U.S. Army Research Institute
for the Behavioral and Social Sciences

Research Report 1761

# Basic Rifle Marksmanship Training with the Laser Marksmanship Training System

**Joseph D. Hagman**
U.S. Army Research Institute

July 2000

**U.S. Army Research Institute**
**for the Behavioral and Social Sciences**

**A Directorate of the U.S. Total Army Personnel Command**

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14. ABSTRACT *(Maximum 200 words)*: This research compared the relative impact of two approaches for training Basic Rifle Marksmanship (BRM). One hundred and eighty four One-Station Unit Training (OSUT) infantry trainees (i.e., the experimental group) trained under a U.S. Army Reserve (USAR)-developed, device-based (i.e., the Beamhit™ Laser Marksmanship Training System [LMTS]) approach, and 202 infantry trainees (i.e., the control group) trained under the standard U.S. Army Infantry School BRM program of instruction. Results revealed that the experimental group outperformed the control group on shot grouping, weapon zeroing, and known-distance firing. No between-group differences were found, however, for record fire qualification scores or for performance during pop-up target engagement practice periods leading up to qualification. The implications of these findings for initial marksmanship training are discussed along with plans for follow-up USAR-sponsored research to assess (a) the impact of LMTS-based training on sustainment performance, and (b) the feasibility of using LMTS-based performance to predict live-fire qualification scores.

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Research Report 1761

# Basic Rifle Marksmanship Training with the Laser Marksmanship Training System

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## FOREWORD

The United States Army Reserve (USAR) is looking for more effective and efficient ways to train and evaluate rifle marksmanship through the use of training devices. To this end, and at the request of the U.S. Army Reserve Command (USARC), the U.S. Army Research Institute's Reserve Component Training Research Unit (ARI-RCTRU) has been working in partnership with the 84th Institutional Training Division (DIVIT) (i.e., USARC's marksmanship executive agent) and Small Arms Training Team (SATT) to develop and evaluate device-based (i.e., the Beamhit™ Laser Marksmanship Training System [LMTS]) rifle and pistol marksmanship training programs for use at home station (i.e., reserve centers). The common goal of this cooperative effort is to field companion programs that will produce rifle and pistol marksmanship proficiency levels that meet, or exceed, unit readiness requirements while minimizing the resources needed to do so.

To date, the rifle program has been developed and plans are underway to answer questions about its potential payoff. A preliminary step in the implementation of these plans is to answer a U.S. Army Infantry School (USAIS) query about the potential impact of the program on the level of Basic Rifle Marksmanship (BRM) performance displayed at initial entry. This report describes the research conducted to answer this question, what was found, and what the implications are for both initial, and sustainment, marksmanship training.

This research was conducted by the ARI-RCTRU, whose mission is to improve the effectiveness and efficiency of Reserve Component (RC) training through use of the latest in training technology. This research is supported under Work Package 207, "Maximizing Payoff of Reserve Training," of ARI's Science and Technology Program for Fiscal Year 1999.

This research was sponsored by USARC under a continuing Memorandum of Understanding initially signed 12 June 1985. Findings have been presented to Deputy Chief of Staff for Training, Training and Doctrine Command (TRADOC); Director, USARC; Deputy Chief of Staff for Operations, USAR 84th DIVIT; and Director of Training, USAIS.

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BASIC RIFLE MARKSMANSHIP TRAINING WITH THE LASER MARKSMANSHIP TRAINING SYSTEM


## EXECUTIVE SUMMARY

Research Requirement:

Determine the relative impact of using the Beamhit™ Laser Marksmanship Training System (LMTS) to train Basic Rifle Marksmanship (BRM).

Procedure:

One hundred and eighty four One-Station Unit Training (OSUT) infantry trainees were assigned to an experimental group, and 202 were assigned to a control group. The control group used the dime [washer], target/shadow box, Multipurpose Arcade Combat Simulator (MACS) and Weaponeer, whereas the experimental group used LMTS, to support BRM training. Trainee marksmanship performance was then measured in terms of the number of targets hit and/or rounds fired during the live-fire instructional periods leading up to, and including, record fire qualification.

Findings:

Use of LMTS (a) reduced the number of rounds fired, while increasing the number of trainees firing to standard, during live-fire shot grouping and weapon zeroing, and (b) increased the number of known-distance target hits. It did not improve record fire qualification scores.

