Research Report 2006

Reliance on Simulation in Initial Entry Rifle Marksmanship Training and Future Directions for Simulation

Jean L. Dyer
Consortium of Universities of Washington

Louis C. Miller, and Victor J. Ingurgio
U.S. Army Research Institute

Blake Ledford, and John T. Miller II
Consortium of Universities of Washington

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14. ABSTRACT

This report summarizes the impact on marksmanship performance in Initial Entry Training when the reliance on simulation increased and live-fire decreased. Two Infantry One Station Unit Training platoons received increased simulation training via a drill based-program called Test-D. The Test-D platoons had five days of simulation training and two live-fire periods (zeroing and practice record fire). Two Baseline platoons executed the current marksmanship training, which had four live-fire periods (including zeroing and practice record fire), two days of Engagement Simulation Training, and a day of dry-fire. The comparison was conducted during training with iron sights. On the two criterion measures, the percentage of Soldiers who zeroed on their initial attempt and the score on the first practice record fire, the Baseline platoons performed significantly higher than the Test-D platoons. Primary explanations for the Test-D findings were the grouping target in the simulation, inconsistent application of the drills, lack of formal systematic monitoring of Soldier performance, and Soldiers' lack of confidence in weapon handling and shooting skills with their personal weapon. Recommendations are made for improving the training features and increasing the accuracy requirements in future marksmanship simulations in order to substantially impact the skill level of novice firers.

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Scott Graham, Chief

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RELIANCE ON SIMULATION IN INITIAL ENTRY RIFLE MARKSMANSHIP TRAINING AND FUTURE DIRECTIONS FOR SIMULATION

EXECUTIVE SUMMARY

Research Requirement:

Historically, most marksmanship simulation/device research in initial entry training has examined the effectiveness of devices in some combination with live-fire. In addition, the simulation applications have been for preparatory stages of training, for remedial training, for a specific training exercise, or to supplement live-fire. The current research was considered exploratory as simulation training replaced all but two required live-fire days --- zeroing the M4 carbine and firing practice record fire (PRF). Simulation training was used for the other five days. The approach was a substantial deviation from previous research and applications of simulation in initial entry marksmanship training, and was an initial step in determining how to best apply simulation training extensively in this context. The Directorate of Training and Doctrine (DoTD), Maneuver Center of Excellence (MCoE), Fort Benning, GA initiated the effort, and requested that the U.S. Army Research Institute (ARI) for the Behavioral and Social Sciences at Fort Benning, GA develop the data collection tools, collect and analyze the data, and report the findings.

Procedure:

A drill-based, simulation training program (herein referred to as Test-D) was compared to the baseline or current marksmanship training program during the M4 carbine / back-up iron sight phase of training in an Infantry One Station Unit Training (OSUT) company. The research was conducted in February - March 2016, with two platoons receiving the Test-D simulation training (Test-D platoons) and two platoons receiving the current rifle marksmanship program of instruction (Baseline platoons). All platoons had to execute weapon zeroing and PRF via live-fire. As stated, for the Test-D platoons simulation training was used for the other five training days. For the Baseline platoons, the other five days of training consisted of two days of Engagement Skills Trainer (EST) 2000 training, one day of dry-fire, and two days of live-fire (confirmation of zero, and engaging multiple and single targets). Test-D platoon training was executed by Drill Sergeants (DSs) and contractor personnel; Baseline platoon training was executed by DSs only. All training periods were observed and performance measures were recorded.

Findings:

On the two primary criteria (zeroing and PRF), the Baseline platoons' performance was significantly better than the Test-D platoons' performance. More Soldiers in the Baseline platoons zeroed initially (77% vs. 54%) and they averaged 4 points higher on the first PRF. In terms of marksmanship qualification categories on PRF, more Soldiers in the Baseline platoons

scored as Sharpshooters compared to the Test-D platoons (31% vs. 14%, respectively), and fewer Soldiers scored as Unqualified (23% vs. 46%, respectively).

Primary explanations for the zeroing results for Soldiers in the Test-D platoons included inconsistent application of the Test-D drills, Soldiers not held to an objective standard for grouping/zeroing, and Soldiers not exposed to the standard Army zero target in the training session prior to zeroing. Primary explanations for the Test D platoons' PRF results were no live-fire confirmation of zero, inconsistent application of the simulation drills, no embedded training or instructional system to formally monitor Soldier progress, skill progression primarily by firing order rather than by individual proficiency, and Soldiers' lack of confidence in skills with their personal weapon because of limited live-fire practice. Baseline platoon Soldiers were more confident in their weapon handling and shooting skills.

Utilization and Dissemination of Findings:

The findings were presented to the DoTD in the MCoE and to the participating company's chain of command at the battalion and brigade levels. The DoTD forwarded the findings to the Training and Doctrine Command (TRADOC) agencies involved in simulations. Important and some unexpected lessons were learned regarding the challenges presented when simulation is the primary means of training rifle marksmanship for initial entry training Soldiers. The critical role of the trainer in developing marksmanship skill, with or without simulation capabilities, was also reinforced by the research findings. General recommendations were made for future training when simulation is used extensively with novice firers. Similarly, recommendations were made regarding improving the training features of and the accuracy requirements in future marksmanship simulations, if simulation is to have a substantial positive impact on Soldier marksmanship skill. Research is needed to address these design issues and determine their impact on Soldiers' preparation for live-fire.

RELIANCE ON SIMULATION IN INITIAL ENTRY RIFLE MARKSMANSHIP TRAINING AND FUTURE DIRECTIONS FOR SIMULATION

CONTENTS

CONTENTS (continued)

Reliance on Simulation in Initial Entry Rifle Marksmanship Training and Future Directions for Simulation

Introduction

This report summarizes the major findings from an exploratory assessment of the application of simulation in all but two of the first seven periods in initial marksmanship training. Recommendations are made regarding future training with simulations, and on research needed to improve training features and to raise the performance requirements embedded in marksmanship simulations. The assessment was the first time that a heavy reliance had been placed on simulation as the primary means of marksmanship training. It deviated substantially from prior marksmanship research conducted since the 1980s where training devices/simulations were combined with live-fire[1]. The Directorate of Training and Doctrine (DoTD), Maneuver Center of Excellence (MCoE), Fort Benning, GA initiated the effort, and requested that the U.S. Army Research Institute (ARI) for the Behavioral and Social Sciences at Fort Benning, GA develop the data collection tools, collect and analyze the data, and report the findings. The simulation used was a drill-based system, referred to as Test-D in this report.

This report describes the training that was executed and provides possible explanations for the findings. The research findings and prior simulation research led to the recommendations regarding the embedded software in future marksmanship simulation systems.

Method

Training Concept/Plan

The rifle marksmanship (RM) training was conducted in February and March of 2016 with an Infantry One Station Unit Training (OSUT) company at Fort Benning, GA. The research compared two platoons trained with the Test-D training program (Test-D platoons) to two platoons trained with the current marksmanship program of instruction (Baseline platoons). The research and training period covered only back-up iron sight (BUIS) training, not training with the close combat optic (CCO) which followed BUIS training. In summary, only the RM1 through RM7 periods were in the assessment. During the following RM8 through RM18 training periods with the CCO, all Soldiers received the same training. Although these periods were not in the assessment, record fire scores were obtained.

Table 1 shows the planned schedules for the Test-D and Baseline platoons. There were three common periods of instruction for the Test-D and Baseline platoons. These were preliminary marksmanship training (RM1), 25m live-fire zero (RM3) and Practice Record Fire (RM7). Test-D simulation training was used in all the other RM periods. In contrast, the Baseline platoons conducted live-fire for the RM4 and RM6 periods, and the Engagement Skills Trainer (EST) 2000 was used for RM2 and RM5 periods. Modifications were required to this schedule once the training started and are described in the Results section.

[1] Refer to Appendix D for a summary of prior marksmanship research with simulations/training devices.

Table 1
The Planned Marksmanship Training Schedule

Day/RM Period	Baseline Platoons	Test-D Platoons
0 / RM1	Preliminary Marksmanship Training	Same as Baseline
1 / RM2	EST 2000 (grouping/zeroing)	Test-D Drills
2 / RM3	Dry-Fire Training	25m Live-Fire Zero
3 / RM3a	25m Live-Fire Zero	Test-D Drills
4 / RM4	Confirmation of Zero (40 rds/Soldier)	Test-D Drills
5 / RM5	EST 2000 (singles and multiples)	Test-D Drills
6 / RM 6	Live-Fire (singles and multiples) (80 rds/per Soldier)	Test-D Drills
7 / RM7	Practice Record Fire (live-fire)	Same as Baseline

Notes. RM1 is labeled as "Day 0" as it came almost two weeks prior to the start of RM2 training.

As shown in Table 1 there were three periods of instruction which were the same for the Test-D and Baseline platoons. RM1 was conducted in a 200-person classroom for all Soldiers in the Company. It consisted primarily of PowerPoint slides covering such topics the Soldier's weapon, types of ammunition, safety procedures, and fundamentals of marksmanship. The 25m live-fire zero was conducted on a 25m range. Five-round shot groups were used and Soldiers were to zero within 40 rounds. RM7, practice record fire, was conducted on a record fire range using the record fire scenario shown in Appendix B, Figure B1. The same scenario was used for all qualification scenarios with the CCO. More information on the Test-D training drills and the Baseline platoon training are presented in the next two sections.

The planned CCO training in RM8 through RM18 included introduction to the CCO, zeroing the CCO, confirming zero at distance, engaging single and multiple targets, barrier shoots, engaging moving targets, practice qualification, and record fire qualification. All periods were live-fire.

The Test-D Training Drills

The Test-D simulation equipment was set-up to train a maximum of 15 Soldiers simultaneously per classroom. The simulation scenes and targets were projected on a series of large screens, and targets were scaled in size to simulate the distance from the Soldiers' firing line. Soldiers fired an untethered gas-powered weapon with a built-in laser. The Test-D equipment was set-up in three separate large classrooms in the brigade building.

The Test-D training program had a wide variety of rapidly executed drills and exercises, which focused on different marksmanship skills. Switching from one drill to another was easy and quick. The drills were typically short, and therefore could be repeated several times within a brief period of time. The specific drills selected were those determined to be most appropriate for initial entry Soldiers. Test-D contractor personnel recommended a set of drills, but the final set was determined in coordination with the OSUT unit participating in the assessment. The

drills selected for the most part stressed basic rifle marksmanship fundamentals appropriate for trainees, many of whom had never fired a rifle.

The drills were categorized into nine major types:

- grouping and zeroing drills,
- distance from center drill (measure of firing accuracy following grouping and zero calibration),
- known distance (KD) drills (untimed) using E-silhouettes at 100, 200 and 300 yards,
- record fire (RF) tables (prone supported, prone unsupported and kneeling),
- timed drills at a 200 yard E-silhouette target,
- drills with the Alternative C qualification course target (Alt C drill),
- sight reference drills which focused on target discrimination and proper sight alignment,
- moving target drills (simulated the vertical drop of a silver dollar), and
- sight relief drills designed to teach Soldiers how to maintain the same eye relief on the weapon no matter what firing position was assumed.

Soldier competition could also be incorporated in some of these drills. Each variation within a drill category was treated as a different drill. For example, each RF table (i.e, each firing position) was considered a separate drill; all three tables did not need to be executed at the same time. Thus, the DS/trainer could focus on one position or set of targets more than another, if desired. Also a competitive option for a drill was considered a separate drill. The drills are described in more detail in Appendix A.

The grouping drill was used daily prior to system calibration of weapon zero. Soldiers did not adjust their BUIS in order to zero; the system calibrated their zero once grouping was satisfactory. The distance from center (accuracy) drill was designed to verify the zero calibration of the weapon before continuing to other drills. Because the grouping and distance from center drills were used frequently, the target images for these drills are shown in Figure 1.

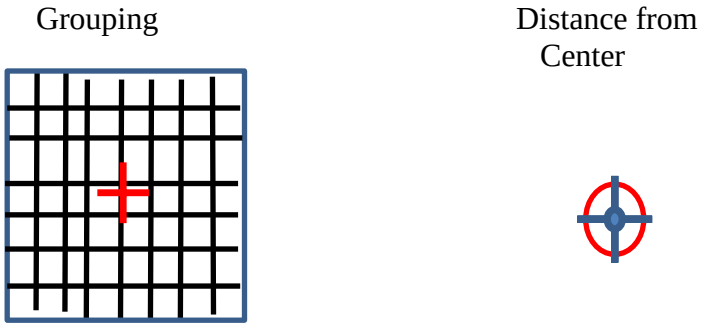


Figure 1. Illustrations of the target images for grouping and distance from center (accuracy) drills. [The images are not the actual images shown to the Soldier, nor are they to scale.]

Except for application of the grouping and distance from center drills on the first day of Test-D training (see Appendix C, Table C1), which preceded live-fire 25m zero (RM3), there was no direct relationship between the drills and the RM periods of instruction as presented

previously in Table 1. The focus was on the contribution of drills to success in PRF, and the record fire drills replicated that scenario. There was no drill which "substituted" for live-fire confirmation of zero (RM4), nor were there drills which paralleled the singles and multiples tables (RM5 and RM6). KD drills, used historically in rifle marksmanship, were included. Also the Alt C drill corresponded to a dry-fire exercise incorporated in the Baseline platoons' training. However, the sight reference, eye relief, and silver dollar drop drills did not correspond to any of the RM2 through RM7 marksmanship periods (see Table 1). Consequently, the Test-D training program differed from what has been done historically, where simulations replicate parts of live-fire training (see Appendix D).

The Specific Baseline Platoon Training Periods

The rifle marksmanship training prior to live-fire 25m zero for the Baseline platoons consisted of EST 2000 training and dry-fire training (RM2 and RM3, see Table 1). The EST 2000 is a marksmanship simulator. In the EST, Soldiers use a simulated weapon with an integrated laser, not their own weapon, and engage simulated targets. RM2 training in the EST is on grouping and zeroing where Soldiers fire at a graphic of the standard 25m zero target. The criterion for grouping is to achieve two consecutive shot groups in a 4cm circle within 15 rounds. Once grouped, an automatic zeroing routine is then run on the EST 2000 which aligns the Soldier's group with the 4cm circle on the target (Soldiers cannot adjust their sights in the EST 2000 to achieve a zero). Then Soldiers must 'zero' by achieving two consecutive shot groups in the designated 4cm circle on the target within 15 rounds. If Soldiers do not meet the criterion, they must reshoot until the criterion is achieved. The EST accommodates a maximum of 15 Soldiers at a time (the same number of firing lanes as the Test-D equipment). Each Baseline platoon was assigned to a separate EST classroom.

