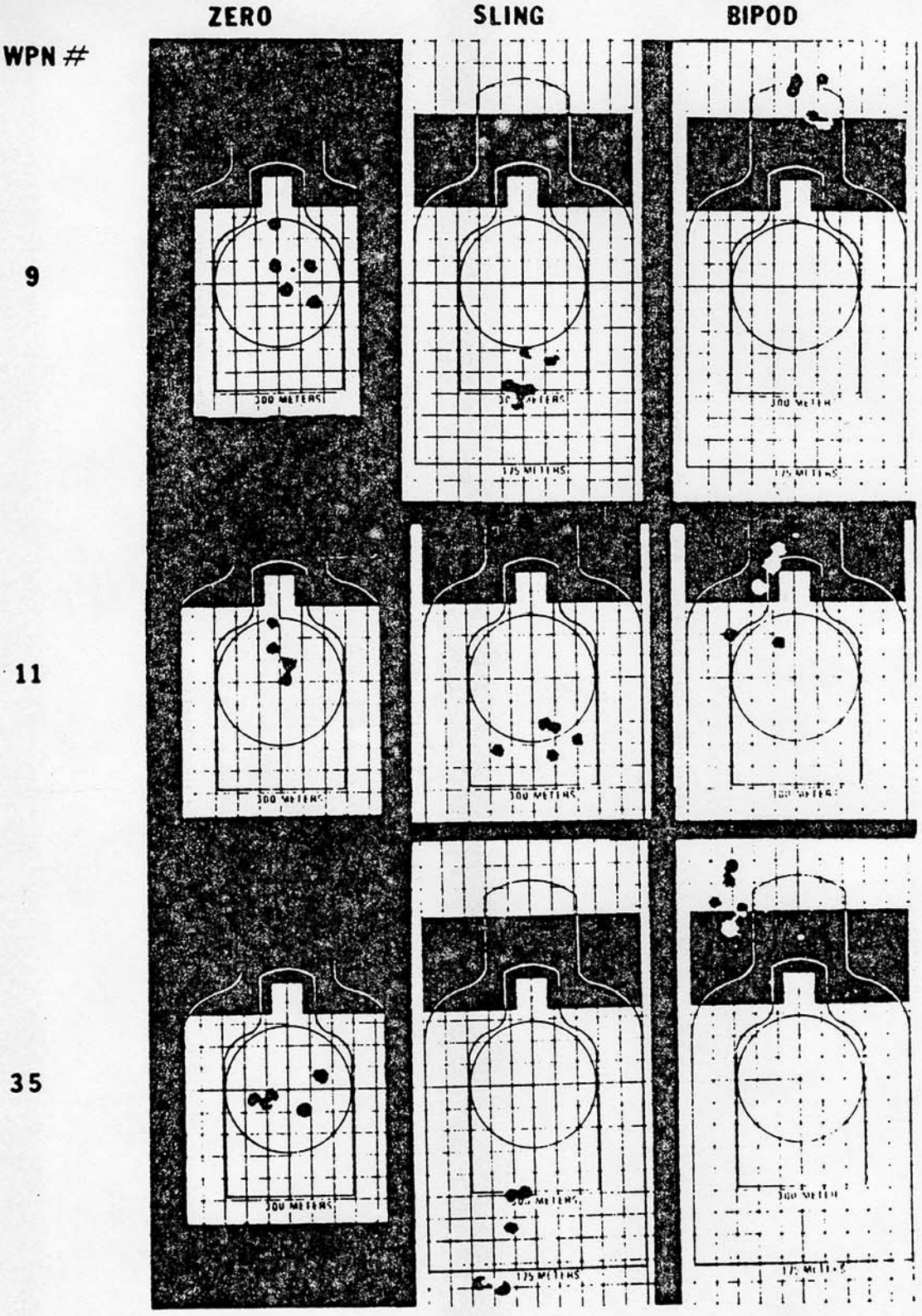
Incl. 10

# RIFLE AIMING - NIGHT