Use of Findings:

These findings suggest that LMTS-based BRM training would improve initial entry rifle marksmanship performance and save ammunition in the process. This payoff could be expected to increase, and perhaps extend to qualification firing, as instructors become more familiar with the device and the LMTS-based program of instruction is augmented to include a pop-up target engagement practice course of fire. These findings should encourage U.S. Army Reserve (USAR) pursuit of plans for follow-up research to assess (a) the impact of LMTS-based training on marksmanship sustainment, and (b) the feasibility of using LMTS-based performance to predict live-fire qualification scores.

BASIC RIFLE MARKSMANSHIP TRAINING WITH THE LASER MARKSMANSHIP TRAINING SYSTEM

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# BASIC RIFLE MARKSMANSHIP TRAINING WITH THE LASER MARKSMANSHIP TRAINING SYSTEM

## Introduction

Budget cutbacks, escalating ammunition costs, reduced access to live-fire ranges, reported performance deficiencies (e.g., San Miguel, 1998), and ever-present training time constraints have prompted the U.S. Army Reserve (USAR) to search for more effective and efficient ways to train small arms marksmanship through the use of devices. To this end, the U.S. Army Research Institute (ARI) is working in partnership with the U.S. Army Reserve's (USAR's) 84th Institutional Training Division (DIVIT) and Small Arms Training Team (SATT) to develop and evaluate device-based rifle (M16A2) and pistol (M9) marksmanship sustainment training programs for use at home station (Plewes, 1997, Oct 9).

As the U.S. Army Reserve Command's marksmanship executive agent (MEA), the 84th DIVIT is responsible under this partnership for project coordination/conduct and shares responsibility with SATT for development of the two programs of instruction. ARI is responsible for designing the research needed to support program development and subsequent evaluation. The common goal of this cooperative effort is to field companion sustainment training programs that will produce rifle and pistol marksmanship proficiency levels that meet, or exceed, unit readiness requirements while minimizing the resources needed to do so (Plewes, 1997, Nov 24).

To date, the rifle program has been developed (Commander, SATT, 1999). It calls for device use to (a) identify which soldiers need sustainment training, (b) support the relearning and practice of marksmanship fundamentals (i.e., steady position, aiming, breath control, and trigger squeeze), as well as shot grouping and weapon battlesight zeroing procedures, (c) enable indoor record fire qualification practice, and, eventually, (d) reduce the frequency of live-fire qualification with device-based qualification when live-fire range facilities are not readily available.

After completing a relative capabilities analysis of several candidate training devices (Memorandum For Record, 1997, Dec 14), the USAR has selected the Beamhit™ Laser Marksmanship Training System (LMTS) (Beamhit, Inc., 1999) as the device best suited to support the above objectives. LTMS is an indoor, laser-emitting device that enables the engagement of targets without the firing of live ammunition. The device's major components include a battery-powered laser transmitter, a mandrel to which the transmitter is attached/aligned, a variety of laser sensitive targets (Figure 1), and a laptop computer. One end of the mandrel holds the laser transmitter while the other end slips into the muzzle of the weapon. The transmitter is designed to function under two modes of operation. Under a trigger-activated mode, vibrations from the rifle's firing mechanism activate the transmitter when the weapon is dry fired and the location of the emitted beam (i.e., shot location feedback) is "picked up" by the laser-sensitive target(s) (Dulin, 1999). This information is then recorded and stored on the laptop for future reference (e.g., during shot group analysis and weapon prezeroing). Under a constant-on mode, precise aiming point location feedback is provided against the background of a reflective version of the 25m Zeroing Target (Figure 2).

Unlike other marksmanship training devices in the Army's inventory (e.g., Multipurpose Arcade Combat Simulator [MACS] [e.g., Purvis & Wiley, 1990; Schroeder, 1985)], Weaponeer [Schendel, 1985; Schendel, Heller, Finley, & Hawley, 1985]), and the Engagement Skills Trainer [EST] [Hagman, 1998; Scholtes & Stapp, 1994]), LMTS allows soldiers to train with their own weapons with the laser transmitter and mandrel attached as a muzzle insert. The device is also relatively inexpensive and, therefore, could be fielded in quantity to most, if not all, reserve center locations. These reasons, coupled with the device's ease of setup, operation, and upkeep prompted the USAR's selection of LMTS to support both rifle and pistol training program development.