Dry-fire training is all non-live-fire. It consists of exercises to facilitate skill with trigger control, breathing, sight picture, weapon stability, different firing positions (prone supported, prone-unsupported, kneeling), using ballistic eye protection, weapon safety, malfunction procedures, etc. For example, the dime-washer exercise is used to practice trigger control and reinforce body positions and breath control. A dime or washer is placed on the barrel of the weapon and the Soldier must fire (pull the trigger) six consecutive times without the dime or washer falling to the ground.

RM4, confirmation of 25m zero, involves checking the adequacy of sight adjustments made at 25m meters by live-firing at distance (e.g., 100, 200, or 300m). Any necessary fine-tuning of the Soldier's zero settings is made at this time.

Shooting at single and multiple pop-up timed targets, in either the EST (RM5) or with live-fire on a range (RM6) is when Soldiers are exposed to timed targets. Only single targets are presented first and with longer exposures than in record fire. Then multiple-exposure targets (two targets) are incorporated to increase marksmanship difficulty. Exposure times are also longer than the double-exposure targets in record fire. These scenarios are documented in the marksmanship FM (FM 3-22.9, DA, 2008). The EST scenarios are the same as live-fire scenarios.

Data and Data Collection Procedures

The primary performance measures of interest to the DoTD were: scores and marksmanship categories on Practice Record Fire (PRF, RM7), percentage of Soldiers who zeroed their BUIS at 25m, ammunition consumed (RM2-RM7), and training time. The program of instruction called for only one execution of PRF, but the participating company conducted two iterations.

Additional data were collected to obtain performance results during the BUIS marksmanship periods, to describe the training, and to help explain the performance results. These data included: the number of rounds each Soldier used during 25m zeroing, Soldier surveys at the end of both RM7 (PRF) and RM18 (record fire [RF]), surveys of and a focus group with the DSs who executed the Test-D training, digital performance records from the Test-D system, all Baseline platoon training scores, training observations and records of each training period for both the Test-D and Baseline platoons, and observations of DS preparation on the Test-D training program. This DS preparation occurred for five days during the week prior to the start of the marksmanship training (i.e., RM2). Lastly, record fire scores and marksmanship categories at the end of rifle marksmanship training (RM16-18, RF with the CCO) were examined.

Two ARI researchers were assigned to the Test-D platoons and two to the Baseline platoons, although a fifth researcher was sometimes required to obtain all the data. The Test-D training occurred in three rooms, but only two of the three rooms could be observed. There were approximately 30 Soldiers in each room, who formed two firing orders of 15 each. For the EST training with the Baseline platoons, each platoon was assigned to a separate room with an ARI researcher in each room. Two researchers collected the live-fire data for RM4 and RM6. Five researchers obtained 25m zero data for the Test-D platoons and three researchers obtained 25m zero data for the Baseline platoons. Four researchers obtained the RM7 (PRF) and RM16-18 (RF) data, and administered the Soldier surveys.

Participants

The initial number of Soldiers in the Test-D platoons was 87. It was 86 for the Baseline platoons. On final record fire with the CCO, there was some attrition of Soldiers, with 78 in the Test-D platoons and 81 in the Baseline platoons.

Training Personnel

The DSs were those assigned to the respective platoons in the company. There was no effort to assess differences in DS experience or account for any other differences.

The Test-D personnel used the preparation week to expose DSs to the variety of drills. In addition, the DSs and Test-D personnel determined the drills to use, and the protocols for executing the training (e.g., simulating range safety procedures). Not all DSs assigned to the two Test-D platoons could attend every day of this training, as they were needed to train the OSUT

Soldiers on other skills during this period (land navigation, CBRN [chemical, biological, radiological, and nuclear], mines, and communication). Also due to a limited number of DSs, both Test-D personnel and DSs served as trainers. Training on a remedial training station, for Soldiers identified as having marksmanship problems, was conducted only by Test-D personnel.

Baseline platoon training was conducted by the DSs assigned to the two Baseline platoons. The only exception was that during the EST periods, government-contracted civilians operated the EST system, while DSs monitored the Soldiers and provided remedial assistance as needed.

Results[2]

Zeroing Results

More Baseline Soldiers zeroed in the initial 25m zero period (RM3a) than Test-D Soldiers (RM3) (76% for Baseline platoons vs. 59% for Test-D platoons). Also a higher percentage of Baseline Soldiers achieved their initial zero within the 40-round criterion (68% for Baseline platoons vs. 41% for Test-D platoons). Zeroing details are in Appendix B, Table B1.

The low percentage of Soldiers who zeroed in the Test-D platoons impacted the remaining marksmanship training. To get all Soldiers in the Test-D platoons zeroed, changes were required to the schedule as outlined previously in Table 1. Non-zeroed Test-D Soldiers returned to the 25m range and joined the Baseline platoons during their initial 25m zero (RM3a). Because not all of these Test-D Soldiers were able to zero on this second attempt, a final zero session was held for these Soldiers during RM6. In this last session, not all Test-D platoon Soldiers were able to zero because some were not able to fire due to time and ammunition constraints. When these Test-D Soldiers were attempting to zero again, they were not in Test-D training, which was a change from the scheduled training outlined in Table 1.

Having Soldiers from both groups firing during the 25m zero period for the Baseline platoons also impacted the zero results for the Baseline Soldiers. Although the Baseline platoon Soldiers were given priority, time and ammunition had to be allocated to the non-zeroed Test-D Soldiers. As a result, not all Baseline Soldiers were able to zero during this initial period (RM3a).

Three other changes were required to the Baseline training schedule because not all Soldiers in the Baseline platoons zeroed initially at 25m. First, only the Soldiers in the Baseline platoons who had zeroed initially at 25m were able to confirm zero at 200m during RM4. Second, for RM4 the unit had the range for only half a day, and thus could not zero the Soldiers who had not zeroed at 25m during this confirmation of zero period (RM4). Dry-fire training was conducted during the remainder of the day. Third, the Baseline platoon Soldiers who had not zeroed initially, attempted to zero during RM6. As with the Test-D platoon Soldiers, not all zeroed as some did not fire during RM6 because of time and ammunition constraints.

[2] Complete data tables are in Appendix B.

Table 2 presents the training schedule as executed, starting with RM2. Deviations from the planned schedule (Table 1) are in italics in Table 2. Prior to PRF (RM7), 87% of the Soldiers in each group had zeroed. Company personnel indicated that not getting everyone zeroed in RM3/3a was an atypical result.

Table 2
The Revised Training Schedule

Day/RM Period	Baseline Platoons	Test-D Platoons
1 / RM2	EST 2000 (grouping/zeroing)	Test-D Drills
2 / RM3	Dry-Fire Training	25m Live-Fire Zero
3 / RM3a	25m Live-Fire Zero	Test-D Drills *//25m Zero*
4 / RM4	Confirmation of Zero for Soldiers who Zeroed*// only ½ day; dry fire for ½ day*	Test-D Drills
5 / RM5	EST 2000 (singles and multiples)	Test-D Drills
6 / RM 6	Live-fire (singles and multiples) *// 25m Zero*	Test-D Drills *//25m Zero*
7 / RM7	Practice Record Fire (live-fire)	Same as Baseline

Note. Changes in italics after the "//" indicate the changes in scheduled training for some Soldiers.

Possible Explanations for the Zeroing Results

It is not possible to definitively say what caused the 25m zero results, or whether there was a single factor or multiple factors. Possible explanations are provided below.

Inconsistencies in Test-D training. Three drills focused on grouping and zeroing (grouping-prone supported, grouping-kneeling, and distance from center). Although these drills were executed the day prior to 25m zero live-fire, many other drills were also executed (see Appendix C, Table C1). The number of repetitions of the drills varied from room to room and the number of repetitions by each firing order within a room also varied (see Appendix C, Table C1). Also no relationship was found between drill and live-fire performance (see Appendix B, Table B10).

Standards for grouping and zeroing not applied. The Army standards for grouping and zeroing (i.e., two consecutive shot groups within a 4cm circle; for 5-round shot groups this means 4 out of 5 rounds followed by 4 out of 5 rounds in the 4cm circle) were not applied in the drills conducted by the Test-D platoons.

Failure to expose Test-D Soldiers to the standard Army target before live-fire. Soldiers were not exposed to the standard Army zero target before live-fire zeroing (see Figure 2). Although the standard target is not necessary to group, failure to expose the Soldiers to this target could have resulted in negative transfer to the live-fire zero range. Anecdotal information from the DSs indicated that often Test-D Soldiers could group, but did not have a consistent point of aim. Practice with the standard 25m target could have reduced this problem. That

Soldiers have difficulty zeroing with the BUIS is not new. They have problems determining center of mass on the 25m zero target (black front sight post against a black silhouette), and do not aim consistently. Figure 2 shows examples of two "marked-up" targets from prior ARI research efforts, illustrating how trainers mark targets with additional lines to clarify the location of center mass and where Soldiers should aim.

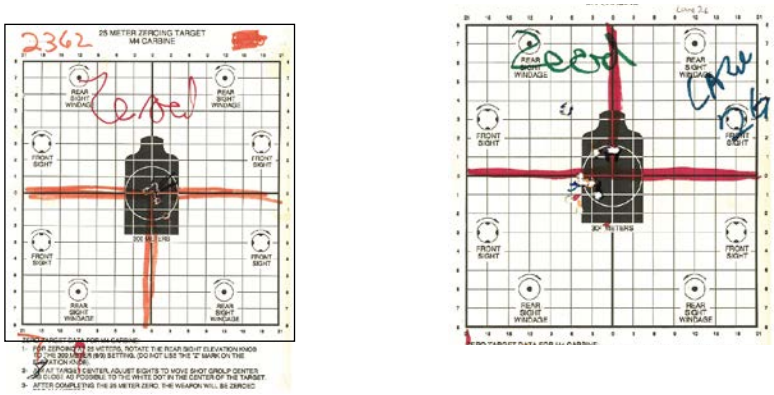


Figure 2. Examples of marked-up 25m zero targets from prior marksmanship research.

Too many Soldiers in a firing order. Fifteen Soldiers in a firing order during the drills made it difficult to determine who needed assistance with firing positions and other fundamentals of shooting. The Soldiers were very close to each other, which inhibited DSs' ability to monitor individual Soldiers. This is not unique to the Test-D simulation training, but the effects may have been exacerbated by the other factors cited here.

Feedback on individual performance was limited. Individual differences were not formally addressed via feedback provided from the drill displays or permanently recorded in the system for use by the DSs. Lack of a formal feedback system, including a "roll-up of Soldier performance" made it impossible for a DS to review the status of Soldiers after a series of drills or at the end of a day to determine relative status and who needed help vs. who was performing well. Lack of a formalized feedback system also limited Soldiers' full understanding of their progress over time.

Practice Record Fire (PRF - RM7) Results

Although the company fired two iterations of PRF, the program of instruction specified only one. The scores from the first iteration were considered the best measure of training effectiveness as this iteration directly followed the training. On the other hand, the second iteration reflected not only the training but also any additional skills gained from the live-fire experience of the first iteration of PRF.

Baseline platoons had significantly higher scores on the first iteration of PRF (RM7) than the Test-D platoons (Table 3). These means were 26.96 for the Baseline platoons and 23.03 for the Test-D platoons. The Baseline platoons had 23% more Soldiers who qualified (77% in the

Baseline platoons vs. 54% in the Test-D platoons). The differences between the two groups was reflected in the relative percentage of Sharpshooters and Unqualified Soldiers.[3] On the first iteration, the percentage of Test-D Soldiers who were Unqualified was twice that of the Baseline platoons (46% vs. 23%, respectively). However, the percentage of Sharpshooters in the Baseline platoons was more than double that in the Test-D platoons (31% vs. 14%, respectively). Table 3 presents the results on the first iteration. Similar results occurred on the second iteration (see Appendix B, Tables B2 and B3 for the second iteration). PRF results were based on only the Soldiers who had zeroed; those who had not zeroed were eliminated from the analyses.

Table 3
Practice Record Fire (RM7) Results: First Iteration (zeroed Soldiers only)

	#	Score		Marksmanship Categories [b]			
Group	Soldiers	Mean [a]	SD	% UQ	% MM	% SS	% EX
Test-D	70	23.03	6.80	46%	37%	14%	3%
Baseline	70	26.96	5.70	23%	40%	31%	6%

[a] t (138) = 3.68, p = .0003.
[b] χ^2 (3) = 10.07, p = .014.

Performance on the three PRF positions was also examined because DSs and trainers used the Test-D drills to conduct more training in the kneeling position. The expectation was that the Test-D Soldiers might outperform the Baseline Soldiers in the kneeling position. However, the Baseline platoons scored significantly higher in every position on each iteration, except for kneeling on the second iteration (see Appendix B, Table B4). In addition, Soldier surveys showed a trend for more Baseline Soldiers (58%) to be confident in the kneeling position than Test-D Soldiers (50%). Again, this was not expected. In contrast to the kneeling confidence ratings, Soldier surveys indicated that at least 80% of all Soldiers were confident in their prone supported and prone unsupported positions.

The DSs provided insights into the Test-D results. They indicated the closeness of the Soldiers in the firing order often prevented Soldiers from getting into a good firing position. In hindsight, they thought the firing orders should have had 9 to 10 firing points rather than the 15 that were typically used. DSs indicated that some Soldiers used the alternate prone supported position, where one leg is bent. For kneeling, Test-D trainers focused on using the pistol grip for stability; DSs preferred using the forehand as well. The DSs indicated they made adjustments to the firing positions of some Soldiers from the Test-D platoons during CCO training.

[3] Marksmanship category definitions: Expert 36-40; Sharpshooter 30-35; Marksman 23-29; Unqualified – below 23.

Training for Practice Record Fire

This section summarizes the training the platoons received after their initial 25m zero period and prior to PRF. In addition, the relationships between training scores and PRF scores are documented. The training times for the two groups of Soldiers were similar (see Appendix B, Table B5).

Test-D platoon training as executed. After the initial 25m zeroing period, Soldiers in the Test-D platoons executed four days of training with the Test-D drills. The exceptions to this were the two days when the non-zeroed Soldiers attempted to finally achieve zero on their weapon (see Table 2). Inconsistencies in the Test-D platoon training occurred during these four days of training (Appendix C, Tables C2 through C5). Table 4 is a snapshot of what occurred. It presents a sample of the drills and the number of repetitions of the drills in each room by training day (the number of the day in the first column of Table 4 corresponds to the day cited in Table 1). Although only a snapshot, Table 4 illustrates the inconsistencies in execution of the drills within a room and across rooms.

The overview in Table 4 also shows that the drills executed did not directly correspond to the training sequence in the RM program of instruction. However, there was a tendency to shift to the RF scenarios, including the Alt C drill, as the training progressed and to conduct fewer grouping drills.