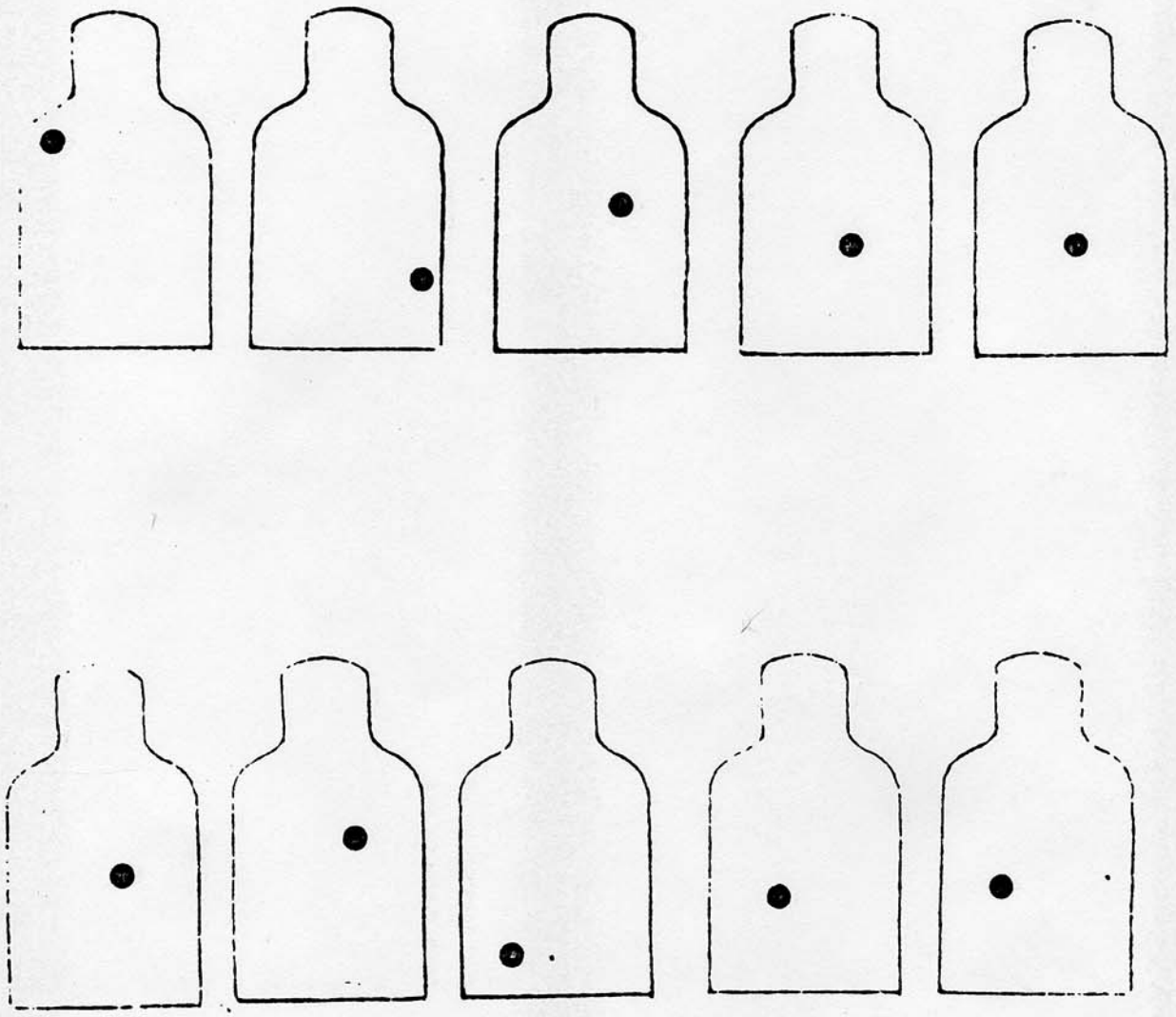
ALIGN FOUR LUMINOUS DOTS AND PLACE TARGET AT CENTER.