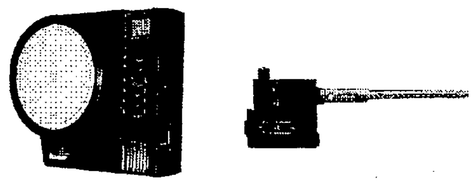

Figure 1. An LMTS electronic target and laser transmitter with attached mandrel.

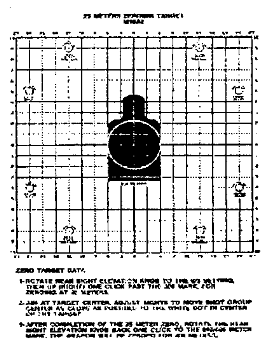

Figure 2. The M16A2 Rifle 25m Zeroing Target.

Now that the rifle program has been developed, questions about its potential payoff need to be answered. Planning is underway for the conduct of a series of investigations to answer questions about program effectiveness/efficiency, as well as others regarding LMTS usage to diagnose marksmanship deficiencies and to predict live-fire qualification performance. A preliminary step in the implementation of this plan is to collect the data necessary to answer a U.S. Army Infantry School (USAIS) query about what the impact of LMTS-based training might be on the level of Basic Rifle Marksmanship (BRM) performance displayed at initial entry. The LMTS-based program's emphasis on the practice/reinforcement of marksmanship fundamentals, plus the device's capability to deliver precise aiming point and shot location feedback along with laser-supported grouping and zeroing practice, suggests the program's potential for producing a measurable payoff in terms of better trainee performance and reduced ammunition costs. As a test of this notion, USAIS provided support for research, designed and monitored by ARI, to compare the relative payoff of current BRM training with that of an LMTS-based approach. This report describes how this research was conducted, what was found, and what the implications are for initial marksmanship training as well as USAR plans to use LMTS for sustainment and prediction purposes.

## Method

### *Participants*

A total of 386 infantry trainees participated in the research as part of One-Station Unit Training (OSUT) at Fort Benning, GA. None of the participants was familiar with LTMS or had undergone any military-conducted rifle marksmanship training prior to research participation.

### *Design and Procedure*

A between-Ss, two-group, gross comparison data collection design was used with 184 trainees assigned to an experimental and 202 trainees assigned to a control group, with group assignment based on the order of trainee arrival for OSUT. The control group was trained in October of 1999; the experimental group was trained in March of 2000.

*BRM.* For this research, BRM training was restricted to the first 11 scheduled periods of instruction leading up to and including firing for qualification (i.e., record fire). Period 1 (Introduction to Basic Rifle Marksmanship and Mechanical Training) consisted of lecture-based, classroom instruction covering the history, nomenclature, operation, functioning, care and cleaning, maintenance, sight adjustment, and immediate action of the M16A2 rifle along with a brief introduction to the four fundamentals of fire (i.e., steady position, aiming, breath control, and trigger squeeze). Periods 2 and 3 (Marksmanship Fundamentals I and II) featured hands-on trigger squeeze and aiming/sight picture practice, device-based assessment of adherence to marksmanship fundamentals and shot grouping practice, a discussion of safety procedures, and dry-fire practice from the firing positions (e.g., foxhole supported and prone unsupported) to be employed later at the live-fire range. During Periods 4 (Grouping Procedures) and 5 (Zeroing Procedures), trainees were taken to a 25m live-fire range to demonstrate their ability to (a) shot group (i.e., place six consecutive live rounds within a 4cm circle located anywhere on the target), and then (b) zero their weapons (i.e., place five out of six consecutive rounds within a 4cm circle located in the middle of the zeroing target). During Period 6 (Obtain Down Range Feedback), trainees fired at E-type, paper target silhouettes placed at known distances (i.e., 75, 175, and 300 yards) to experience the influence of wind (if present) and gravity on shot location. During Periods 7 and 8 (Field Fire I and II), trainees practiced the detection and engagement of single (Period 7) and multiple (Period 8), timed-presentation, E- and F-type, pop-up, silhouette targets presented at distances of from 75-300m. During Periods 9 and 10 (Practice Record Fire I and II), trainees practiced the detection and engagement of 40 timed, single/multiple pop-ups presented at distances of from 50-300m, with (Period 9) and without (Period 10) coaching, in preparation for qualification firing on a similarly configured Remote Electronic Targeting System (RETS) range during Period 11 (Record Fire). During all but the last period, remedial training was provided on the spot to correct individual trainee shooting problems, whereas 2.5hr of reinforcement training (a USAIS term) was set aside after hours for trainees in need of special attention. (See USAIS [2000, draft] for a complete description of the tasks, conditions, and standards for each BRM period.)