Table 4
Number of Repetitions for a Sample of the Drills Executed in Each Room (A, B, and C) by Each Training Day After 25m Zeroing

	Drill						
Day - Room	Group Prone	Group Kneel	KD 200	PS RF	Kneel RF	Alt C	Sight Ref 1
3-A	**10**	2	3	1	2	1	1
3-B	**13**	2	3	---	1	2	8
3-C	---	3	---	---	**5, 6**	4	2
4-A	**3, 7**	2	1, 2	---	---	4, 5	---
4-B	**3**	1, 2	1	1	---	---	2
4-C	0, 1	4	0, 1	2	**5, 9**	4, 6	1, 2
5-A	**4**	---	2	1	2	2, 3	1
5-B	1, 3	**2, 6**	1	0, 1	0, 2	1, 3	1
5-C	---	**11, 15**	---	0, 2	4, 7	2, 7	1, 2
6-A	---	1, 2	**11**	3	4	8	1
6-B	1, 3	3, 4	---	3, 4	5	**6, 7**	2
6-C	---	2, 3	1	**2, 9**	---	2, 6	0, 1

Note. Highest number of repetitions in each room on each day is in boldface. When more than one number is presented, the number of repetitions differed for the two firing orders. A "---" in a cell means that the referenced drill was not executed in that room on that day.

The drill labels in Table 4 refer to the following drills.

Group Prone: Grouping drill from prone position
Group Kneel: Grouping drill from kneeling position
KD 200: KD drill – 200yd target
PS RF: Prone supported position in record fire course
Kneel RF: Kneeling position in record fire course
Alt C: Alternative C drill
Sight Ref 1: Sight reference level 1 drill

One explanation provided by DSs for the discrepancies in drill execution was that it was a matter of personal preference. Another possible explanation relates to the challenge of conducting the Test-D simulation training over four days. There were many drills that could be and were used, but it was not known a priori how long it would take novice Soldiers to learn the associated skills, nor what sequence of drills would work best. So the choice of drills on a given day could easily have been a judgement call on part of the DSs/trainers given the marksmanship status of the Soldiers in each room.

In addition, the rotation of Soldiers was typically by firing order instead of individual proficiency. As understood by the authors of this report, the Test-D training was the only marksmanship training (except for the required 25m zeroing) that the Soldiers received prior to PRF (e.g., no dry-fire training).

Baseline platoon training as executed. The Baseline platoon training after the 25m zero is shown in Table 2. Because of time restrictions on the range, only Soldiers who zeroed at 25m confirmed zero at 200m (RM4). Dry-fire was also conducted on this day. The EST training (RM5) was executed to standard and all Soldiers successfully met the criteria for the singles and multiple tables (see Appendix B, Table B6 for means). One iteration of the record fire scenario was also executed for familiarization in the EST. All Soldiers who zeroed fired the single and multiple target tables via live-fire (RM6). If they did not meet the criterion, they did not fire again as there was limited live-fire ammunition and range time. Instead, they were directed to execute dry-fire practice on the range. Lastly, those Soldiers identified as having problems with the live-fire multiple target scenario fired one iteration of the practice record fire scenario (see Appendix B, Table B6 for means). With regard to EST training (RM2 and RM5), each Soldier was required to meet the standards. In order to address the Soldiers who did not meet the standard initially, sometimes fewer than 15 Soldiers were on the firing line.

Relationship between training scores and Practice Record Fire. This section compares mean simulation scenario scores to mean live-fire scores on the same scenarios. It also examines correlations between scores on training exercises and PRF live-fire scores.

Simulation versus live-fire comparisons. For both groups, the simulation scenarios produced higher scores than the corresponding live-fire scenarios. For the Test-D platoons, a comparison was made between the RF drills and RM7 PRF Iteration 1 scores (see Appendix B, Table B8). On average, the simulation score tended to be 5.8 points higher than the corresponding live-fire score. For the Baseline platoons, a comparison was made between the

scores on the singles and multiple target scenarios (RM5 – EST vs. RM6 – Live-fire). The comparison was based on only the Soldiers who fired both scenarios; some did not fire RM6 as they had to zero their weapons. On the singles scenario, the average simulation score was 10.7 points higher; on the multiples scenario, the average simulation score was 5.6 points higher. In each case, the difference was significant (see Appendix B, Table B9).

***Correlations among training scores and live-fire scores*.** Also examined was whether training scores related to PRF (RM7) on an individual basis. That is, did Soldiers' scores order similarly on both the training and live-fire measures? In summary, there was only one significant correlation for the Test-D platoons (KD 200 yard drill with the second PRF). On the other hand, there were more significant correlations between some EST scores and PRF scores (EST number of groups with both PRF iterations [negative correlations], EST singles with second PRF, and EST multiples with both PRF iterations). These results are shown in Appendix B, Tables B10 and B13.

What Soldiers Said

Soldiers were surveyed twice, after they completed PRF (RM7) and after they completed record fire (RM18) with the CCO. Their comments are summarized here.

In the RM7 survey, Soldiers were asked about their level of confidence on 16 skills (e.g., maintaining a comfortable firing position, reacting to malfunctions, obtaining a good sight picture, trigger squeeze control, able to zero sights on their own). The question simply asked them to choose whether they were confident or whether they needed more training on each skill. Only two skills showed a significant difference between the two groups with the Baseline platoon Soldiers being more confident on performing immediate action than Test-D platoon Soldiers (84% vs. 69%, respectively), and on detecting and engaging pop-up targets (95% vs. 79%, respectively).

For the Test-D platoon Soldiers, a high percentage (77%) said they perceived the drills as valuable and thought they were most proficient on the last day of training. The most challenging drills were the pop-up targets in the RF scenarios (marked by 43%). A relatively high percentage (63%) also said they needed more live-fire training. The primary reasons given for more live-fire were: a general response that they needed more live fire; they needed more time with their personal weapon as the recoil and/or trigger squeeze with their personal weapon differed from the Test-D simulation weapon; they preferred live ammunition when practicing for qualification; they needed live-fire for confidence in their shooting; and they needed the "full experience" of firing on a range.

Both groups of Soldiers were asked to compare their personal M4 weapon to the weapon they used in their respective simulator (Test-D or EST) on recoil, trigger pull, weapon weight, and the back-up iron sight. A majority of both groups said the simulation weapon had less recoil (72% of Test-D platoons, and 82% of Baseline platoons who used the EST)[4]. (See Appendix D

[4] Contractor personnel for the Test-D simulation stated the weapon's recoil is 80% of the M4 carbine.

regarding prior research findings on simulation weapon recoil.) However, on the other three dimensions, more Test-D Soldiers than Baseline Soldiers noticed differences. The biggest difference was on trigger pull with 62% of the Test-D Soldiers saying there was more slack and less resistance compared to their M4 (only 20% of the Baseline Soldiers indicated that was the case with the EST).

After RM18, Soldiers were again asked about their level of proficiency on marksmanship skills. In general, the profiles for the two groups were very similar (no significant differences). But there were some trends which seemed to reflect the reliance on simulation in the Test-D platoons, and were consistent with the RM7 survey findings. Of interest is that there was a continuing trend for the Test-D platoon Soldiers to say they needed more training on reacting to weapon malfunctions as compared to the Baseline platoon Soldiers (26% vs. 14% respectively). The groups also differed on how live-fire with the BUIS helped them in zeroing with the CCO. More Baseline platoon than Test-D platoon Soldiers indicated the BUIS helped them with two skills --- trigger squeeze control (77% vs. 63%, respectively) and with steady position for zeroing (74% vs. 60%, respectively). Lastly, for nine skills, Soldiers were asked whether these skills remained the same as during BUIS training vs. whether these skills increased with CCO training. On average, 45% of all Soldiers said their skills increased during CCO training. But for detecting "multiple pop-up targets and engaging them before they fall" 70% of the Test-D platoon Soldiers said their skills increased during CCO training vs. 58% of the Baseline platoon Soldiers, indicating that more Baseline Soldiers perceived themselves at a higher level of proficiency prior to CCO training than did the Test-D Soldiers.

Soldiers were also asked about their comfort level on a 10-point scale in using their weapon system in live-fire situations when they first started firing. "Using their weapon system" included reacting to malfunctions on their own, use of eye and hearing protection in live-fire situations, weapon carry techniques, safety procedures, modifying their point of aim, ability to assume a steady firing position quickly, etc. Baseline platoon Soldiers had significantly higher (better) ratings on this scale than the Test-D platoon Soldiers (see Appendix B, Tables B19 and B20).

Soldiers' answers to open-ended questions about the Test-D training program were generally positive on both surveys. They thought they had good training, were trained well on the fundamentals, and the Test-D training program helped them as novice shooters. They expressed reservations about the training program in that they perceived the simulator experience as different from their live-fire experience with the M4, and that the live-fire experience was needed to improve their confidence and actual proficiency with their weapon. Consequently, they wanted more live-fire to be integrated in the training program.

What Drill Sergeants Said

The DSs were surveyed and a focus group was held with them. Although the number of the Test-D platoon DSs who provided input from the Test-D platoons was limited to four, their input was valuable. The focus group also included DSs from the Baseline platoons who interacted with the Test-D platoon Soldiers during CCO training.

The Test-D platoon DSs indicated that Soldier performance on the drills did not allow them to identify who would do well on PRF nor who would do poorly on PRF, in part because most Soldiers in the Test-D platoons were performing well. As stated previously, the digital data from the Test-D system supports this explanation (i.e., Soldiers performed better in simulator scenarios than corresponding live-fire). The DSs felt the Test-D feedback from the drills was clear and understandable to the Soldiers.

Anecdotal information from the DSs during the CCO marksmanship phase was that the Test-D platoon Soldiers were observed to lack some weapon handling skills: unable to react to malfunctions, being "startled" when initially firing their weapon, leaving their weapon on "semi" as opposed to "safe", etc. These observations are consistent with the 10-point rating scale results cited previously in the RM18 survey results. (See also prior marksmanship simulation research in Appendix D that had a similar finding regarding weapon-handling skills.)

Possible Explanations for the Practice Record Fire Results

As with the zeroing results, it is not possible to say definitively what could have caused the lower performance in PRF by the Test-D platoon Soldiers. Mostly likely, however, they were the result of multiple factors.

- No live-fire confirmation of zero for the Test-D platoon.

  Live-fire confirmation of zero is used to check the 25m zeroing setting at distance and make sight adjustments if necessary. Many Baseline platoon Soldiers made some adjustments to their zero settings. Thus is it likely that some Test-D platoon Soldiers also did not have the "best" zero at 25m, and more-live fire would have increased their confidence and experience with their personal weapon as well.

- Inconsistencies in the drill training.

  The variations and inconsistencies in the drill training did not provide a solid basis for developing marksmanship skills. These inconsistencies were apparently driven by differences in instructor preferences and lack of consensus on a comprehensive training plan for a period of several days, as there was no prior research with novice firers to guide such decisions.

- Formal standards and detailed feedback were not incorporated in the drills.

  The lack of formal standards made it difficult for the DSs/trainers to determine whether each Soldier had achieved the intended level of proficiency. Basic hit/miss feedback is central and was given, but when Soldiers are learning a skill, more detailed feedback is typically needed to enable them to know what behaviors should be changed (e.g., firing position, sight picture, steadiness with the rifle).

- Soldier progression was primarily by firing order, not by individual proficiency.

  The transition from one drill to another drill was executed by firing order, regardless of Soldier proficiency. There were two exceptions to this procedure. On occasion, a firing order stayed on-line to repeat a drill as some Soldiers needed more practice. And in some cases, Soldiers were sent to the remedial station. In comparison, Baseline platoon Soldiers in the EST were given a formal Go or NoGo on a scenario. If they did not meet the standard, they came back later or stayed on the firing order while Soldiers who met the standard rotated out. With either procedure, Soldier progression with the EST was by individual proficiency.

- Soldier proximity on the firing line.

  The closeness of Soldiers in a firing order inhibited the DSs/trainers' ability to thoroughly check each Soldier's fundamentals, including firing positions, before multiple repetitions of a drill occurred, thereby increasing the likelihood of repeating bad habits. In hindsight, DSs recommended firing orders of 9 to 10 Soldiers, not 15, in order to monitor firing positions. Both Test-D and Baseline platoon DSs noted they had to change some Test-D Soldiers' firing positions during the follow-on CCO training. It is noted that 15 Baseline Soldiers were often firing simultaneously with the EST, but that the EST operators would sometimes have fewer Soldiers in a firing order if the closeness of the Soldiers prevented them from getting into a good firing position.

- Test-D platoon Soldiers were not confident with their personal weapon.

  The lack of confidence may indicate that more live-fire was needed at strategic points in the Test-D training. A heavy reliance on simulation in a marksmanship training program for novice shooters may be premature unless a simulation generates confidence in the skills critical for live-fire events. In addition, limited live-fire opportunities did not provide Soldiers with a perspective on how simulation could help them improve their skills. In fact, a couple of Soldiers commented in the RM18 survey that their live-fire experience with the CCO provided them a perspective on their Test-D training: "Now that I have more range and live-fire experience, I see how [the simulation training] played a major role in developing the fundamentals." "At first I didn't think it helped, but in the end it all fell into place."

- Simulation proficiency was higher than live-fire.

  Proficiency in the Test-D simulator was easier to achieve than in live-fire; the simulation was not sufficiently rigorous to prepare Soldiers for live-fire. This finding also occurred with the EST scenarios. The implications of this finding for software training design in future marksmanship simulators are discussed in more depth in the Discussion and Recommendations section.

Record Fire Results with the Close Combat Optic

On record fire iterations with the CCO, there were no significant differences between the two groups with mean scores ranging between 31 and 33. Complete results are in Appendix B, Table B15 which documents familiarization fire (two iterations of RM16), practice record fire (two iterations of RM17, which was actually executed as a record fire), and "final" record fire (one iteration of RM18). The policy in effect at the time the research was conducted was to take the top score from the three iterations executed during RM17 and RM18 as the official qualification score for each Soldier. It is noted that all Soldiers qualified after firing the first two iterations of RM17, although they fired three iterations in total.

Conclusions

This section focuses on the major findings, and how both the structural characteristics of and the implementation of the Test-D training program could have affected these findings.

Soldier Performance

In this exploratory assessment, Soldier performance on the BUIS was better with Soldiers in the current marksmanship program (Baseline) than the Soldiers in the Test-D program as it was implemented. On the two primary performance criteria, more Baseline platoon Soldiers zeroed initially at 25m and had higher PRF scores. Also, Baseline platoon Soldiers consumed fewer rounds per Soldier on the initial 25m zero attempt. Training times for both groups appeared to be similar.

