CRESST REPORT 783

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# REVIEW OF RIFLE MARKSMANSHIP TRAINING RESEARCH

JANUARY 2011

**The National Center for Research on Evaluation, Standards, and Student Testing**

Graduate School of Education & Information Sciences
UCLA | University of California, Los Angeles

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January, 2011

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The work reported herein was supported under Naval Postgraduate School Award Number N00244-08-1-0044, as administered by the Naval Postgraduate School. The findings and opinions expressed in this report do not necessarily reflect the positions or policies of the Naval Postgraduate School.

To cite from this report, please use the following as your APA reference:
Chung, G. K. W. K., Nagashima, S. O., Delacruz, G. C., Lee, J. J., Wainess, R., & Baker, E. L. (2011). *Review of rifle marksmanship training research.* (CRESST Report 783). Los Angeles, CA: University of California, National Center for Research on Evaluation, Standards, and Student Testing (CRESST).

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## Abstract

The UCLA National Center for Research on Evaluation, Standards, and Student Testing (CRESST) is under contract from the Naval Postgraduate School (NPS) to conduct research on assessment models and tools designed to support Marine Corps rifle marksmanship. In this deliverable, we first review the literature on known-distance rifle marksmanship research in Section I. In Section II we examine USMC combat marksmanship. Because the USMC Combat Marksmanship Program (CMP) (including moving targets) is new, there is no current research that we know of that has specifically examined assessment of CMP elements and we thus identify assessment issues. Section III reviews the use of sensors in the assessment of rifle marksmanship skill, and we provide detailed information on our prior work on developing and validating measures for known-distance rifle marksmanship. Section IV provides an overview of various marksmanship training systems in use by the USMC as of 2006. Based on the available information, we examined each system with respect to capabilities needed to support research on marksmanship. Section V provides a detailed research plan and schedule intended to investigate the assessment issues covered in Sections I to IV.

## SECTION I: KNOWN-DISTANCE RIFLE MARKSMANSHIP

### Background

Rifle marksmanship is a core value of the Marine Corps. The creed "Every Marine is a Rifleman" embodies the value Marines place on marksmanship. Marines are recognized as having the best marksmanship training and riflemen of the uniformed services and the Marines' competitive marksmanship program has consistently generated world-class shooters since its inception. Marines have to undergo annual qualification and their performance accounts for part of a promotional decision. Regardless of occupation, whether their job is infantry, air combat, or support, and regardless of weapons specialty, every Marine[1] must qualify on a rifle at least as a marksman or it is unlikely he or she will be promoted.

### Why Is Consistently Hitting a Target Difficult?

One of the most remarkable achievements in USMC marksmanship training and weaponry is in developing a shooter's skill to routinely hit a 19-inch circular area at 500 yards in the prone position. Five hundred yards is about 1.5 times farther than the distance between two people at opposite ends (lengthwise) of the Los Angeles Coliseum (see Figure 1). What makes this achievement even more remarkable is that virtually any deviation of the rifle from the center line will result in a miss. A rifle muzzle deflection of 1/16 inch (about the thickness of a quarter) from the center line will result in the bullet strike being off by about five inches at 100 yards and over 2 feet at 500 yards.

[1] Some exemptions apply based on experience or rank, such as Marines with 20 years or more of active duty, Colonels and above, Sergeants Major or Master Gunnery Sergeants, and CWO 4 and 5.

*Figure 1.* Example of the USMC qualification distance in the slow-fire prone position: approximately 1.5 stadium lengths of the Los Angeles Coliseum.

Adding to this complexity are uncontrollable factors such as wind velocity, gravity, and ammunition ballistics. For example, a 10-mph breeze (enough to raise dust and loose paper) displaces a round about 2 feet over 500 yards. Gravity alone results in the round dropping 20 inches over 300 yards. Variations in the amount of propellant across bullets result in 10-inch shot groups at 300 yards for skilled shooters (U.S. Army, 1989).

These examples do not take into account factors associated with the shooter—perhaps the most variable component. Normal breathing in the standing position can displace the rifle muzzle 1/2 inch from inhale to exhale, while changes due to the heart pulse can also displace the muzzle a fraction of an inch. If a shooter's sight alignment is off by a fraction of an inch, the shooter is unlikely to hit the target. Fatigue decreases results by causing shaking, wobble, or other instabilities; flinching or bucking due to recoil or reaction to the report causes the shooter to jerk the rifle, as does pulling or yanking the trigger. Exacerbating position instability is the emotional state of the shooter—anxiety and other factors increase the heart and breathing rates. Finally, the recoil from the rifle can cause the muzzle to rise about 20 milliradians (Torre, Maxey, & Piper, 1987). Figure 2 shows how minute changes of the rifle affect the bullet strike under ideal conditions. For example, moving the muzzle 1/8 of an inch results in the bullet strike being off-center by nearly 2 feet at 200 yards.