*Treatment Differences.* Control and experimental group training differed in terms of the training devices used during BRM Periods 2 and 3. The control group used the dime [washer]

(100 per company) to practice trigger squeeze technique, the target/shadow box (100 per company) to practice aiming/sight picture alignment, MACS (four per company) to assess the level of trainee adherence to marksmanship fundamentals, and Weaponeer (four per company) to assess the subsequent application of these fundamentals during the simulated process of shot grouping. At the end of Period 3, control group trainees set their weapon sights to "mechanical zero" (Department of the Army, 1989, p.G-14) in preparation for live-fire grouping and zeroing during Periods 4 and 5.

The experimental group, in contrast, substituted LMTS for the above four devices. One hundred LMTS laser/target combinations were used to complete three LMTS-based exercises. Exercises 1 (Reflective Target) and 2 (Interactive Dry Fire) covered the development and refinement of marksmanship fundamentals, whereas Exercise 3 (Grouping and Zeroing) was devoted to shot grouping practice followed by weapon prezeroing with LMTS in preparation for subsequent live-fire grouping and zeroing during Periods 4 and 5 (See either Appendix A for a more detailed description of each exercise, or Commander, SATT [1999] for a complete description of the LMTS-based program of instruction.).

*Instructors.* Trainees in both groups were trained by a cadre of 12 USAIS-certified drill sergeant instructors (nine were common to both groups) from Company C, 1st Battalion, 19th Infantry Brigade (C 1/19) and a six-member cadre from the 2nd Battalion, 29th Infantry Regiment (2/29). Besides being responsible for range control, the latter operated the Weaponeer for the control group during shot grouping practice/assessment and the LMTS for the experimental group during grouping and prezeroing, whereas the former conducted all other aspects of BRM training. Both groups of instructors were trained by representatives from the 84th DIVIT and SATT on how to conduct LMTS-based training in accordance with the USAR-prescribed program of instruction.

## Results

Trainee performance was measured in terms of the number of targets hit and/or rounds fired during live-fire Periods 4-11. In general, the results favored the experimental group during grouping, zeroing, and known-distance firing (i.e., Periods 4-6) but showed no consistent advantage for either group thereafter. The specific results found for each period are described below.

### *Periods 4 (Grouping Procedures) & 5 (Zeroing Procedures).*

All trainees successfully grouped and zeroed. A count of target bullet holes revealed, however, that the control group fired about three rounds more per trainee than did experimental group trainees to achieve an acceptable shot group, $t(383) = 2.22$, and about five more per trainee to zero their weapons, $t(383) = 2.91$, with the rejection region set at $p \leq .05$ for this and all subsequent analyses[1] (see Table 1). The 5-6% experimental group advantages in the percentage

[1] Where normality and/or equality of variance assumptions were not met, both parametric ($t$-test) and nonparametric (Mann-Whitney U) comparisons were performed. The results of each were comparable in all instances. Thus, only $t$-test values are reported.

of trainees who successfully grouped within the specified 27-round standard and zeroed within the specified 18-round standard, however, were not statistically significant.

Table 1
*Grouping and Zeroing Results*

| Periods 4 & 5 | Group | |
|---|---|---|
| | Control | Experimental |
| Grouping: | | |
| Mean Number of Rounds Fired Per Trainee | 16.35 | 13.52* |
| Percentage of Trainees Firing to Standard | 87 | 92 |
| Zeroing: | | |
| Mean Number of Rounds Fired Per Trainee | 26.55 | 20.97* |
| Percentage of Trainees Firing to Standard | 49 | 55 |

$^*p \leq .05$.