The performance differences between the Baseline and Test-D platoons were both statistically significant and substantial. To put the results in perspective, the high percentage of Soldiers who did not zero initially in the Test-D platoons was an atypical result, as company personnel indicated that usually only one day is required to zero half a company. This zeroing result had continuing schedule and logistical impacts (more ammunition required). The PRF results for the Test-D platoons were also atypical, as company personnel indicated the typical percentage of Soldiers qualifying corresponded more closely to the Baseline platoon percentage. The difference in the initial PRF scores of four points is more meaningful when converted to marksmanship categories, where the Test-D platoons had twice the percentage of Unqualified Soldiers compared to the Baseline platoons, and the Baseline platoons had at least double the percentage of Sharpshooters compared to the Test-D platoons.

Parts of the assessment were executed as planned and other parts were not. The Test-D training program replaced the two live-fire periods of BUIS instruction as planned. It also replaced dry-fire instruction executed in the current marksmanship training program. It is important to state that some Test-D Soldiers did not receive the full five days with the Test-D training program as they had to return to a 25m range to zero their M4 carbine.

There were substantial inconsistencies in execution of the Test-D training program, although good training was observed to occur. Progressive development of each individual's

marksmanship skill was not applied consistently due to the inconsistencies in training, lack of formal criteria for the drills, and Soldier progression being primarily based on firing order, not individual proficiency.

Immediately after Test-D training, Soldiers in the Test-D platoons said the training was good; it focused on fundamentals. However, 63% of these Soldiers stated they needed more live-fire to gain proficiency and confidence with firing their personal weapon. Most Soldiers also noticed differences between their M4 carbine and the Test-D simulated weapon, with the Test-D weapon having less recoil and the trigger pull having less resistance.

Performance differences between the Test-D and Baseline platoons disappeared by the time the Company reached CCO record fire. However, during CCO training, DSs reported some problems with weapon handling (react to malfunctions, weapons safety) and in firing positions with Soldiers who had the Test-D training program. Soldier responses on the final survey supported the DSs' observations, as some Soldiers indicated they were not comfortable with weapon handling procedures.

The Test-D Training Program and System for Novice Firers

As a training program and system for novice firers, the Test-D software provided a wide variety of drills, was flexible, and was easy to use. It was easy to switch from one drill to the next; the drills were easy to select from the computer interface; competition could be incorporated which increased motivation; the target screen could be divided into thirds to accommodate different firing positions (e.g., standing, kneeling, prone); etc. Software engineers easily made desired changes to the scenarios. However, the Test-D simulation training program lacked trainer-useful features such as: guidelines on how to leverage training capabilities (recommended training sequences/drill options including non-traditional approaches or core drills to reinforce performance); a formal technical capability to record or summarize Soldier status and progress for Soldiers or trainers; and systematic features to help DSs diagnose Soldier problems or to assess when a Soldiers should progress to a more demanding level of proficiency. Trainer and Soldier feedback was primarily hit and miss. Formal criteria/standards for the drills were not applied. It is noted that other marksmanship simulations lack some of the same trainer features (see Appendix D), but their absence could be more critical when the primary mode for training novice firers is simulation, versus the more traditional mode of a combination of dry-fire, simulation, and live-fire.

The Test-D Training Program as Executed

As executed, the trainers were able to stress certain skills more than is the case in the current live-fire program (e.g., firing from the kneeling position). Although the concept of drills has direct and valuable application to training marksmanship skills, for the novice firers in the assessment, more attention was needed to insure that their fundamental skills were initially sound (a slower execution pace, careful attention to each firer) during drill execution. The lack of prior mapping of drills to fundamental skills and the inconsistency in which drills were applied did not facilitate progressive development of skill for novice firers. Also, given the initial zeroing

results, the Test-D target imagery for the grouping/zeroing drills should be changed to images of the Army's standard zero target to ensure positive transfer to live-fire on the 25m range with that zero target.

Almost two-thirds of the Soldiers in the Test-D platoons indicated a desire for more live-fire training with the primary reasons being they lacked confidence in shooting their weapon, felt they needed to improve their weapon handling skills, and preferred live ammunition when practicing for qualification. With regard to the current research, it was not possible to determine whether more live-fire would have been the only solution to solving such issues (e.g., dry-fire is used to train some weapon handling skills), when more live-fire scenarios/events should have been executed, or what additional live-fire scenarios would have been best. However, a high reliance on most existing marksmanship simulations, as they are designed currently, appears to be inappropriate for novice firers as they do not provide the level of confidence that live-fire with the actual weapon provides. More live-fire could be included in training and/or enhancements made to simulation software (see Discussion and Recommendations section below and Appendix D).

Despite the best intention of the DSs involved, the simulator training area was not treated as a live-fire training area. Running the simulator similar to a live-fire range by using the same commands, and reinforcing the same habits would likely have reinforced weapon handling fundamentals and reduced safety violations. Ample training space was provided, and Soldiers had their assigned weapons present. Supplemental weapon handling exercises (e.g. clearing procedures, dry fire exercises, and immediate action drills) could have been conducted while firing orders were waiting to shoot.

Simulations do not eliminate the need for skilled trainers. A lesson learned is that multiple means of training-the-trainer on new simulations should be available. In particular, DSs have multiple demands on their time, and may not always be able to attend all face-to-face training sessions. Backup training materials (hand-outs, digital training, a Trainer's Guide, etc.) should be available to account for such contingencies. The goal, in all cases, should be to fully enable DSs to execute multiple days of training on their own, without assistance from simulation-developer personnel.

Discussion and Recommendations

This section addresses implications of the assessment findings for the use of simulation in marksmanship training and for the design of future marksmanship simulations/devices. The general discussion points and the four recommendations made here emerged from the heavy reliance on simulation that occurred in this assessment research. As stated initially, this was the first-known extensive application of simulation-based training in initial marksmanship training. As such, some unexpected results occurred, which bear on the application and design of future marksmanship simulations and training. These discussion points and recommendations go beyond the initial scope of the assessment.

Marksmanship Training Implications when Simulation is the Primary Training Method

Training Recommendation #1:

It is recommended that important live-fire marksmanship skills that are not trained or not adequately supported with a simulation system be addressed with other forms of training. This is particularly critical as most marksmanship simulations are part-task training systems.

Because marksmanship simulators/training devices are part-task trainers, there are cumulative negative effects of not practicing all component skills or repeatedly practicing them in the "wrong" way. Two illustrations of this in the current effort were the slack trigger squeeze on the Test-D weapon and weapon handling issues (reaction to malfunctions, safety concerns). Dry-fire dime and washer drills would be one way to give Soldiers practice with the trigger on their own personal M4 carbine. It is likely that Soldiers in the current effort adjusted to the slack trigger pull with the Test-D weapon over time, and did not have sufficient experience with their personal M4 to acquire the proper trigger pull with it. Regarding safety, everyone needs to treat the firing line in a simulator environment as if the firers are on a live-fire range (e.g., not walk in front of Soldiers, ensure the weapon is on safe when not aiming at a target).

Training Recommendation #2:

It is recommended that "Soldiers start right" in a simulation and "not practice wrong" steps or actions during the initial marksmanship skill acquisition process whenever simulation replaces live-fire events.

Any additional steps or procedures that are needed before firing in a live-fire environment should also be taken prior to firing in a simulation (e.g., check each individual's firing position, natural point of aim, and understanding of the shot process [relationship between front and rear sights and the target]). Such procedures will reduce the likelihood of Soldiers practicing "bad or poor habits" which will not transfer appropriately to live-fire conditions. This point was reinforced in the current assessment when DSs changed the firing positions of some Soldiers from the Test-D platoons during live-fire CCO training. It was hard for DSs to check on each Soldier's position given the closeness of the Soldiers in the simulation firing order. Having fewer Soldiers in the firing order would have enabled the DSs to monitor Soldiers better, even though more firing orders might have been required during the initial stages of training. In summary, drills are good if Soldiers practice good habits; drills are bad if Soldiers practice bad habits and/or do not repeat all critical behaviors necessary for success. Trainers need to thoroughly understand the advantages and disadvantages of the simulation system, and visualize how Soldiers will perform tasks over time to ensure that the necessary procedures are executed prior to Soldiers starting to "shoot" in the simulator.

Research on the Design of Future Marksmanship Trainers/Simulations

Design Recommendation #1: Create an effective and efficient training feedback system.

It is recommended that research be conducted on the best user-friendly and informative feedback training procedures that provide what Soldiers and trainers need at different stages of learning, yet still support the throughput required by marksmanship programs of instruction in initial entry training.

Feedback is critical to learning a skill. One advantage of simulation system software is that more types of feedback on Soldier proficiency can be provided than is possible with live-fire (most live-fire simply provides hit/miss feedback). With most one-on-one marksmanship training devices developed in the 1980s and 1990s, which are primarily self-paced trainers, all or most feedback goes directly and automatically to the firer. The extent and the type of feedback are dependent on the firer's marksmanship progress. The feedback is more than the basic hit and miss information. However, these devices are also designed to be used on a limited basis, e.g., remedial training, platoon-bay training. See Appendix D for a discussion of these training devices and the feedback they provide.

With the advent of group training simulations, such as the EST and Test-D, which train multiple Soldiers on one system simultaneously, the feedback Soldiers and trainers typically receive has often reverted to hit and miss information. Even though diagnostic feedback may exist, it is not always shown to the Soldier and/or trainer. For example, although the EST has diagnostic features, in practice these features are infrequently shown to the Soldier and/or the DS; feedback depends on the EST system operator. Moreover, when multiple Soldiers are trained simultaneously, the feedback is not necessarily tailored to the Soldier's marksmanship status.

Another part of any feedback system is that it should also incorporate "trainer-useful" features. Such features would enable more consistency in training and greatly assist new trainers when first exposed to the system. It should include a technical capability to record or summarize Soldier status and progress immediately after each drill/exercises (training roll-ups). There should also be a Trainer's Guide to assist trainers in understanding and leveraging the training and feedback features of the system (e.g., recommended training sequences/drill options, core drills/exercises to reinforce, and use of diagnostic tools).

Another "trainer-useful" feature would be to enable Soldiers on the firing line to execute different scenarios or different levels of difficulty of the same scenario at the same time. This capability would enable tailored training and feedback, and would address the individual differences in skill that were observed on the firing lines for both groups of Soldiers in the current research. However, this capability might make it more difficult for trainers to diagnose shooting problems, and could be very complicated for an inexperienced trainer.

The technology exists to provide such feedback and training capabilities in simulation software, and the research literature provides a basis on which to determine the feedback that would benefit Soldiers. However, historically, a major concern has been that providing more detailed and/or tailored feedback requires too much training time, and therefore conflicts with the throughput requirements of the program of instruction in initial entry training. The research challenge is determining how to best balance feedback requirements for the Soldiers and trainers with the more practical demands of the time limitations of actual rifle marksmanship training. The best solution needs to be determined empirically.

Design Recommendation #2: Make the simulator training sufficiently challenging so Soldiers can meet or exceed desired live-fire performance.

It is recommended that research be executed on marksmanship simulation solutions that address increased accuracy requirements and how to incorporate the effects of round dispersion that would result in the desired live-fire performance.

A consistent finding with both the EST and Test-D marksmanship simulation systems used in the current research was that performance in the simulation scenarios was higher than the corresponding live-fire scenarios. This is not the first time that performance on training simulators has been found to be better than comparable live-fire scenarios (see Appendix D on the EST). If simulation were to become dominant in marksmanship training, then the simulation must prepare Soldiers better for live-fire.

With flight simulators, efforts have been made to make the simulation training more difficult than actual flight by having the simulation operate at faster than normal time (called above real-time training or a fast simulation approach). Results have shown higher degrees of positive transfer compared with standard training (see Appendix D for more information). With marksmanship simulators, it is argued that the analog to incorporating faster time in flight simulators is incorporating greater accuracy requirements and/or the effects of round dispersion in marksmanship simulations/simulators. However, research is needed in this area, as it is not known what simulator software modifications would achieve the intended effects. Examples of possible simulation options are given below.

With regard to demanding a higher level of accuracy, one approach would be to modify the eventual zeroing/grouping standard in the simulator from a 4cm circle to a 3cm circle. Novice firers would progress from 4cm to 3cm. This would be a challenge for some Soldiers, probably at least one-third of them based on the data in this assessment, as one-third required more than eight 5-round shot groups to group in the EST. The criteria of interest with this change in simulation grouping/zeroing procedures are the percentage of Soldiers who zero with live-fire on the 25m range within the Army criterion and the average number of rounds used by Soldiers.

Another means of making the simulation more challenging is to incorporate the factor of round dispersion in scoring procedures. The ballistics of small-arms rounds including dispersion by type of round and target distance is fully documented (for example, see Department of the Army, FM 3-22.9, *Rifle Marksmanship M16-M4 Series*, 2008). However, current laser-based systems do not incorporate round dispersion, only round trajectory is modeled. A hit in the head is scored the same as a hit in the chest, even though when round dispersion is considered the likelihood of actually hitting a target is greater with a chest hit than a head hit. Many options exist for incorporating the effects of round dispersion; four options are cited in the next paragraph.

One option would be consistent with the Multipurpose Arcade Combat Simulator (MACS) system. The MACS (light pen technology) had two scoring procedures: one was hit or miss, and the other was an aiming or accuracy score which determined the distance of hits from the center mass of the target. The accuracy score was used to determine whether a shooter should progress to a higher level of training. A second option would be to show the "laser hit" plus the dispersion of the round at the target distance and calculate another score indicating the Soldier's likelihood of hitting the target (higher likelihood when a greater percentage of the dispersion area is on the target). A third option would be to consider the dispersion area for each shot and randomly pick a shot location within that area to be counted as a hit. Thus, for example, a shoulder hit with a laser could be treated as a miss, given the dispersion area of the live-round. A fourth option would be to only count valid shots as those in a certain area of the target rather than any location on the target.

It is hypothesized that such approaches, applied to pop-up and/or KD target scenarios, would increase the difficulty of the simulation scenarios, and would therefore improve marksmanship skills (steady position, sight picture, trigger squeeze, etc.). The research challenge is in determining which approaches will make the marksmanship simulation experience more difficult, and which are effective in enabling Soldiers to effectively transition to the desired performance levels on critical live-fire situations such as zeroing and record fire.

Relevance of the Recommendations to Current Marksmanship Simulations

As stated at the beginning of this report, this was an exploratory investigation in applying simulation to most periods of a major phase of marksmanship training for initial entry training Soldiers. Unexpected results occurred, as is likely in any such exploratory effort. They are not unique to this specific marksmanship effort. It is likely that unexpected results would have occurred with any simulation that might have been used, considering the substantial change in the marksmanship training (and one that differs from previous research with simulations and training devices). Thus, the findings should be viewed in this context, and the results should not be viewed as a rejection of the specific training simulation capabilities used in this exploratory research.

The suggested training changes in this final section could easily be made in future marksmanship efforts. However, the recommended software design changes regarding

feedback/instructional design and appropriate difficulty levels, although easily made in most simulations, need to be evaluated empirically, as the optimum solutions are not known a priori. Both types of design changes are needed if marksmanship simulations are able to provide the needed Soldier proficiency with minimal live-fire training.