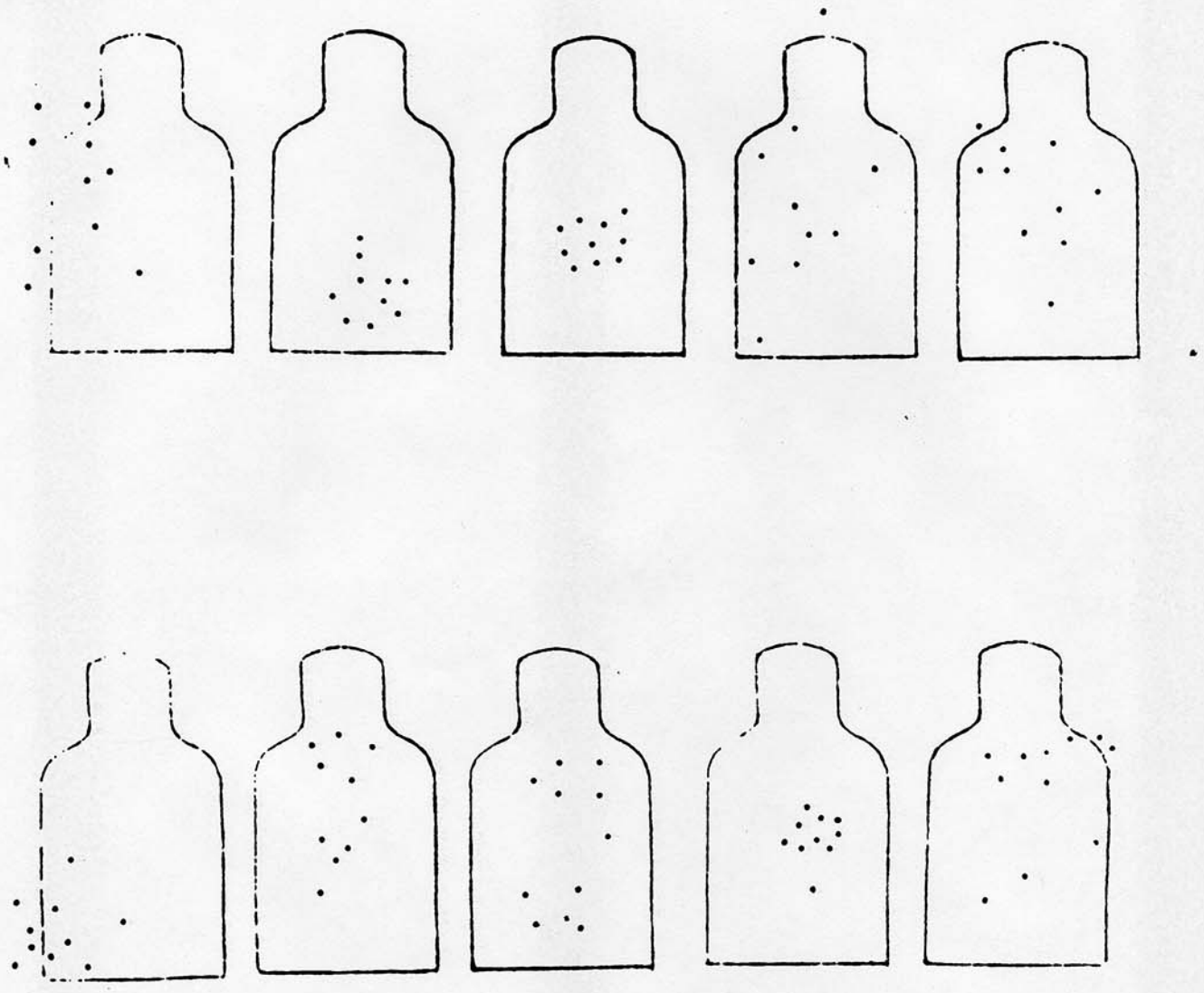
These targets were fired with a bipod supported M16A1 using 5-round burst at distances of 50 and 100 meters. Projectile location equipment was used to accurately plot the firing sequence and location of each round. The first three rounds of each burst are represented by the small dots and rounds four and five are represented by the large dots.