*Period 6 (Obtain Down Range Feedback)*

The experimental group also outperformed the control group during known distance (KD) range firing. The control group fired a total of 40 rounds (10 at 75-, 20 at 175-, and 10 at 300-yard target distances). The experimental group, however, did not fire from 75 yards because of range modifications that were on going at the time of data collection. Therefore, only the number of target hits at the two longer distances were counted. As shown in Table 2, the experimental group scored more hits at both target distances, with $t(249)$, = 2.86, and $t(322)$ = 4.10, for the 175 and 300 yard targets, respectively. In addition, a greater percentage of the experimental group met the 14-out-of-20 hit standard at 175 yards, $\chi^2(1) = 7.90$, and the 5-out-of-10 hit standard at 300 yards, $\chi^2(1) = 17.29$. Thus, the positive impact of LMTS-based training found for experimental group grouping and zeroing performance carried over to performance on the KD range.

Table 2
*Down Range Feedback Results*

| Period 6 | Group | |
|---|---|---|
| | Control | Experimental |
| Mean Number of 175yd Target Hits | 13.34 | 14.75* |
| Mean Number of 300yd Target Hits | 4.32 | 5.38* |
| Percentage of Qualifiers at 175yd | 54 | 69* |
| Percentage of Qualifiers at 300yd | 44 | 66* |

$^*p \leq .05$.

*Period 7 (Field Fire I)*

Neither group outperformed the other on timed, pop-up target engagements during Field Fire I. As shown in Table 3, experimental and control group performance did not differ significantly in the mean number of targets hit or in the percentage of trainees meeting the 22-out-of-36 hit standard. Thus, the heretofore advantage displayed by the experimental group during grouping, zeroing, and KD firing did not carry over to the engagement of pop-up targets.

*Period 8 (Field Fire II)*

In contrast to earlier periods, the control group outperformed the experimental group during Field Fire II. As shown in Table 3, a greater percentage of the control group met the standard of 27 out of 44 targets hit on the first run[2], $\chi^2(1) = 6.45$. Control group trainees also hit significantly more first-run targets, $t(359) = 2.93$.

Table 3
*Field Fire I and II Results*

| Periods 7 & 8 | Group: Control | Group: Experimental |
|---|---|---|
| Field Fire I: | | |
| Percentage of Qualifiers | 36 | 41 |
| Mean Number of Targets Hit | 19.93 | 19.45 |
| Field Fire II: | | |
| Percentage of First-Run Qualifiers | 55* | 42 |
| Mean Number of First-Run Targets Hit | 26.90* | 24.82 |

*$p \leq .05$.

*Periods 9 (Practice Record Fire I) & 10 (Practice Record Fire II)*

Neither group consistently outperformed the other during the two scheduled practice record fire periods. As shown in Table 4, the 3% difference in first-run qualifiers (i.e., those firing 23 or more hits out of a possible 40) favoring the experimental group at Period 9 switched in favor of the control group at Period 10. These percentage differences, as well as the differences found between groups for the number of first-run targets hit, however, were not statistically reliable. It should be noted that experimental group trainees did not have the opportunity to refire during Period 9 because of the need to undergo a company-wide weapon function/safety inspection. The control group, in contrast, conducted up to four refire runs primarily for trainees unable to score at least 23 hits on their previous run(s). Interestingly, the lack of time to refire at Period 9

[2] From this period on, most trainees who did not meet the specified standard on their first run were allowed to refire. Refire performance comparisons were not made, however, because of group differences in the number/percentage of first-run nonqualifiers who actually refired.

did not adversely affect first-run experimental group performance at Period 10. There was a numerical shift in the percentage of first-run qualifiers favoring the control group, along with a significant group main effect increase in the number of first-run hits over the two periods, $F(1, 340) = 20.32$, but the Group x Period interaction for number of first-run hits was not significant ($F < 1$).

Table 4
*Practice Record Fire I and II Results*

| Periods 9 & 10 | Group: Control | Group: Experimental |
|---|---|---|
| Practice Record Fire I: | | |
| Percentage of First-Run Qualifiers | 49 | 52 |
| Mean Number of First-Run Targets Hit | 22.17 | 21.66 |
| Practice Record Fire II: | | |
| Percentage of First-Run Qualifiers | 62 | 59 |
| Mean Number of First-Run Targets Hit | 23.69 | 23.15 |

*Period 11 (Record Fire)*

As shown in Table 5, record fire qualification performance also did not differ for the two groups. Although the overall percentage of first-run qualifiers, end-of-period qualifiers, and those qualifying at the marksman level numerically favored the experimental group, neither these differences nor that for the mean number of first-run hits was significant. Thus, LMTS-based training did not produce better record fire performance than that resulting from the standard BRM program of instruction.