References

U.S. Department of the Army. (2008). *Rifle Marksmanship M16-M4 Series* (FM 3-22.9). Washington, DC: Author.

Appendix A

Drill Descriptions

1) Drill name: **Grouping**

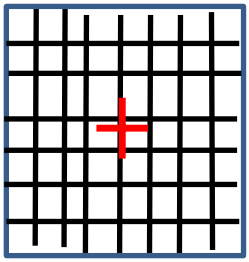
2) Description of Drill: The Grouping Drill was the first drill run by Soldiers as they came onto the firing line. Each Soldier fired five shots at each grouping target. The target comprised a grid background with a red cross in the center. On the fourth day an Army standard battle sight zero target was added as an alternative for this drill. All of these targets were scaled to an apparent 25m distance.

   The drill performance was scored via average distance of all shots from center of the target no matter where the shot landed on the screen.

   Shot location feedback was provided to the Soldier.

3) Intent of the Drill: The drill was designed to teach and measure Soldier consistency in shooting.

4) Image: (Rough illustration of the graphic image presented on this drill. The graphic is not the actual image.)



1) Drill name: **Distance from Center (Accuracy)**

2) Description of Drill: In this drill Soldiers shot at a small cross within a small circle. The target was not scaled to any particular distance.

   All Soldiers shot at the target for five rounds in either the prone supported or the kneeling position. There was no time limit on this drill and scoring was based upon average distance from center of target for the five shots.

3) Intent of the Drill: This drill was designed to verify calibration of the weapons before continuing onto other drills.

4) Image: (Rough illustration of the graphic image presented on this drill. The graphic is not the actual image.)

1) Drill names: **Set 1: KD (100, 200, 300 yard) E-Silhouette** (untimed)
Set 2: 200 yard E-Silhouette (timed)

2) Description of Drills: Set 1 of KD drills was not timed and Soldiers shot at standard E-type silhouette at distances of 100, 200, or 300 yd. With Set 2 of drills, Soldiers were timed and shot at a standard E-type silhouette at 200 yd.

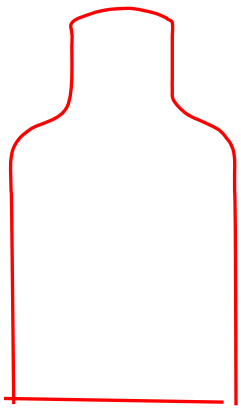
   For the KD drills (Set 1), all distances had a 10 shot maximum at each target. Each trial of the drill presented one target at a specific distance and all 10 shots were recorded against that target. This drill was shot from prone supported, prone unsupported, and kneeling firing positions on separate instances. A separate variation provided an enlarged view of the target for immediate feedback. For the enlarged view variation, an enlarged view of the target placed above the actual target displayed the sequential real-time hits on the target.

   The Set 2 drills were two timed variations of the 200 yard drill. One variation was a two-shot race with the first Soldier to hit the target with both shots as the winner. The other variation was 10 shots in one-minute competition with the first shooter to hit the target 10 times as the winner. This was typically done from the prone supported position.

   The feedback provided was the impact point of all rounds on the target as well as time to engage, and number of hits and misses. All impact points were numbered sequentially. The same feedback was provided for all distances and all firing positions.

3) Intent of the Drills: The KD drills were designed to train the difference between point of aim and point of impact for rounds as the distance to target changes. The reason for emphasis of the 200 yard target was this distance provides the greatest deviation between the point of aim and the point of impact based upon the bullet's trajectory. The set of timed drills was intended to place additional pressure on the Soldier.

4) Image: (Standard E-silhouette. The graphic is an outline of an E-silhouette. It is not the actual image used in the Test-D drill.)



1) Drill name: **Record Fire Tables (PS, PUS, and Kneeling)**

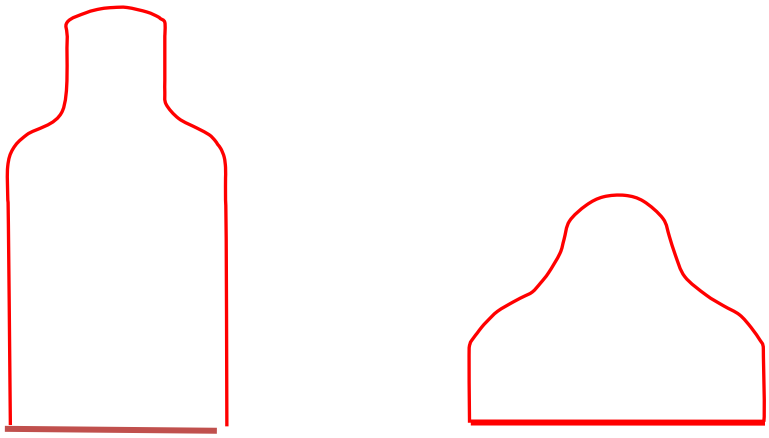
2) Description of Drill: Soldiers fired at F-type silhouettes at distances from 50m to 100m and at E-type silhouettes from 150m to 300m. In this set of drills, the Army Standard Qualification tables were replicated in firing position order, target presentation order, target presentation time, and round limit. However, labels for the distance to each target appeared above each target displayed. As each firing position (prone supported, prone unsupported, and kneeling) was considered a drill, the drill for a specific position was sometimes executed independently of the other firing positions.

   Soldier feedback was number of hits.

   A variation of the prone supported drill was to present the targets in a random order, with target pairs, target distance, and exposure times being the same as the qualification table.

3) Intent of the Drill: This drill was designed to provide practice for record fire.

4) Images: (Standard E- and F-silhouettes. The graphics are outlines of the E- and F-silhouettes; they are not the actual images that were shown in Test-D. Also they are not to scale.)



1) Drill name: **Alt C Technique/Alt C Competition Technique**

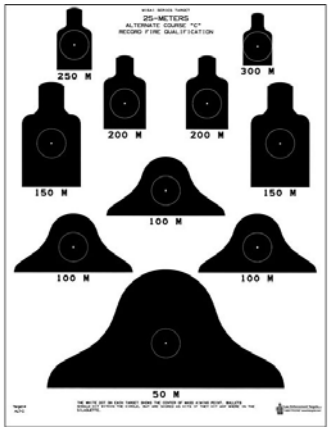
2) Description of Drill: In this drill, the Soldiers engaged the Alt C targets with a 30 shot maximum and 10 hits were required to end the trial. The target was similar to the Alt C target used in live-fire events. The drill was shot in either the prone supported or the kneeling position, although prone supported was typically used. The specific target to be engaged was black while all other targets were grayed out. A red 'X' was displayed where the shot hit if it was not on target. Hits and misses as well as total time were displayed for the Soldier.

   Alt C Competition was the same, except that missing a target resulted in having to start the series of targets over from the beginning. There was no upper time or round limit. Hits and misses along with total time were displayed for the Soldier.

   The drill protocol did not correspond to the Army qualification procedures (FM 3-22.9), although the target was the same.

3) Intent of the Drill: The alternative record fire course ("Alt C") is used when Soldiers do not have access to a firing range with normal targets.

4) Image: (Alt C target image obtained from the Internet; see also FM 3-22.9.)



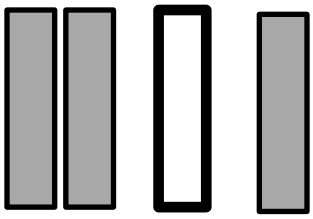
1) Drill name: **Sight Reference**

2) Description of Drill: Soldiers were presented with four vertical bars with one bar presented as white. The white bar was the target for the drill. There were three different levels of sight reference with the spacing of the bars decreasing, the bars became thinner and shorter as the difficulty increased. The position of the target bar also changed within a difficulty level. The Soldiers were also required to change firing positions between prone supported and kneeling within a drill session. A different target was only presented after a successful hit on the target. On the hardest Sight Reference level, a miss would cause the drill to reset to the beginning and the Soldier would have to re-shoot the sequence. The target was notionally scaled to 25m. The maximum number of rounds was 30 with 9 hits required to complete the drill.

   Scoring of the drill was in terms of total hits and misses, and elapsed time to complete the drill.

3) Intent of the Drill: This drill was designed was to train target discrimination, proper sight profile (keeping the weapon oriented vertically to the target), quick target acquisition, and aiming principles.

4) Image: (Illustration of the graphic image presented to the Soldier on this drill. No distinction is made between the three levels of difficulty, but as stated above the bars became thinner and shorter as the difficulty increased. The graphic is not the actual image.)



1) Drill name: **Eye Relief**

2) Description of Drill: For the Eye Relief drill, Soldiers started in the prone supported firing position to engage a target at the bottom third of the screen. Once the target was successfully engaged, the target moved to either the middle or upper third of the screen indicating the Soldier needed to change firing positions to either the kneeling or standing position based on where the target was located. After each target was successfully engaged, the target moved at random to one of the other positions requiring the Soldiers to keep moving and maintaining their weapon eye relief. Each Soldier engaged a target in each position three times. The target was not scaled for any particular distance.

   Feedback was provided in hits, misses and total time for the drill.

3) Intent of the Drill: This drill was designed to teach the Soldiers how to maintain the same eye relief on the weapon no matter which firing position was assumed.

4) Image: (Image was similar to the grouping image shown under the Grouping drill.)

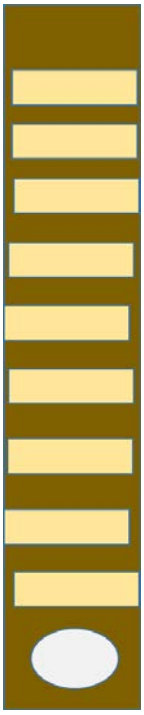
1) Drill name: **Silver Dollar Drop**

2) Description of Drill: The target was a circle that fell through a vertical pipe. The pipe had horizontal slots starting at the top where the circle could be seen. At the bottom of the pipe was a cut-out the size of the circle. The task of the Soldier was to hit the circle before it fell off the screen. This could be accomplished by hitting the circle either through the slots or the final cut-out as long as it was hit prior to leaving the screen. This drill was performed from either a prone or kneeling position. Multiple trials were executed, and as the trials continued the drop speed increased progressively.

   Scoring of the drill was in terms of total hits and misses.

3) Intent of the Drill: This was an advanced drill designed to teach the fundamentals of tracking and trapping when engaging moving targets.

4) Image: (Rough illustration of the image presented on this drill. The graphic is not the actual image.)



Appendix B

Data Tables

Zero Results

Table B1 summarizes the 25m zero data available from all zero days. The Army standard for zeroing is to have 8 of 10 rounds in the 4cm circle on the zero target from two consecutive shot groups. The last row in the table shows that prior to PRF (RM7) 87% of the Soldiers in each group had zeroed their weapon.

Table B1
25m Zero Results with the BUIS

	Group	
Measure	Test-D Platoons	Baseline Platoons
Initial Zero Period		
Number of Soldiers on Range	87	86
Percentage of Soldiers who Zeroed [a]	59% (51 of 87)	76% (65 of 86)
Mean Rounds Fired per Soldier on Initial Zero	46.13 (80 Soldiers)	39.44 (63 Soldiers)
Percentage of Soldiers who Zeroed in 40 Rounds[b] (not all Baseline Soldiers were observed)	41% (21 of 51)	68% (30 of 44)
Additional Zero Days	2	1
Number of Test-D Soldiers observed on Second Attempt to Zero and Results [c]	17 (12 zeroed; 5 did not zero)	NA
Last Attempt to Zero		
# Soldiers on Range	25	25
# Soldiers who Zeroed or Confirmed Zero	14	14
# Soldiers who did not Zero	11 (did not fire)	11 (8 did not fire; 3 failed to zero)
Percentage of Soldiers who Finally Zeroed	87% (76 of 87)	87% (75 of 86)

[a] $z = 2.37$, $p = .0177$.

[b] $z = 2.63$, $p = .0085$. The Baseline percentage is based on only 44 Soldiers as it was not possible to observe all the Baseline Soldiers who zeroed.

[c] Not all Soldiers from the Test-D platoons were observed on the second attempt to zero.

Confirmation of Zero – Baseline Platoons. With the exception of one Soldier, all Baseline Soldiers who zeroed at 25m initially also confirmed zero at 200m. Baseline Soldiers could not confirm zero at 100m because of limited range time; thus they used 20 rounds, not 40, per Soldier.

Practice Record Fire Results (RM7)

Two iterations of PRF (RM7) were fired. Results are in Tables B2 through B4. For both iterations only the results for Soldiers who zeroed at 25m were analyzed. Almost all who did not zero were Unqualified. In addition, during the first iteration, it was discovered during firing order 10 that a target on lane 9 was malfunctioning. Therefore, it was necessary to delete the data from Soldiers in firing orders 1 through 10 who were on lane 9. Consequently, the number of Soldiers with valid data was 10 less on iteration 1 than on iteration 2.

Table B2
Mean RM7 (PRF) Scores with BUIS (<u>without</u> non-zeroed firers and lane 9 firers [iteration 1])

	Iteration 1		Iteration 2	
All Valid Firers	N	Mean (SD)	N	Mean (SD)
Test-D Platoons	70	23.03 (6.80)	76	23.54 (6.53)
Baseline Platoons	70	26.96 (5.79)	74	26.03 (4.91)
Significant Difference?	Yes t (138)= 3.68, p = .0003		Yes t (148) = 2.63, p = .009	

Table B3
Percentage of Soldiers in Marksmanship Categories with BUIS (<u>without</u> non-zeroed firers and lane 9 firers [iteration 1]) on RM7 (PRF)

PRF Iteration and Soldier Group (n)	# (%) Soldiers in Marksmanship Categories			
	Unqualified	Marksman	Sharpshooter	Expert
Iteration 1				
Test-D Plts (70 firers)	32 (46%)	26 (37%)	10 (14%)	2 (3%)
Baseline Plts (70 firers)	16 (23%)	28 (40%)	22 (31%)	4 (6%)
Iteration 2				
Test-D Plts (76 firers)	31 (41%)	35 (46%)	9 (12%)	1 (1%)
Baseline Plts (74 firers)	17 (23%)	39 (53%)	17 (23%)	1 (1%)

Notes. Iteration 1. χ^2 (3); 10.57, p = .014. Iteration 2. χ^2 (3), 6.74, p = .08.

As shown in Table B3, the primary shifts in the distribution of Soldiers in the marksmanship categories were that the Test-D platoons had relatively more Unqualified Soldiers and relatively fewer Sharpshooters compared to the Baseline platoons. The percentages in the Marksman and Expert categories were similar.

Table B4
Subscores on Firing Positions on PRF1 and PRF2 (zeroed firers only).