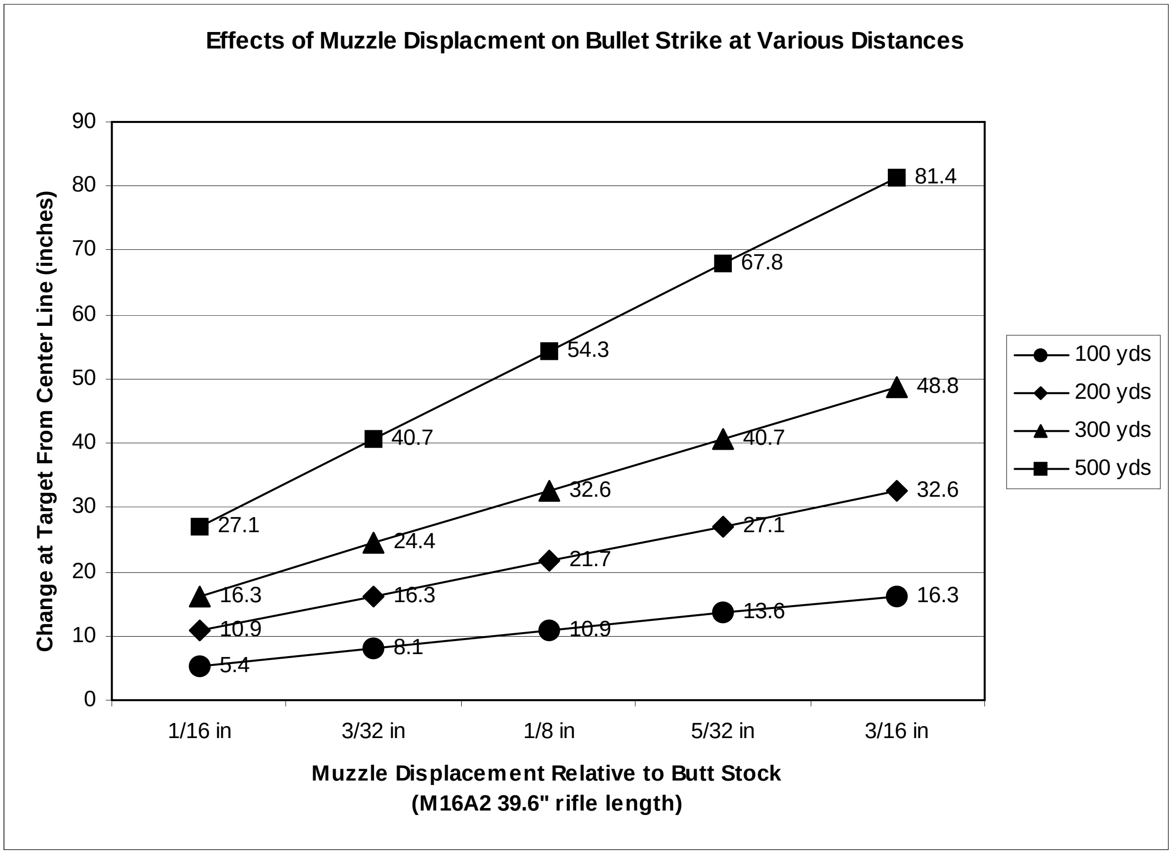



*Figure 2.* Estimated effects of muzzle displacement on bullet strike at different distances under ideal conditions. Actual displacement is greater.

Thus, accurately and consistently hitting a target is a complex interaction of factors immediately before, during, and immediately after the round goes off: establishing and maintaining sight alignment on the target, maintaining postural steadiness, not disturbing the rifle while squeezing the trigger, and adjusting for environmental effects. Virtually any deviation from a motionless position will result in a miss, virtually any deviation from a perfectly aligned and sighted rifle will result in a miss, and lack of compensation for wind, distance, and other environmental factors will result in a miss.