Effects of stress. These zero targets, with a 4cm circle, were fired from a distance of 25 meters. The left targets show the normal zero, the center targets were fired with a hasty sling, and the targets at the right were fired with a bipod attached and downward pressure applied forward of the carrying handle. Note that the difference in bullet strike at 300 meters would be two to four feet.

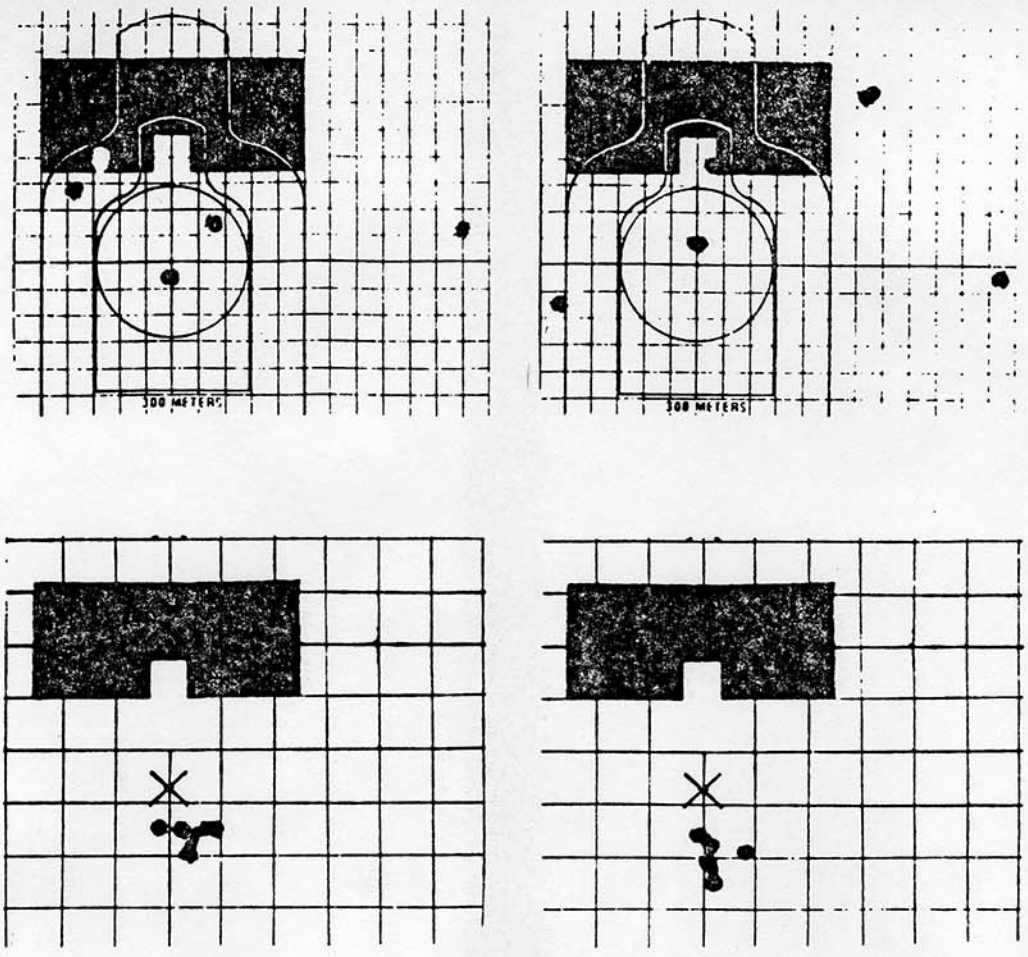


A target at a distance of 200 meters was engaged by 10 different people, using the same M16A1 rifle and the same sight setting. The first round fired by each person is shown. For six of the subjects, this was the first round ever fired from an M16 rifle and for three of the subjects, this was the first time they had fired a real weapon. However, all subjects had received limited training on the Weaponeer and the Multipurpose Arcade Combat Simulator (MACS). Note that each person hit the target and that the average placement of the 10 shots is near target center.