	Test-D Platoons			Baseline Platoons				
Position	Mean	SD	N	Mean	SD	N	t value	*p*
PRF1								
PS	11.48	3.95	70	13.50	3.46	70	3.21	.002
PUS	5.16	2.45	70	6.50	2.28	70	3.36	.001
Kneel	6.38	1.95	70	6.96	1.56	70	1.91	.058
PRF2								
PS	11.79	3.93	75	13.00	3.20	73	2.05	.042
PUS	5.27	2.34	75	6.04	1.67	73	2.31	.022
Kneel	6.56	2.06	75	7.01	2.01	73	1.36	.177

Note. Two-tailed t test; *df* for PRF1 were 138; *df* for PRF2 were 146. (Differences in the *df* were due to problems with one lane during PRF1 and some Soldier scores had to be eliminated from the analysis). PS = prone supported; PUS = prone unsupported.

Baseline platoons scored significantly higher on each firing position than the Test-D platoons except for Iteration 2, kneeling position.

Table B4 shows that kneeling scores tended to be higher than prone unsupported (both positions had 10 targets). It is noted that the prone unsupported position was not practiced as much in the Test-D training as the kneeling and prone supported positions.

Training Times

Table B5
Training Time Estimates by Day (Lunch times omitted)

	Test-D Platoons		Baseline Platoons	
Day	Activity	Elapsed Time (hrs) by am/pm	Activity	Elapsed Time (hrs) by am/pm
1	Test-D	2.50 hrs - am 3.00 hrs - pm	EST (no observations after EST completed)	3.00 hrs - am 1.50 hrs - pm
2	25m zero	2.50 hrs - am 2.25 hrs - pm	Dry-fire in unit – no observations	Time not available
3	Test-D	2.25 hrs - am 2.50 hrs - pm	25m zero	2.50 hrs - am 2.25 hrs - pm
4	Test-D	1.75 hrs - am 3.00 hrs - pm	200m confirm zero (Range closed in pm –no observations)	2.50 hrs - am
5	Test-D	2.00 hrs - am 3.00 hrs - pm	EST (no observations after EST completed)	3.00 hrs - am 1.50 hrs - pm
6	Test-D	2.00 hrs - am 2.25 hrs - pm	Live-fire (stopped when out of ammunition)	2.50 hrs - am 1.25 hrs - pm

Note. On Day 6, all platoons had a 6-mile road march in the morning followed by breakfast on the range. The Test-D Soldiers were then bused back to the simulation training area in their brigade.

Table B5 indicates that time data were incomplete for some Baseline platoon periods, as the number of observers was limited and the priority was on obtaining complete time data for the Test-D platoons. However, the time spent in the initial zero period for each group was the same – 4.75 hrs. In addition, total training time for days on which all time data were available (Days 3, 5, 6) was 14 hrs for the Test-D platoons and 13 hrs for the Baseline platoons.

Baseline Platoon Training Results

Tables B6 and B7 summarize the Baseline Platoon results on the live-fire and simulation scenarios in their training program.

Table B6

Baseline Platoons. Means on RM2, RM5 and RM6 (presented in training sequence)

Measure	Mean	SD	Min-Max	N
RM2 # of shot groups(EST)	10.04	11.25	2-54	84
RM5 Singles (EST)	29.52	5.20	15-39	83
RM5 Multiples (EST)	28.20	5.61	16-39	82
RM6 Singles (live)	19.10	5.57	8-31	49
RM6 Multiples (live)	22.12	5.57	7-34	65
RM6 PRF (familiarization-live)	23.15	6.47	7-37	60

Note. On RM6, nonzeroed firers did not fire.
On RM6 PRF – only those below a score of 27 on multiples on RM6 also fired PRF.
EST shot groups: Median was 10, mode was 6. Skewed to the right.

Table B7

Number of Shot Groups Required to Meet the Grouping Criterion on the EST: Baseline Platoons (Criterion was 2 consecutive shot groups with 8 rounds in the 4cm circle.)

# Shot Groups	N of Soldiers	Cumulative N	Percent of Soldiers	Cumulative % of Soldiers
2	27	27	32.14	32.14
3	8	35	9.52	41.66
4	2	37	2.38	44.04
5	3	40	3.57	47.61
6	10	50	11.90	59.52
8	6	56	7.14	66.66
9	5	61	5.95	72.61
11	2	63	2.38	75.00
12	1	64	1.19	76.19
14	1	65	1.19	77.38
15	2	67	2.38	79.76
17	1	68	1.19	80.95
21	1	69	1.19	82.14
23	1	70	1.19	83.33
24	2	72	2.38	85.71
27	2	74	2.38	88.09
29	1	75	1.19	89.28
30	1	76	1.19	90.47
32	2	78	2.38	92.85
33	4	82	4.76	97.61
39	1	83	1.19	98.80
54	1	84	1.19	100.00

Simulation Comparisons with Live-fire

With both groups it was possible to compare scenarios executed in the simulation (Test-D and EST) to live-fire proficiency on the same scenarios. In both cases, the simulation scores were higher than the live-fire scores. Tables B8 and B9 document these results. For Test-D platoons the comparison was made for the practice record fire scenario (RM7). For the Baseline platoons, the comparison was made for the single and multiple target tables (RM6).

Table B8

Test-D Soldier Performance on the "Record Fire" Scenario: Test-D Simulation vs RM7 Live-fire (zeroed firers only)

Measure	Firing Position			Total Hits
	Prone Supported	Prone Unsupported	Kneeling Unsupported	
Test-D "RF" Scenario				
N of Soldiers	70	59	65	---[a]
Mean Ph / # Hits	.71 / 14.20	.64 / 6.40	.82 / 8.20	28.8
RM7 - PRF- Iteration 1 Live-Fire				
N of Soldiers	70	70	70	70
Mean Ph / # Hits	.57 / 11.48	.52 / 5.16	.64 / 6.38	23.0

Note. Because each position was practiced a different number of times with Test-D, the sample size for each position differs: PS, $n = 70$; PUS, $n = 59$; Kneel, $n = 65$. Total score for Test-D drill training was estimated by summing the position means, despite the differences in number of Soldiers.
Ph = probability of hit
[a] Total number of firers is not provided for the mean because of the differences in sample sizes for each position.

Table B9

Baseline Soldier Performance on the Single and Multiple Target Scenarios: EST Simulation (RM5) vs. RM6 Live-Fire (zeroed firers only)

Measure	N of Soldiers	Mean (SD) Singles Score [a]	Mean (SD) Multiples Score [b]
RM5 – EST	46	30.24 (4.48)	28.92 (5.38)
RM6 – Live-fire	60	19.54 (5.45)	23.35 (5.55)
Difference in Scores		10.70	5.57

Note. The EST scenario had 75m and 175m targets only. For live-fire, these targets were replaced by 100m and 200m targets, respectively, as the live-fire range was a record fire range only, not a modified record fire range. Also the number of Soldiers was larger for the multiples target scenario as more Baseline Soldiers had zeroed by the time the live-fire multiple target scenario was executed. Each comparison was based on only the Soldiers who fired both the EST and the corresponding live-fire scenario.
[a] $t(45) = 9.23$, $p < .001$ (paired sample t-test)
[b] $t(59) = 6.90$, $p < .001$ (paired sample t-test)

Correlations

Correlations among the primary BUIS measures are shown in Tables B10 through B14.

Table B10
Test-D Platoons: Correlations Between Test-D Training Measures and PRF Scores (zeroed firers)

Individual Training Measure	Correlation Coefficients with PRF Live-Fire Scores	
	PRF 1	PRF 2
RM3 rounds consumed on initial zero	-.17	-.11
# of Test-D drill repetitions [a]	.04	.18
Mean Probability of Hit – KD 200 yard drill	.18	.31*
Mean Probability of Hit - KD 300 yard drill [c]	.14	.06
Mean Probability of Hit - PS Record Fire drill [d]	.05	.15
	Kneeling Subscore	Kneeling Subscore
# Repetitions: Sum of Kneeling Position in Record Fire and in Grouping Drills [e]	.09	.16

Note. N is 70 for all drill measures; 66 and 71 for rounds on initial zero. KD = known distance; PS = prone supported.

[a] # of Test-D drill repetitions ranged from 58 to 239, with a mean of 137.10.

[b] Mean probability of hit on 200 yard target drill ranged from .68 to 1.00, with a mean of .90.

[c] Mean probability of hit on 300 yard target drill ranged from .49 to .99, with a mean of .81.

[d] Mean probability of hit from prone supported position in record fire drill ranged from .20 to .92, with a mean of .71.

[e] Number of repetitions in kneeling position ranged from 2 to 56 with a mean of 24.31.

* $p <$. 05. Correlations above +/- .24 were significant at the .05 level (KD 200 yard drill with PRF 2).

Table B11
Correlations Between PRF Scores and Subscores– Soldiers From All Platoons (zeroed firers)

Score	PRF1	PRF2	PS1	PUS1	KN1	PS2	PUS2	KN2
PRF1	___	.**48***	.90*	.80*	.66*	.42*	.28*	.31*
PRF2		___	.41*	.43*	.27*	.87*	.71*	.60*
PS1			___	.56*	.41*	**.39***	.21*	.27*
PUS1				___	.38*	.37*	**.35***	.22*
KN1					___	.21*	.12	**.26***
PS2						___	.43*	.26*
PUS2							___	.24*
KN2								___

Note. PS = prone supported; PUS = prone unsupported; KN = kneeling. "1" refers to the first iteration; "2" refers to the second iteration. Correlations between the same scores and subscores for PRF1 and PRF2 are in boldface.
*$p < .05$. Correlations above +/- .17 were statistically significant at the .05 level.

Table B12
Baseline Platoons: EST Correlations

EST Measure	EST # of Groups	EST Singles (RM5)	EST Multiples (RM5)
EST # of Groups	---	-.38*	-.50*
EST Singles		---	.76*
EST Multiples			---

Note. Pairwise deletion of firers. .
* $p < .05$. Correlations above +/- .22 were significant at the .05 level

The correlation of .76 between singles and multiples on the EST is the highest correlation found in the data. It appears there was an impact of the "EST environment" on the scores. A negative correlation between # of groups and the Singles and Multiple scores is what one would expect.

Table B13
Baseline Platoons: Correlations Between EST Training Measures and Live-fire Scores (zeroed firers)

	EST Measure		
Live-fire Measure	EST # Groups	EST Singles (RM5)	EST Multiples (RM5)
Initial Zero Rounds	-.04	-.02	.00
RM6 - Singles	.06	-.25	-.31*
RM6 - Multiples	-.06	.10	.09
RM6 - PRF	-.28*	.18	.20
RM7 - PRF1	-.45*	.16	.33*
RM7 - PRF2	-.41*	.34*	.44*

Note. Pairwise deletion of firers.
*$p < .05$. Correlations above +/- .27 were significant at the .05 level.

Negative correlations between # of groups in EST and PRF scores for zeroed firers. Also the EST multiple scenario correlated higher with PRF than EST singles.

Table B14
Baseline Platoons: Live-fire Correlations

Live-fire Measure	Initial Zero Rounds	RM6 - Singles	RM6- Multiples	RM6- PRF	RM7 PRF1	RM7 PRF2
Initial Zero Rounds	___	-.32*	.06	-.03	-.21	-.03
RM6 - Singles		___	.52*	.51*	.38*	-.04
RM6 - Multiples			___	.16	.39*	.04
RM6 - PRF				___	.35*	.42*
RM7 - PRF1					___	.38*
RM7 - PRF2						___

Note. Pairwise deletion of firers.
*$p < .05$. Correlations above +/- .27 were significant at the .05 level.

CCO Results

Table B15 presents the CCO results on the record fire scenario. This scenario was also used for familiarization fire.

Table B15
Marksmanship Categories and Means on Familiarization Fire and Record Fire with the CCO (RM 16-18) (Army Record Fire/Qualification Course)

Platoons and Measures	N	Marksmanship Category (# and %)				Mean/SD
		Unqualified	Marksman	Sharpshooter	Expert	
Fam Fire 1						
Test-D	75	6 (8%)	21 (28%)	33 (44%)	15 (20%)	31.09/5.14
Baseline	77	1 (1%)	22 (29%)	40 (52%)	14 (18%)	31.38/4.42
Fam Fire 2						
Test-D	78	4 (5%)	19 (24%)	35 (45%)	20 (26%)	31.74/4.96
Baseline	82	6 (7%)	11 (13%)	43 (52%)	22 (27%)	32.28/4.79
RF 1						
Test-D	78	3 (4%)	21 (27%)	34 (43%)	20 (26%	32.06/4.64
Baseline	81	0 (0%)	14 (17%)	40 (49%)	27 (33%)	33.31/3.86
RF 2						
Test-D	78	3 (4%)	23 (29%)	32 (41%)	20 (26%)	31.35/4.81
Baseline	80	2 (2%)	23 (29%)	41 (51%	14 (18%)	31.31/4.54
RF 3						
Test-D	77	3 (4%)	18 (23%)	37 (48%)	19 (25%)	31.65/5.05
Baseline	81	2 (2%)	16 (20%)	43 (53%)	20 (25%)	32.52/4.11
Highest of RF 1-3						
Test-D	78	0 (0%)	10 (13%)	31 (40%)	37 (47%)	34.72/3.71
Baseline	80	0 (0%)	5 (6%)	37 (46%)	38 (48%)	35.04/3.19

Note. All Soldiers qualified at the end of RF 2. RM 16 was Familiarization Fire 1 and 2. RM17 was RF 1 and 2. RM 18 was RF 3.

The following analyses were conducted.
Repeated measures ANOVA on RF1-RF3 (RM 17-18): No significant group differences (Test-D vs. Baseline), $F(1,155) = 1.37$, $p = .243$.

When univariate ANOVAs were conducted on each of the RF measures, none showed a significant difference between the two groups.

Repeated measures ANOVA on (RM 16-18): No significant group differences (Test-D vs. Baseline), $F(1,147) = .699$, $p = .405$.

Correlations Between BUIS and CCO Scores

Tables B16 through B18 document the correlations between BUIS measures and CCO scores. Variables are the rounds used in the initial zero period (not total rounds), PRF1 and 2 with the BUIS (RM7), and FF1 and 2 (RM16) with the CCO, and RF 1-3 with the CCO (RM17-18). Given the sample sizes, some relatively low correlations were significant. However, correlations above +/-.30 are more meaningful given the correlations that are often found with marksmanship data. Comments here are based on the .30 "cut-point" (referred to as scores being "correlated").

In general, BUIS performance did not correlate with CCO performance. Although the number of rounds used during the initial zero period correlated negatively with BUIS and CCO performance, no correlation was above .30 cut-point. Also PRF1 and PRF2 with the BUIS correlated with each other (.38 to .48). The only correlation above .30 between BUIS and CCO scores was between PRF1 (BUIS) and RF1 (CCO) (r = .35). Lastly, the CCO scores correlated with each other.