Further, accurately predicting shooting performance may be difficult given the low reliability of record-fire scores (Schendel, Morey, Granier, & Hall, 1983). The relationships between successive trials have been found to range from no relationship (Marcus & Hughes, 1979) to moderate correlations in the .5 range (Vielhaber & Lauterbach, 1966), to high correlations (MacCaslin & McGuigan, 1956) in the mid- to high .80s.

## Prior Rifle Marksmanship Research

There has been little effort to understand rifle shooting as a complex skill as opposed to other sports (c.f., baseball [French, Nevett, Spurgeon, Graham, & Rink, 1996; French, Spurgeon, & Nevett, 1995; Nevett & French, 1997], tennis [McPherson, 1999a, 1999b; McPherson & French, 1991; McPherson & Thomas, 1989; Nielsen & McPherson, 2001]). In general, the conceptual framework behind marksmanship research has been driven by improving training on the "fundamentals of rifle marksmanship"—the physical and mental factors believed to underlie skilled shooting performance. The basic set of relationships among postural stability, rifle handling, distance, and weather were established by World War I. For example, the 1916 Marine Corps Score Book (Harllee, 1916) describes the set of marksmanship fundamentals that are also covered in the Marine Corps Rifle Marksmanship Manual (U.S. Marine Corps, 2001). The basic procedures for aligning sights, maximizing position stability, and establishing and maintaining breath and trigger control remain essentially unchanged. Most of the research on rifle marksmanship has been conducted by the U.S. Army where the focus has traditionally been on developing and evaluating different training programs (e.g., Evans, Dyer, & Hagman, 2000; Evans & Osborne, 1998; Evans & Schendel, 1984; Hagman, 1998, 2000; Hagman, Moore, Eisley, & Viner, 1987; Hagman & Smith, 1999; McGuigan, 1953).

Studies that have explicitly attempted to predict rifle performance have been conducted in the context of evaluating how well performance on a rifle simulator relates to actual record-fire performance on the firing range (e.g., Hagman, 1998; Marcus & Hughes, 1979; Schendel, Heller, Finley, & Hawley, 1985; Smith & Hagman, 2000; Torre et al., 1987). Another body of research has used shooting as a platform to study skilled behavior in relation to psychophysiological constructs and measurements (e.g., Bird, 1987; Hatfield, Landers, & Ray, 1987; Janelle et al., 2000; Kerick, Iso-Ahola, & Hatfield, 2000; Konttinen & Lyytinen, 1992, 1993; Konttinen, Lyytinen, & Konttinen, 1995).

A complementary approach that we have adopted is to conceptualize the domain of rifle marksmanship performance as a function of skill and environment. We have conceptualized the skill component as being composed of three interrelated dimensions: perceptual-motor, cognitive, and affective. The environment component is composed of two factors that are uncontrollable, equipment and environment.

Unfortunately, shooting has not been conceptualized as a skilled sport and there has been little in the way of theoretical development to point to the set of important variables or processes underlying skilled shooting performance (Chung, Delacruz, de Vries, Bewley, &

Baker, 2006). By extension, prior research provides little specific guidance on which variables to measure. However, one conclusion that is clear from prior research is that consistently hitting the same area of a target is difficult. This difficulty is presumably due to the requirement to simultaneously coordinate gross-motor control of body positioning with fine-motor control of the trigger finger, minute movements of the hands, elbows, legs, feet, and cheek, and perceptual cues related to the target, front and rear sights, rifle movement, and body movement, while under stressful conditions. Thus, from a theoretical stance, little is known about which variables differentiate shooters of different skill levels; how perceptual-motor, cognitive, and affective variables relate to each other over time; how fast shooting skill decays over time; how sensitive shooting performance is to shooting conditions; or the relative importance of different shooting position variables.

**Knowledge of Rifle Marksmanship**

Chung et al. (2004) conducted a cognitive task analysis for rifle marksmanship, which resulted in identifying 119 key knowledge components culled from the USMC rifle marksmanship doctrine manual (USMC, 2001). The knowledge components are given in Appendix A. The knowledge was separated into 37 factual and 38 causal knowledge components. Further refinement of the knowledge components resulted in identifying key factual knowledge (Appendix B) and key causal knowledge. Factual knowledge covered basic definitions and procedures and in general, could be acquired via rote memorization. Causal knowledge covered cause-effect relations (Appendix C) and was considered more conceptual. To determine which knowledge components to sample in potential assessments, Chung et al. asked the USMC marksmanship coaches to identify the topics most relevant to shooting performance. As a result of this consultation, Chung et al. eliminated topics related to weather or the environment (e.g., effects of overcast), uniform (e.g., effects on placement of the rifle butt in the shoulder), ammunition, physiology (e.g., perspiration, rapid fatigue), and equipment (e.g., effects of rifle chamber temperature). The remaining knowledge elements were the major elements presumed to be most directly related to placing a round on target. Table 1 shows the topics and subtopics that Chung et al. sampled across their assessments and represent the most relevant knowledge related to known-distance rifle marksmanship.