Table 5
*Record Fire Qualification Results*

| Period 11 | Group: Control | Group: Experimental |
|---|---|---|
| Percentage of First-Run Qualifiers | 78 | 80 |
| Percentage Marksman | 42 | 44 |
| Percentage Sharpshooter | 31 | 31 |
| Percentage Expert | 5 | 5 |
| Percentage of End-Of-Period Qualifiers | 96 | 99 |
| Mean Number of First-Run Targets Hit | 26.98 | 26.88 |

*Ammunition Count*

Although the record fire qualification performance of the two groups failed to differ, a count of the total number of pre-record fire rounds fired at pop-up targets during Periods 8-10 revealed that the control group fired 47 rounds more than the experimental group per trainee. Thus, the experimental group fired fewer rounds than the control group during training to achieve comparable record fire results. This efficiency advantage for the experimental group, however, cannot be attributed to LMTS-based training, given that the experimental group showed no performance advantage over the control group during Field Fire I (Period 7) where the number of rounds fired by trainees was still the same. The majority of the round savings occurred during Period 9 as a result of the unscheduled weapon's inspection, not as a function of differential performance of the two groups. The lack of a difference between groups on first-run Period 10 and 11 performance reveals that the extra rounds fired by the control group produced no measurable advantage and suggests these rounds may have been fired unnecessarily.

## *Discussion*

The above results show that the early segments of BRM training would benefit from the adoption of LMTS-based training. Replacement of traditionally used training devices (i.e., the dime [washer], target [shadow] box, MACS, and Weaponeer) with LMTS during Periods 2 and 3 would (a) reduce the number of rounds fired during live-fire grouping and zeroing (Periods 4 and 5), and (b) increase the number of target hits on the KD range (Period 6). Presumably, the combination of a better grasp of marksmanship fundamentals resulting from LMTS-based training, the practice/reinforcement these fundamentals with LMTS during shot grouping, and finally the opportunity to prezero weapons with LMTS before taking them to the range (see Smith & Hagman, 1999, for more on the expected benefits of prezeoing), all contributed to the reliable performance advantage displayed by the experimental group when asked to live-fire group, zero, and engage KD targets. These differences are noteworthy given the relatively limited familiarity of USAIS instructors with the LMTS-based training approach. One could, therefore, speculate that even a greater payoff would be found as instructor familiarity with LMTS, and its use during the training process, were to increase over time. Additional research is required, however, to test the validity of this notion.

The benefits of LMTS-based training, however, stopped with Period 6. That is, no LMTS-based training benefits were found once the firing of pop-up target engagements began. Consequently, group performance failed to differ at qualification, or consistently during the four pop-up target engagement periods (i.e., 7-10) leading up to qualification.

One can only speculate as to why LMTS training benefits did not carry over to pop-up target engagements. First, the additional need for trainees to detect when and where targets popped up and, then, to make the necessary aiming point adjustments before the target presentation time elapsed may have outweighed any fundamental skill benefits resulting from LMTS-based training. The lack of a robust correlation between performance on the 25m Alternative Qualification Course (Alt C) and performance on a standard pop-up target record fire course (Martere, Hunt, & Parish,1987) suggests that different skills may come into play under different targeting conditions. Thus, performance benefits found under one targeting condition may not generalize to another. Second, because problem shooters received remedial training along the way, the skill level of control group trainees may have simply "caught up" with that of experimental group trainees as time went on, thereby precluding the likelihood of findings group performance differences during the later training periods. Third, a simple count of target hits may have been too gross of a measure to identify any experimental group advantage that may have existed in the "quality" (e.g., closer to center of mass) of target hits. Fourth, and lastly, it may have simply been unreasonable to expect an LMTS training benefit with pop-up targets when this training did not include practice on pop-up target engagements. This would especially be true if the above notion that different skills are required under different targeting conditions holds merit. Development of an LMTS-based pop-up target engagement practice course is currently underway by the device's manufacturer (BeamHit, Inc.). Once completed, this course could be included within the current LMTS-based program of instruction to provide this added capability. Additional research would be required, however, to assess the impact of such a program addition, as well as to examine the validity of the other suggested explanations for the failure of LMTS-based training benefits to generalize to pop-up target engagements.