Table B16
BUIS and CCO Correlations for All Soldiers

	BUIS			CCO				
Live-fire Measure	Initial Zero Rounds	PRF1	PRF2	FF1	FF2	RF1	RF2	RF3
BUIS								
Init Z Rds	___	-.23*	-.10	-.13	-.17	-.20*	-.15	-.06
PRF1		___	.48*	.15	.23*	.35*	.18*	.04
PRF2			___	.15	.14	.25*	.02	.19*
CCO								
FF1				___	.40*	.45*	.37*	.44*
FF2					___	.49*	.43*	.38*
RF1						___	.51*	.30*
RF2							___	.44*
RF3								___

Note. . Pairwise deletion of firers.
*p < .05. Any correlation above +/- .17 was statistically significant at the .05 level

Table B17
BUIS and CCO Correlations for Baseline Soldiers

Live-fire Measure	BUIS			CCO				
	Initial Zero Rounds	PRF1	PRF2	FF1	FF2	RF1	RF2	RF3
BUIS								
Init Z Rds	___	-.21	-.03	-.27	-.17	-.10	-.23	-.11
PRF1		___	.38*	.11	.25	.34*	.26	.11
PRF2			___	-.01	.14	.22	.01	.31*
CCO								
FF1				___	.37*	.42*	.35*	.39*
FF2					___	.52*	.49*	.29*
RF1						___	.46*	.30*
RF2							___	.46*
RF3								___

Note. Pairwise deletion of firers.
*$p < .05$.scores. Any correlation above +/-.27 was statistically significant at the .05 level

Table B18
BUIS and CCO Correlations for Test-D Soldiers

Live-fire Measure	BUIS			CCO				
	Initial Zero Rounds	PRF1	PRF2	FF1	FF2	RF1	RF2	RF3
BUIS								
Init Z Rds	___	-.17	-.11	.00	-.16	-.26	-.10	.00
PRF1		___	.48*	.17	.19	.31*	.12	-.03
PRF2			___	.25	.14	.25	.03	.09
CCO								
FF1				___	.42*	.47*	.38*	.48*
FF2					___	.46*	.39*	.45*
RF1						___	.56*	.28*
RF2							___	.43*
RF3								___

Note. Pairwise deletion of firers.
*$p < .05$. Any correlation above +/- .26 was statistically significant at the .05 level

RM18 Survey: Results on Overall Comparison Question

Tables B19 and B20 show the results from the final question on the RM18 survey where Soldiers rated their performance at the start of training and at the end of training.

The question was:
Rate your comfort level with *using your weapon system* in live-fire situations when you **very first started firing** in rifle marksmanship training **and** what it is **today.** "*Using your weapon system*" includes firing it as well as reacting to malfunctions on your own, use of eye and hearing protection in live-fire situations, weapon carry techniques, safety procedures, modifying your point of aim, ability to assume a steady firing position quickly, etc.
(Check 1 box [1 --- 10] for each comfort rating. Rate both items (a and b).)

Table B19
Number of Soldiers Marking Each Rating Category on Comfort Level With Using Their Weapon System in Live-fire Situations

Group and Question	# of Soldiers by Rating Category									
	Low level of comfort. Uncertain or unaware of many aspects of firing.									High level of comfort. Can react well to different firing conditions.
Rating (1-10)	1	2	3	4	5	6	7	8	9	10
Test-D platoons										
a. Initial Firing	3	6	10	9	13	10	16	3	5	3
b. Today	0	0	0	1	1	0	5	15	28	28
Baseline platoons										
a. Initial Firing	6	3	10	5	10	12	8	10	8	9
b. Today	1	0	0	1	0	4	3	10	23	39

Test-D: Means - Initial Firing = 5.35, Today (end of RM18) = 8.90
Baseline: Means - Initial Firing = 5.95, Today (end of RM18) = 9.00

Table B20
Percentage of Soldiers in Rating Categories on Comfort Level Question

Group & Question	1 to 4 Ratings	5 to 7 Ratings	8 to 10 Ratings
Test-D: Initial Firing	36%	50%	14%
Baseline: Initial Firing	30%	37%	33%
Test-D: Today (RM18)	1%	8%	91%
Baseline: Today (RM18)	2%	9%	89%

There was a significant difference on the initial firing ratings in these three rating categories:
$\chi^2(2) = 8.16$, $p = .0168$.

Table BF21
Frequency Distributions of all Record Fire Scenarios: All Soldiers

Score	# of Soldiers						
	PRF1 BUIS	PRF2 BUIS	FF1 CCO	FF2 CCO	RF1 CCO	RF2 CCO	RF3 CCO
6	0	1	0	0	0	0	0
7	0	1	0	0	0	0	0
8	2	0	0	0	0	0	0
9	1	0	0	0	0	0	0
10	0	3	0	0	0	0	0
11	0	0	0	0	0	0	0
12	2	0	0	0	0	0	0
13	3	0	0	0	0	0	0
14	2	1	0	0	0	0	0
15	3	4	0	1	0	0	0
16	3	6	1	0	0	0	0
17	5	2	0	1	0	1	0
18	6	2	1	1	0	1	1
19	2	6	0	1	0	0	0
20	5	7	2	1	1	0	0
21	7	7	2	2	0	2	1
22	7	8	1	2	2	1	3
23	5	6	3	2	1	2	3
24	5	12	8	1	2	4	4
25	9	6	6	2	5	10	5
26	11	10	2	4	7	5	8
27	11	16	6	10	6	10	5
28	3	16	8	8	6	8	3
29	10	8	10	3	8	7	6
30	6	3	10	10	7	14	10
31	9	11	8	10	6	9	14
32	6	4	10	12	13	17	13
33	6	1	12	17	16	9	12
34	1	5	14	16	19	13	10
35	4	2	19	13	13	11	21
36	5	0	13	21	13	9	13
37	0	1	11	6	14	15	12
38	1	1	4	8	12	7	6
39	0	0	1	5	8	0	6
40	0	0	0	2	0	3	2
N	140	150	152	159	159	158	158
Mean	24.99	24.77	31.24	32.02	32.70	31.33	32.09

Note. The lines in the table indicate the divisions between the marksmanship categories.

Record Fire Scenario

Figure B1 presents the record fire course used in RM7, RM16-18, plus the EST and Test-D scenarios. This course is the same as that in FM 3-22.9 (DA, 2008). Standards for the marksmanship categories are: Expert 36-40; Sharpshooter 30-35; Marksman 23-29; Unqualified below 23.

Table 1. Prone Supported or Foxhole Supported				Table 2. Prone Unsupported		Table 3. Kneeling	
Range(m)	Time(sec)	Range(m)	Time(sec)	Range(m)	Time(sec)	Range(m)	Time(sec)
50	3	100		200	6	150	8
200	6	200	8	250	8	50	4
100	4	150	10	150	6	100	5
150	5	300		300		150	6
300	8	100	9	200	10	100	5
250	7	250		150		50	4
50	3	200	6	200	12	100	5
200	6	150	5	250		150	6
150	5	50	6	150	9	50	4
250	7	100		150	6	100	5

Figure B1. Record Fire table in FM 3-22.9 Rifle Marksmanship M16-/M4- Series Weapons (2008). (Based on DA Form 3595-R, September 2008). [Double target exposures are indicated when there is no line separating targets at two different distances and a single time exposure is given, e.g., 100m and 200m are exposed for 8 seconds in Table 1 (prone supported) of record fire.]

Appendix C

Drill Repetitions

Explanation of the information in Tables C1 through C5 is as follows:

- The same Soldiers were not always in the same room every day.
- A Soldier did not always stay in the same firing order on a given day.
- The drills were not executed in the order cited in the tables, but were put in logical groups for purposes of the report.
- Two numbers in a cell indicate that the firing orders had different numbers of repetitions. The two numbers are presented from low to high, not by first and second firing order.
- The numbers in the tables cannot be used to determine the minimum and maximum number of total repetitions for Soldiers in a room.
- The tables show inconsistencies in drills used across the training rooms as well as within a room.
- The numbers do not represent the number of trigger pulls, as the number of shots taken varied with the drill (see Appendix A).

The data were from the digital records recorded on the Test-D system.

Table C1
Test-D Drills on Day 1 (RM2) Prior to 25m Zeroing: Number of Repetitions

Drill	Room A	Room B	Room C
Distance from Center	3	2	4
Grouping – Prone	10	4	3
Grouping – Kneeling	0 & 2	0	2 & 3
KD – 100 E-Silhouette	2 & 3	1 & 4	2 & 3
KD – 200 E-Silhouette	2 & 4	2 & 5	2
KD – 300 E-Silhouette	1 & 2	1 & 2	2 & 3
PS (RF)	1	0	1
PUS (RF)	1	0	1
Kneel (RF)	1	0 & 1	1
Alt C	2 & 3	1	1 & 2
Alt C Competitive	1	1	2
200 yard E-Silhouette– 10 shots wi/1 min	0 & 2	0 & 1	1 & 2
200 yard E-Silhouette – 2 shots wi/1 min winner	0 & 1	0	0 & 1
Sight Reference 1	2	0 & 1	0
Sight Reference 2	2	0	0

Note. The number "3" in the Distance from Center by Room A cell indicates there were 3 repetitions of this drill for all Soldiers in the room. The numbers "0" and "2" in the Grouping-Kneeling by Room A cell indicate that one firing order did not execute this drill, while another firing order executed it twice.

Table C2
Test-D Drills on Day 3: Number of Repetitions

Drill	Room A (1FO)	Room B (1 FO)	Room C (1FO)
Distance from Center	2	1	1
Grouping – Prone	10	13	0
Grouping – Kneeling	0	2	3
KD – 100 E-Silhouette	2	5	0
KD – 200 E-Silhouette	3	3	0
KD – 300 E-Silhouette	4	2	9
PS (RF)	1	0	0
PUS (RF)	1	0	0
Kneel (RF)	2	1	5 & 6
Alt C	1	2	4
Alt C Competitive	1	2	3
200 yard E-Silhouette– 10 shots wi/ 1 min	3	2	0
200 yard E-Silhouette – 2 shots wi/ 1 min winner	2	0	0
Sight Reference 1	1	8	2
Sight Reference 2	1	1	2
Sight Reference 3	2	0	6

Note. 1 Firing order (FO) in each room; 42 Soldiers trained on Test-D; the remaining Soldiers were on the 25m zero range.

Table C3
Test-D Drills on Day 4: Number of Repetitions

Drill	Room A	Room B	Room C
Distance from Center	0	0	0 & 2
Grouping – Prone	3 & 7	3	0 & 1
Grouping – Kneeling	2	1 & 2	4
Zero Targets	1 & 2	5 & 7	1 & 5
KD – 100 E-Silhouette	1	1	0 & 1
KD – 200 E-Silhouette	1 & 2	1	0 & 1
KD – 300 E-Silhouette	0	1	1 & 2
PS (RF)	0	1	2 plus random [a] (0 & 1)
PUS (RF)	0	0	1
Kneel (RF)	0	0	5 & 9
Alt C	4 & 5	0	4 & 6
Alt C Competitive	0	0 & 1	1 & 4
200 yard E-Silhouette– 10 shots wi/ 1 min	0	1	0
Sight Reference 1	0	2	1 & 2
Sight Reference 2	0	2	1
Sight Reference 3	0	0 & 1	2
Eye Relief Drills	1	0	0

[a] Random refers to a scenario that presented the targets in the PS (RF) scenario in random sequence.

Table C4
Test-D Drills on Day 5: Number of Repetitions

Drill	Room A	Room B	Room C
Distance from Center	1	0	3 & 4
Grouping – Prone	4	1 & 3	0
Grouping – Kneeling	0	2 & 6	11 & 15
Zero Targets	2 & 3	2 & 3	0
KD – 100 E-Silhouette	1	1	0
KD – 200 E-Silhouette	2	1	0
KD – 300 E-Silhouette	0 & 1	1	0
PS (RF)	1	0 & 1	0 & 2
PUS (RF)	1	0	0
Kneel (RF)	2	0 & 2	4 & 7
Alt C	2 & 3	1 & 3	2 & 7
Alt C Competitive	0 & 1	0	1
200 yard E-Silhouette– 10 shots wi/ 1 min	4 & 5	0 & 3	0 & 2
Sight Reference 1	1	1	1 & 2
Sight Reference 2	1	1	1 & 4
Sight Reference 3	1	1	1 & 2
Eye Relief Drills	0	2	2 & 3
Silver Dollar Drop	0	0	2 & 3

Table C5
Test-D Drills on Day 6: Number of Repetitions

Drill	Room A	Room B	Room C
Distance from Center	0	3 & 5	0 & 2
Grouping – Prone	0	1 & 3	0
Grouping – Kneeling	1 & 2	3 & 4	2 & 3
Zero Targets	0	2	0
KD – 100 E-Silhouette	8	0	0 & 1
KD – 200 E-Silhouette	11	0	1
KD – 300 E-Silhouette	4	0	2 & 8
PS (RF)	3	3 & 4 (plus random[a] 1 & 2)	2 & 9
PUS (RF)	1	3	0 & 1
Kneel (RF)	4	5	0
Alt C	8	6 & 7	2 & 6
Alt C Competitive	0	3 & 5	0
200 yard E-Silhouette 10 shots wi/ 1 min	4	2	0
Sight Reference 1	1	2	0 & 1
Sight Reference 2	1	2	0 & 1
Sight Reference 3	0	2	0 & 1
Eye Relief Drills	3	1	2 & 4
Silver Dollar Drop	2	1 & 3	2 & 4

Note. Some Soldiers on 25m zero range, not in Test-D training
[a] Random refers to a scenario that presented the targets in the PS (RF) scenario in random sequence.
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Appendix D

Training Device/Simulation Research: Lessons Learned

Appendix D addresses two major training infrastructure or instructional subsystem feature issues in marksmanship training devices/simulations that emerged from the Test-D research. One is the feedback/instructional support infrastructure in the training simulation software. This issue focuses primarily on the initial learning of marksmanship skills. The second is the difficulty of the simulation exercises. This second issue focuses on the level of skill that is eventually needed in a device/simulation, so the skills will transfer to the desired levels of live-fire performance. As stated in the body of the report, research is needed to address these feedback/instructional support and exercise difficulty issues in marksmanship training simulations, if marksmanship simulations are to progress beyond their current levels of training effectiveness.

Feedback/Instructional Infrastructure in Marksmanship Training Simulations

The "early" marksmanship training devices (i.e., 1980s-1990s) were typically one-on-one devices (Weaponeer, Multipurpose Arcade Combat Simulator [MACS], Laser Marksmanship Training System [LMTS]/Beamhit). Some are still used in marksmanship training.