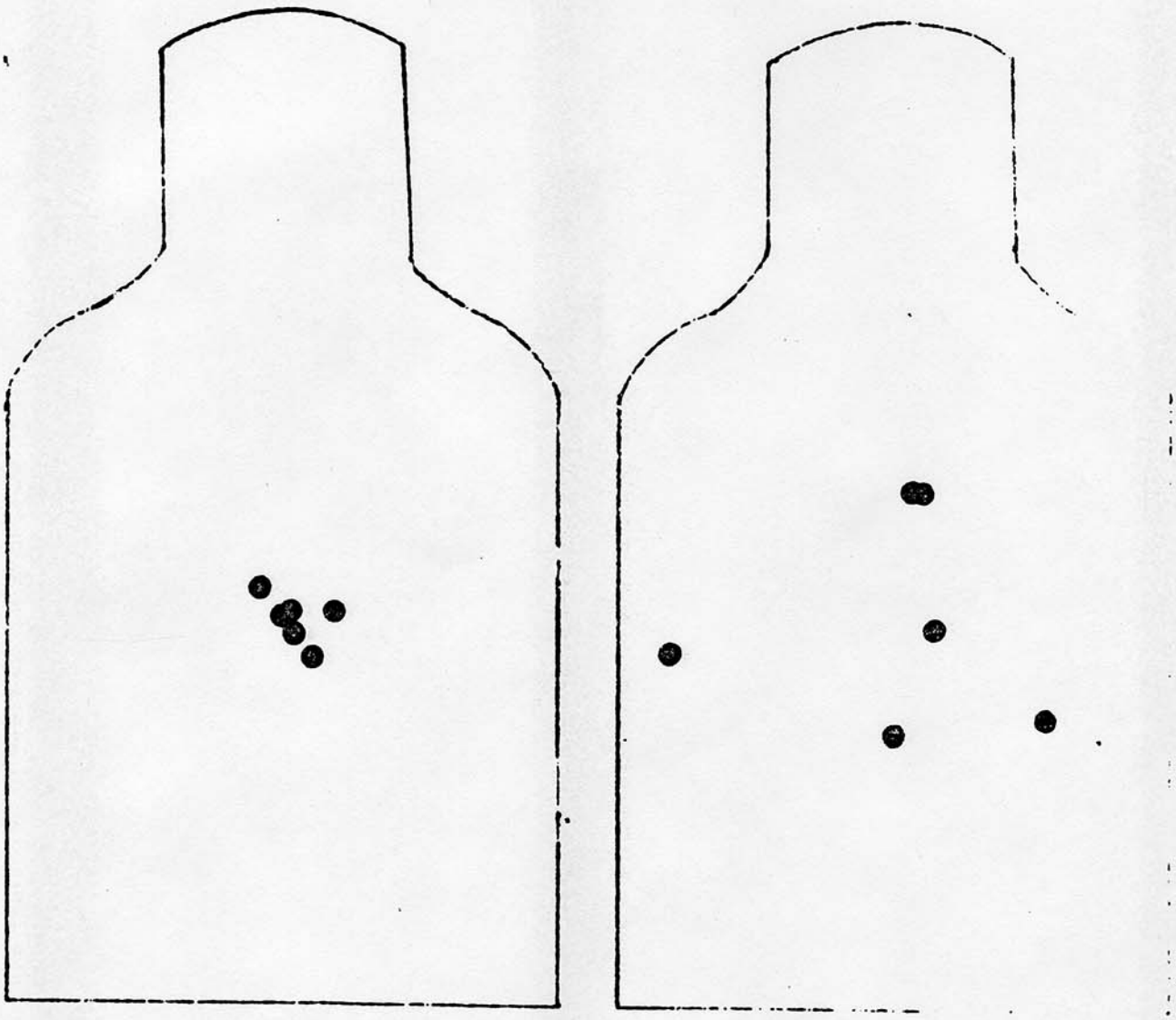


A target at a distance of 200 meters was engaged by 10 different people, using the same M16A1 rifle and the same sight setting. Only hit/miss feedback was provided during the firing of 10 rounds each. Five of these subjects had little or no previous shooting experience, but had received limited training on Weaponeer and the Multipurpose Arcade Combat Simulator (MACS). Note that 87% of the bullets were target hits and that sight changes are not needed for at least seven of the ten firers.