Before addressing the implications of this research, it should be noted that an alternative explanation for the finding of an LMTS-based training benefit cannot be totally ruled out. For example, because it was impossible, given safety and other operational concerns, to measure marksmanship proficiency levels before the start of BRM training, it could be argued that control and experimental group trainees simply began training with preexisting proficiency differences that carried though to create those observed during training. Use of a relatively large number of trainees in both groups, as well as the fact that consistent differences favoring one group over the other were not found throughout, however, tend to minimize the validity of this argument. This plus efforts to enforce a comparable instructor-to-trainee ratio, as well as to ensure that both groups used the same weapons, fired on the same ranges under comparable weather conditions, and were trained by the same instructor cadre (except for 3 of 12 drill instructors) also all but eliminated the potential differential impact of these additional factors on the obtained results.

## Implications

### *Initial Training*

The implications of this research for initial entry BRM training are at least threefold. First, LMTS-based training could enhance shot grouping and weapon zeroing performance, thereby reducing ammunition expenditures and associated costs. On the average, about eight rounds per trainee (i.e., three during shot grouping and five during zeroing) could be saved at a cost of $.36 per round. Thus, for a typical company of 200 trainees, the savings would be about 1,600 rounds and $576 (i.e., 200 trainees x 8 rounds per trainee x $.36 per round). Although not much for a particular company, these savings would start to add up when multiplied by total number of companies trained per year (i.e., 89 in 1999, and a projected 128 for 2000) (LTC G. Davis, personal communication, May 9, 2000) at Fort Benning. In addition, even greater savings might be realized as instructors become more familiar with LMTS and as an LMTS-based pop-up target engagement training capability is added to the BRM program of instruction. The latter might also have a favorable impact on ammunition expenditures during pop-up target engagement practice and enhance qualification scores.

Second, because LMTS-based training was found to "work" when LMTS was used *in place of* traditional devices, it should also work (perhaps even better) if LMTS were used *in addition to* these devices. Of course, the cost of such an augmentation approach would be a primary concern. It's possible, however, that the dime [washer], for instance, could continue to be used as a handy tool for concurrent training conducted at the company area, or for remedial training conducted at the company area or at the range, without an associated cost hike. Using LMTS along with Weaponeer (at a cost of around $40,000 per device), however, might be a different matter. In any event, the notion of augmenting LMTS with at least some of the devices currently in use would seem to merit future consideration if, or when, a decision is made to adopt an LMTS-based training approach.

Third, it is likely that the number of pop-up target rounds fired during Periods 8-10 of the current BRM training program could be reduced even without the introduction of LMTS-based training. The finding that the additional rounds fired by the control group during Period 9 (Practice Record Fire I) did not produce better first-run Period 10 performance, relative to that of the experimental group, certainly suggests that round reductions may be possible. Of course, follow-up research targeted to address this specific issue would be required to provide a more definitive conclusion.

*Sustainment Training*

The results of the present research should also encourage the USAR to proceed with its LMTS-based sustainment training program development and evaluation efforts for several reasons. First, given that LMTS-based training was found to work for initial training, it is likely to also work for sustainment training, although the yet-to-be-determined magnitude of payoff may not be the same. At the very least, the notion of using LMTS for sustainment training is worthy of further pursuit. Second, LMTS-based training should minimize the time and ammunition required to shot group and weapon zero. Given that grouping and zeroing typically consume much of the range time set aside for qualification firing, and that training and evaluation time is always in short supply for USAR units, greater grouping and zeroing efficiency should be a welcomed plus. Third, and lastly, because most USAR soldiers fire the 25m Alternate Qualification Course, their record fire scores should improve as a result of LMTS-based training, given that additional detection and aiming adjustment skills required on the pop-up target range would not be required with the stationary, KD, Alt-C target.