This Appendix addresses some training feedback and instructional features that were not in the Test-D program, yet could be added to it (as well as other marksmanship simulations), and would likely improve Soldier performance. As noted in this report, most Soldier feedback with the Test-D program was "basic" – primarily hit or miss, which is essential but does not take advantage of simulation feedback capabilities. The system had a limited training infrastructure and placed considerable burden on the trainer to monitor multiple Soldiers. On the other hand, some marksmanship training devices (e.g., Weaponeer, MACS), designed and used to train single individuals, incorporate substantial training feedback directly to the Soldier. This feedback is needed to enable the Soldier to progress to a higher level of proficiency.

The feedback and the instructional design features in MACS evolved during its development and testing period (see Broom et al., 1989; Evans, Dyer, & Hagman, 2000). The program is self-paced and adapts to the shooter's status. Feedback and instructional features include the following.

- Trainer alerts as to student status: The color border on the target screen informs the trainer to student status.
- Seven levels of skill are incorporated. As the system is self-paced, the shooter is provided feedback on status and sent back to a prior level if having difficulty. If that is necessary, the shooter is told what is happening and why it is happening.
- Descriptive diagnostic measures of the four fundamentals: steady position, aiming, trigger squeeze, and breath control.
- Shooter feedback is provided on each measure. Initially feedback is augmented, but as the shooter progresses in skill, the amount and type of feedback is withdrawn. Fully augmented feedback provided directly to the shooter takes three forms:

    - Concurrent feedback: bullet strike location, hit/miss, shot replay
    - Information feedback: assessment of performance on the four fundamentals and shot replay (e.g., verbal descriptions - excellent to poor)
    - Learning feedback: delayed feedback – a visual display of the location of previously fired shots at each target range.
- An aiming or accuracy score is based on the distance between the mean points of aim (readings before trigger closure) relative to the center mass of the target. This score is used at certain points to determine whether a Soldier should progress to higher levels of skill training.
- Standards are set progressively harder as the shooter progresses through the levels of training.

Evans (1988) summarized the development of the MACS system and training software. Of particular interest is the research on movement of the rifle in the shot process, how it discriminated between good shooters versus less experienced shooters, and the importance of measuring it and providing the corresponding feedback. This research served as the rationale for showing Soldiers a replay of their rifle movement before and after a shot.

Schendel, Heller, Finley, and Hawley (1984) described the feedback on the Weaponeer as including location of hits and misses, replay of rifle movement in the three seconds prior to firing, and shot displays showing the location of the shot in the order in which it was fired. Also shown are the number of hits and misses on targets, the number of late shots (fired after target dropped), and the total number of shots fired.

The Engagement Skills Trainer (EST) 2000 has some of the diagnostic feedback and instructional design features just described, but the EST operator typically does not show them unless a Soldier is having difficulties. The system automatically shows shot location (hits and misses), indicates whether the standards have been met (e.g., grouping within a 4cm circle, single and multiple target scenarios, and practice record fire), and shows total scores and scores by target distance. If a standard is not met (e.g., grouping), the operator must reset the exercise to enable the Soldier to repeat it. Not automatically shown are such diagnostic features as shot replay, trigger squeeze, and weapon cant.

Another feature that was lacking in the EST 2000 and Test-D simulations is a means of tailoring the training to the proficiency status of the firer. This capability was in MACS, which was a one-on-one training device.

Some of the same feedback features were found on a handgun simulation: weapon pull, cant, barrel movement, and the trace of the muzzle two seconds before trigger squeeze and two seconds after trigger squeeze (Jensen & Woodson, 2012). Scores and location of rounds on the target were shown. For one scenario, the authors indicated that the instructor's control panel was turned toward the firer, which allowed the firer to see the system feedback that was viewed by the instructor. It is noted that the simulation and live-fire targets were color-coded to represent different weightings for shots in six different regions of the target (a hit in the center had more points than one at the bottom of the target). These colors were apparently observable to firers as the engagement distances ranged from 3 to 15 yards.

It would appear that these types of training features could also be incorporated into the Test-D and other marksmanship simulators which train multiple individuals simultaneously. An important factor to stress is that when different forms of feedback can be given directly and automatically to the shooter that in turn reduces the trainer's workload and can also assist the trainer in helping the Soldier. However, supportive feedback should be withdrawn as Soldiers' skills progress, so they do not become dependent on it. With multiple-firer training devices/ simulations, it is incumbent on the trainer to carefully monitor every Soldier when the system itself does not automatically provide detailed, informative, and understandable feedback to the individual Soldiers.

Another needed instructional feature for marksmanship simulators / systems that should be considered are guidelines for the instructor. It is not uncommon to have new instructors or trainers who are not familiar with all the training features of a device. The opportunity to gain formal training is limited and there is no backup provided on how to use the device/simulation, the training features that exist, how and when to leverage training features, etc. There is no trainer guidance. Consequently trainers often use just the minimal, more obvious features. For example, in the Dyer, Pleban, Vaughn, Salvetti, and Clark (2004) research with the EST 2000, the new equipment training team focused on setting up the equipment; there was no train-the-trainer phase or documentation. Moreover, it appears that there still are no materials that describe and explain the training and diagnostic features of the EST 2000 for Drill Sergeants and other trainers. Lack of readily accessible instructional/training guides likely limits the trainer's ability to exploit the training features in marksmanship simulations.

Difficulty Levels in Marksmanship Simulations

If there is to be an increasing reliance on training devices/simulations in marksmanship training, then there needs to be empirical evidence that they provide the desired level of Soldier proficiency. Substantial research has been conducted on marksmanship training devices/simulations, and the empirical evidence is not always consistent. Historically, marksmanship training devices/simulations have been used for remedial training, preparatory training, supplementary training, and/or training for specific scenarios in combination with live-fire training. Devices/simulations have not replaced all or most all live-fire training. Other research has examined the extent to which simulator scores correlate with record fire scores. Examples of this body of research and summaries of such research include the following:

- U.S. Army Infantry Board's (1986, 1987a, 1987b) three concept evaluation program tests with the M16 rifle (called "Gowen South", 1986-1987; MACS, Weaponeer, plus other devices in the 1986 test).
- EST Training Effectiveness Analysis (Scholtes & Stapp, 1994); other EST research (Dyer et al., 2004; Hagman, 1998). Stephens and Tembly (2014) used a system very similar to the EST.
- Summary of MACS research (Evans, 1988).
- Summary of ARI research with training devices (Evans, Dyer, & Hagman, 2000), research with the Weaponeer (Schendel et al., 1984; Schendel & Williams, 1982), and research with the Laser Marksmanship Training System [LMTS] (Hagman, 2000).

As stated, the results of these prior research efforts were often mixed --- immediate positive effects from use of a device for remediation or supplementary training in the early stages of initial entry training but often no lasting effects in the marksmanship program of instruction (e.g., no differences on record fire), no differences with live-fire control groups when used to replace or supplement live-fire, savings in training time or ammunition may occur in early training phases, and devices often help Soldiers with marksmanship problems. Stephens and Tembly's (2014) description that their "findings show that simulator training had a small, positive benefit, but that the overall training was not particularly satisfactory (p. i)" could apply to much of this research. Therefore, when the intent is to replace much marksmanship training with simulation, as was the case in the current effort, the challenge was great and the outcomes were not necessarily predictable.

In the current effort, for both the Baseline and the Test-D platoons, Soldier performance with the simulation was higher than live-fire performance on the same scenario. This occurred for the Baseline platoons (EST 2000) on the singles and multiples scenarios, and for the Test-D platoons on the record fire scenarios. The same result occurred in earlier EST research with initial entry training Soldiers on singles and multiples, and on record fire scenarios (Dyer et al., 2004). However, Hagman (1998) found the opposite result - higher record fire than EST scores with National Guard Soldiers.

The critical question is why was performance on the simulations easier or better than live-fire? Many possible explanations for the higher performance levels in marksmanship devices/simulations have been offered. The reasons offered often include characteristics of the device, the training program, and/or the training conditions (e.g., the shooter is not exposed to the weather, the shooter is very close to the screen even though targets are scaled, target images are easier to detect on the screen, the zero of the simulation weapon is calibrated).

However, another explanation may be the level of difficulty of the training exercises themselves. Having individuals eventually train to a higher level of difficulty may result in positive transfer to live-fire and make live-fire seem "simple" rather than difficult or challenging. This concept is supported by research on flight simulators and some work on gunnery simulators. The flight simulator research is summarized first.

With flight simulators, above real-time training (ARTT) is a training paradigm that places the individual in a simulator that operates at faster than normal time (fast-time training), rather than a training environment that exactly replicates real-time (Crane, Guckenberger, Schreiber, & Robbins, 1997; Guckenberger, Stanney, & Lane, 1993; Guckenberger, Uliano, & Lane, 1993). According to Crane et al. (1997), NASA test pilots in the 1970s reported that, despite training in a simulator at real time, actual flight seemed to take place at a much faster time frame. However, pilots reported that after practicing in simulations operating at 1.4 to 1.5 times faster than real-time before flights, they felt less rushed, more confident, and better able to handle their workload than when using only real-time training.

More systematic research on ARTT with flight simulations since the 1970s has varied the criterion tasks, the faster-than-normal time speeds for training, combinations of different time accelerations, etc. With time-compressed training, performance during training could decline,

but on test trials with more complex tasks, performance was higher (response time, conducting emergency procedures). In addition, with ARTT more training events occur without an increase in clock time, and the additional training trials "result in higher real-time test scores than fewer training trials presented in real time" (Crane et al., 1997, p. 29). Further, ARTT has been shown to yield the same level of performance in less clock training time compared to real-time simulation training. Some other conclusions by Crane et al. were that time-compressed training should not be used in situations where individuals are in their earliest stage of skill learning, where they are learning facts/procedures, and are in the process of understanding cues. Initial training should be real-time. Also ARTT should not be introduced where memory overload occurs. Easy tasks do not benefit greatly from more compressed training.

It is suggested that the analogy to compressing training time in flight simulators is to require a *higher degree of firing accuracy in marksmanship simulators*. It is noted that some researchers have treated the distance to the target as the difficulty factor. However, this research did not show positive transfer effects when target distance was increased in the simulation (Bliss, Lampton, & Boldovici [1992] in tank gunnery, and Schendel et al. [1984] in marksmanship training).

The suggestion that accuracy is the critical difficulty factor for marksmanship is based on two factors. One is the laser-based technology used in most current marksmanship simulators, including the two simulators in the current effort. The other factor is Holding's transfer-of-training concept of inclusion (as cited in Lampton, Bliss, & Meert, 1992).

With laser-based marksmanship simulations, the round's trajectory affects where the round impacts the target, but round dispersion does not, as is the case with live-fire. Also with laser-based simulations, all hits on a target are typically of equal value, making a head shot or a shot that barely hits the shoulder count the same as one that is closer to center-mass, where as in live-fire the shoulder shot has a higher likelihood of being a miss. Requiring more accuracy in the marksmanship simulator with different scoring procedures and/or factoring in the effects of round dispersion would be ways of making simulator exercises more difficult and possibly facilitating transfer to live-fire.

Holding's concept of inclusion (Lampton et al., 1992) applies to situations where the more difficult task includes the easy task. In other words, if you can do the more difficult task, you can also do the easy task. An example given is that if you are trained to hit an apple, you can hit a barn door. Lampton et al. examined this training approach with tank-gunnery. They compared three variations of the target area which were scored as a kill when hit. These kill variations were 150%, 100% and 50% of the target area, with the latter being the most difficult. Regardless of the condition, Soldiers saw the same visual image of the target. After training, individuals were tested, with the training device, on different targets with a kill zone of 100%. Criterion measures were target kills, aiming error, and time to fire. Practice with the most difficult criterion of 50% yielded greater kill percentages and less aiming error, but slower firing times.

The concept of scoring for greater accuracy was also included in the MACS software. Standards were gradually harder as the shooter progressed through the levels of training. The

program was designed so that "…shooters may hit a sufficient number of targets to get through a level but will only pass the level if they have on average also hit close to their centers of mass. In this sense, the standards demanded for record fire in the MACS BRM program are higher than those demanded in actual record fire, where a hit is sufficient" (Broom et al., 1989, p. 14).

Of additional interest is a result found by Stephens and Temby (2014) when comparing marksmanship simulation training (with a simulation similar to the EST 2000) and live-fire training results at 100m, 200m, and 300m. Soldiers indicated that the 200m and 300m target imagery was hard to see in the simulator, yet they performed better on live-fire at these distances, but there was no difference at 100m where the simulation target was easy to see. Although the authors interpreted this as a limitation of the simulator and a need to improve target visibility in the simulator, the result could be interpreted as a by-product of a more challenging condition in the simulator which led to corresponding higher live-fire scores.

This "increasingly-difficult" concept based on shooter accuracy could be applied to current laser-based marksmanship simulation trainers after the appropriate, essential, prerequisite skills have been acquired. More difficult scenarios could include grouping within a 3cm circle, scoring targets for hitting in certain areas of the target, scoring targets on the basis of round dispersion, etc. The impact on the Soldiers would be that the real-life scenario would be perceived as relatively easy. Which option for increasing the difficulty would have the greatest transfer effect to live-fire is unknown at this time, as there is minimal, if any research on this topic. However, it is clear from the flight simulator research and Holding's research (see Lampton et al., 1992) that the more difficult exercises should be introduced at the appropriate stage of learning.

Prior Research Related to Other Issues Raised in the Test-D Effort

Recoil in small arms simulators

Soldiers in the current effort stated that recoil in the Test-D weapon and the EST 2000 weapon was less than their actual M4 carbine. This finding is not new. For example, instructors made the same comment about the lack of recoil in MACS (U.S. Army Infantry Board, 1987a). Participants in the Stephens and Temby (2014) research also commented on the lower recoil in the simulation weapon. Evans (1989) examined the effect of adding recoil to MACS and found that MACS performance did not change. However, he also acknowledged that "this result suggests the accurate reproduction of recoil may be unnecessary in the marksmanship simulator, as long as live firing is a substantial part of the overall training strategy" (Evans et al., 2000, p. 17). This caution is important to consider when simulation is the primary training method.

Weapon handling issues

The DSs in the current effort commented on the lack of weapon handling skills by Soldiers in the Test-D platoons. Test-D platoon Soldiers also rated themselves lower on these skills than the Baseline platoon Soldiers. Of interest is that a similar comment was made by the active component Soldiers who used the EST 2000 (Scholtes & Stapp, 1994), where a concern was raised about less attention paid to weapon safety during EST training than on the range. With the EST 2000 in the current research, Soldiers had to have their weapon on "safe" after firing a scenario as they could not engage targets again unless the weapon was initially on "safe." The EST 2000 operator monitors each Soldier's weapon status on the operator's station. It is not known whether this feature was in the version of the EST 2000 used in the Scholtes and Stapp (1994) research.

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