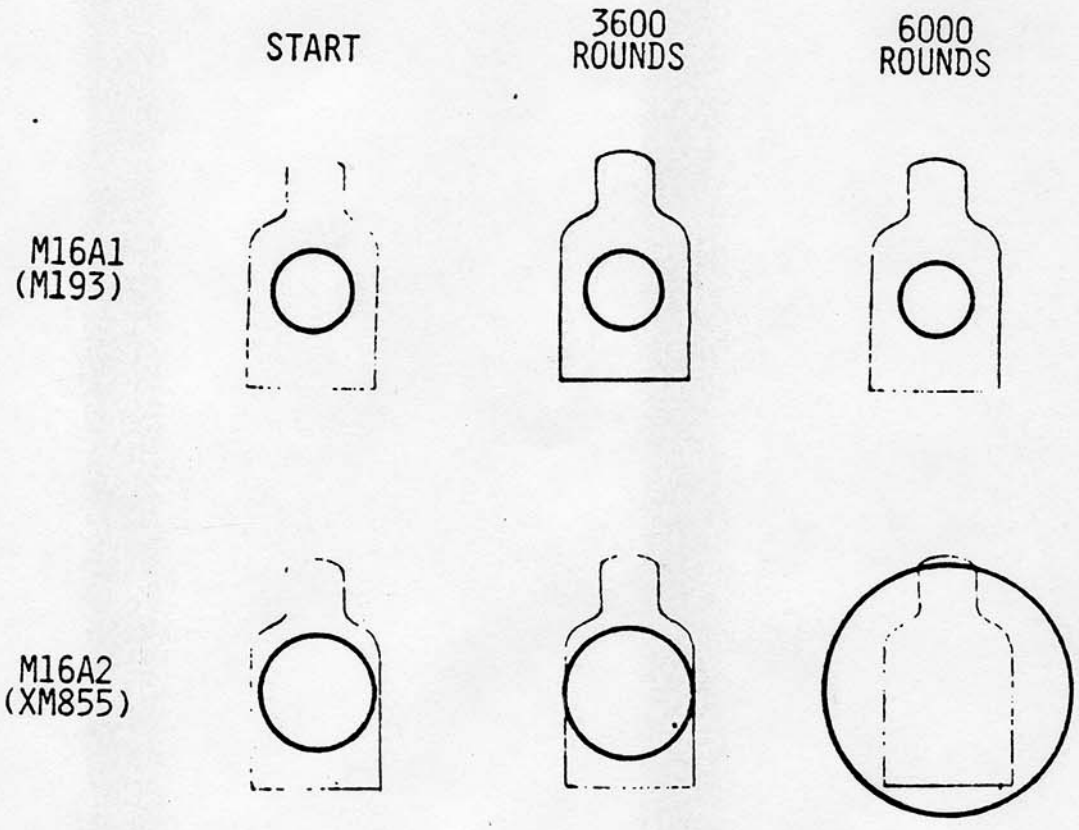
Incl. 15



Serviceability firing checks. These four targets were fired by the same firer with the same rifle from the same supported position on a 25-meter range. Before firing the top two five-round groups, the rifle passed basic serviceability checks: barrel straightness, headspace, bore erosion, muzzle erosion, and trigger pull. Additionally, a physical measurement of the bore, a check of torque readings, and the recording of muzzle velocity for several rounds found those measures to be well within specifications. The bottom two five-round groups were fired after the upper receiver was replaced. With knowledge that the rifle would not shoot accurately, the decision to replace the upper receiver was a judgement call. The only way to determine if this type of repair is needed on the M16A1 is to identify the rifle as a bad shooting rifle.



These two six-round shot groups were fired at a distance of 100 yards by an experienced firer from a supported position, using the same M16A1 rifle. The three-inch group on the left was fired with current ammunition (M193) and the twelve-inch group on the right was fired with new ammunition (SS109).




ENDURANCE AND ACCURACY TESTING RESULTS SHOWN CENTERED ON "E"-TYPE SILHOUETTE TARGETS AT A RANGE OF 300 METERS.