## Future Research

The next steps of the current LMTS-based training program evaluation plan call for research designed to answer questions about the magnitude of program impact on USAR soldier sustainment performance and the ability to predict live-fire qualification scores from LMTS-based scores on a simulated Alt-C course of fire. While data collection is underway to answer both of these questions, recent findings suggest that the answer to the prediction-related question is yes (Smith & Hagman, in preparation). This means that LMTS can not only be used for sustainment training, but also to (a) identify which soldiers are in need of it (i.e., those predicted not to live-fire qualify), (b) determine when enough has been provided (i.e., when successful qualification is predicted), and (c) support device-based qualification, as an alternative to live-fire qualification, when range facilities are not readily available. Of course, the notion of shooting record fire on a device instead of on a range is still controversial. But if, and when, the time comes for its acceptance, the USAR will have already laid the groundwork for its successful implementation.

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*Appendix A*

*LMTS-Based Training Exercises*

*Exercise 1: Reflective Target*

This exercise is designed to assess the degree to which trainees can properly apply the fundamentals of rifle marksmanship while dry firing their weapons. Trainees take a prone supported position (employing sandbags) and, using their own weapons equipped with an LMTS laser insert, fire at an actual-size reflective version of the 25m Zeroing Target. This target enables an instructor (and the trainee) to view, at 25m, the location of laser impact, thereby providing immediate feedback concerning the adequacy of firing position steadiness, sight picture alignment, breath control, and trigger squeeze. These four fundamentals can be evaluated with the laser transmitter in either a constant-on or trigger-activated mode of operation.

*Exercise 2: Interactive Dry Fire*

This exercise is also fired from the prone supported position, but the target is changed from a reflective to a laser-sensitive TR-700 (Figure A-1) capable of sensing and counting the number of laser hits and sending back an associated visual and auditory signal to the shooter. Trainees fire at the target in sets of 10 rounds, with 8 hits on 2 successive iterations required for a "GO." In addition, a Military Mask Set of silhouettes can be superimposed on the target to reduce the targeting area and thereby simulate targets at distances of up to 600m.

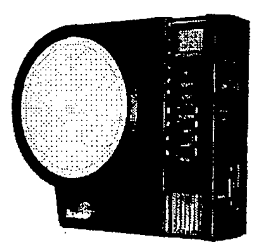

Figure A-1. TR-700 target.

Exercise 3: Grouping and Zeroing

For this exercise, trainees again fire from a prone supported position using their own weapons equipped with a laser insert. A computer-linked, LMTS TR-900 laser-sensitive target (Figure A-2) is used with superimposed 25m silhouettes that dimensionally replicate the 25m Zeroing Target. The computer is used to detect the precise point of impact of each laser round and to calculate center of mass and maximum round dispersion.

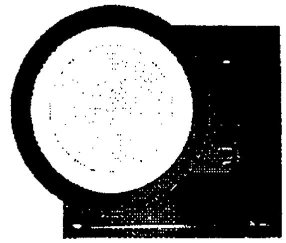

Figure A-2. TR-900 target.

In the grouping phase of the exercise, trainees are allowed to fire up to 27 rounds in 3-round shot groups. Satisfactory grouping is demonstrated when two consecutive 3-round shot groups fall within a 4cm circle located anywhere on the target. If trainees fail to meet this standard, they are sent to a remedial station and then permitted to return later to start anew on the grouping exercise.

Once satisfactory grouping is demonstrated, trainees adjust their sights to bring shot placement within a 4cm circle located in the middle of the target. Trainees fire 3-round shot groups (up to a maximum of 18 rounds), adjusting sights as necessary between groups. When a shot group falls within the 4cm circle, they fire an additional shot group for confirmation. Zeroing is satisfactorily demonstrated when at least five of the six rounds in two consecutive 3-round groups fall within the 4cm circle.

*Remedial Training*

Remedial training, consisting of a systematic check of trainee ability to apply the four fundamentals of marksmanship during the integrated act of firing, begins with a weapons serviceability check and proceeds to an evaluation of the trainee's firing position, sight picture alignment, trigger squeeze technique, and breath control procedure. Once the instructor is satisfied that the trainee understands these four fundamentals, he or she is asked to demonstrate their application using the reflective Zeroing Target.

Depending on the judgment of the instructor, the trainee may then be re-entered into the formal program at either Exercise 2 or 3. Theoretically, trainees may be pulled from the training exercise sequence any number of times, although the evaluative and corrective procedure is designed to produce problem recognition and remediation in one coordinated session.