## RELIABILITY

### PRIMARY TEST, 30 RIFLES EACH, 26,010 ROUNDS

#### M16A1 WITH M193 AMMO

- NO FAILURES TO FIRE
- 3 FAILURES TO FEED DUE TO NOT LOCKING MAGAZINE IN PLACE

#### M16A1E1 WITH XM855 AMMO

- 52 FAILURES TO FIRE
  - 27 - BAD PRIMERS
  - 25 - MECHANICAL MALFUNCTIONS
- 3 FAILURES TO FEED DUE TO IMPROPER MAGAZINE LOADING

## RELIABILITY

COLD WEATHER TEST, 5 RIFLES EACH, 6000 ROUNDS PER RIFLE

M16A1 WITH M193 AMMO

- 4 FAILURES TO FIRE

M16AE1 WITH XM855 AMMO

- 159 FAILURES TO FIRE
- 2 WEAPON FAILURES (BROKEN CAM SPRING)

# TOMORROW'S RIFLE FEATURES

Captain Noyes B. Livingston III

## General

Similar in appearance to an M16 in a traditional semi-pistol grip stock

## Stock

Semi-straight line stock
Raised comb
Semi-pistol grip
Concave recoil pad
Plastic stock and handguard
No carrying handle
Stock does not collapse or fold
Sling swivels flush mounted on right side of stock and handguard

## Operation

Fires from closed bolt position
Fires at moderate cyclic rate
Semi-automatic and recycling burst control firing modes
Gas cylinder, piston, operating rod and bolt carrier assembly mounted above the barrel
Bolt held open after last round is fired
Compatible with Multiple Integrated Laser Engagement Simulation

## Action

Hinged receiver split into upper and lower groups
Receiver held together with a front pivot pin and a rear takedown pin
Chrome plated bore and chamber
Sturdy tapered barrel
1 in 9 inch rifling for 5.56 mm M855 ammunition
Charging handle fixed to bolt carrier on left side of upper receiver
Charging handle large enough to act as bolt forward assist
Covered ejection port on right side of upper receiver
Integral magazine well in lower receiver
Magazines insert straight in well and do not pivot into place
Receiver accomdates a .22 caliber rimfire adapter

## Firing Controls

Clean crisp two stage trigger
All controls accessible in firing position with right hand on semi-pistol grip
Magazine catch on right side of lower receiver
Firing mode selector lever on left side of lower receiver
Bolt catch on left side of lower receiver
All controls large enough to manipulate with gloves on
Trigger guard folds forward against magazine to use trigger with gloves on

Sights (incorporates recommendations by Mellonics)

Front sight is fixed blade .09 inches wide
Single rear aperature sight at back of upper receiver
Rear aperature sight is 2 mm in diameter
Rear and front sights protected by pairs of wings
Luminous night firing dots on front and rear sight wings
Capability to establish a rough mechanical zero with a boresight device
Windage knob at back of rear sight marked left and right
Elevation knob on left side of rear sight
Windage and elevation knobs adjust in direction of desired bullet strike
Rear sight aperature elevation and windage adjustments in one Minute of Angle increments
Elevation knob marked for 200, 250, 300, 25, 400, 500, 15, 600, 700 and 800 meters
Rear sight has definite point of aim-point of impact settings for 250 meter battlesight zero, 25 meter scale silhouettes and 15 meter indoor ranges
After zeroing, a tool is used to reset and lock the windage knob on zero and the elevation knob on 25 meters. The elevation knob is then turned to 250 meters to establish a battlesight zero.
Upper receiver grooved to accept a night sight and sniper scope mount

Magazines

If chambered for 5.56 M855 ammunition, receiver must accept M16 magazines
Plastic or nylon magazines hold 20 and 30 rounds
Short cerimonial magazine fits flush with bottom of magazine well

Accessories

Front sight assembly, gas tube and bayonet lug similar to the M16
Clothespin bipod clips to barrel
Flash suppressor built to also function as a muzzel compensator
Flash suppressor threaded internally to accept screw in blank fire adapter
Upper receiver grooved for cartridge deflector on ejection port for left handed firers
Cartridge catcher attachment fits brass deflector grooves