Table 1

Topics Sampled in Assessments

| Topic | Subtopics |
|---|---|
| Breath control | Breath control, Natural Respiratory Pause, Natural point of aim |
| Trigger control | Bucking, Finger placement, Firm grip, Flinching, Grip of firing hand, Trigger control Trigger squeeze |
| Aiming | Accuracy, Aiming process, Follow-through, Eye on front sight post, Sight adjustment, Sight alignment/picture |
| Position | 7 factors common to all shooting positions, Body placement, Bone support, Eye relief, Feet placement, Finger placement, Firm grip, Forward elbow placement, Forward hand placement, Leg placement, Muscular relaxation, Muscular tension, Rifle butt placement, Stable firing position, Stock weld placement |
| Other | Consistency, Distance effects, Weapons safety, BZO setting |

## Rifle Marksmanship as a Complex Skill

Chung, Delacruz, et al. (2006) called for the use of the skill development framework originally proposed by Fitts and Posner (1967) and extended by Ackerman (1988, 1992) to understand the development of rifle marksmanship skills in novices. Fitts and Posner characterized skill learning in three phases: an initial cognitive or learning phase, an intermediate "associative" or practice phase, and a third "automaticity" phase. Ackerman's extension specified the relative contribution of aptitude, perceptual, and psychomotor variables across the phases, showing the initial importance of aptitude during the learning phase when trainees are learning the task, with diminishing influence of aptitude during the latter phases. Conversely, perceptual-motor and psychomotor skills initially contribute less to overall performance during the learning phase and become increasingly important in the latter phases when trainees already understand the task demands. Note that these relations hold for tasks that are stable with respect to the task goals and features, as is the case with known-distance shooting. It is unclear whether these relations hold for more dynamic tasks such as those in the current USMC Combat Marksmanship Program (CMP).

### Presumed Characteristics of Shooters in the Learning Phase

During the initial learning of a skill, trainees become familiar with the basic rules and procedures underlying the task. Trainees are focused on proper execution of the task procedures, relevant perceptual cues, proper shooting position, how to coordinate breathing and squeezing the trigger, how to hold the rifle, how to align the sights, and how to use results (i.e., where the round hit) as feedback. Learning is focused on the acquisition of basic knowledge and procedures and trainees often engage in verbal rehearsals (e.g., mentally or orally rehearsing facts or basic procedures, such as “squeeze—not pull—the trigger,” Anderson, 1982). A characteristic of the learning phase is that performance is fraught with error and a trainee’s cognitive load is high as the trainee attempts to coordinate verbal and motor dimensions of the task. Performance is low, error-prone, and inconsistent, and requires conscious thought. The high cognitive-processing demands imposed by the task also make performance sensitive to distractions and other ongoing activities. Novice shooters would be expected to have a poor grasp of the fundamentals, score low, exhibit poor coordination and integration of the different elements of the fundamentals, and not be able to recognize correct from incorrect positions. Novice shooters would also be expected to be more sensitive to changes in the environment (e.g., weather, equipment malfunction, anxiety) than more advanced shooters.

While these characteristics presumably generalize across novices, individual differences in aptitude and motor control are expected to contribute to differential rates of skill acquisition. Ackerman’s skill acquisition theory (1988) hypothesizes that when trainees are learning a complex task, high aptitude facilitates acquisition of the knowledge required of the task, while motor skills are less influential. For example, Ackerman found that correlations between measures of aptitude and performance on a simulated air-traffic controller task were highest during the early trials of the task and diminished over subsequent trials. Conversely, perceptual-motor measures showed the opposite pattern, with such measures showing the highest correlations in the latter trials.

### Presumed Characteristics of Shooters in the Practice Phase

During the second phase, trainees have learned the basic rules and are now practicing implementing the skill. During the practice phase, gross errors common in the learning phase occur less frequently and trainees know what to expect of the task. For example, trainees would have a basic knowledge of weapons handling, terminology, and the fundamentals of rifle marksmanship. Attentional demands of the task are reduced and thus trainees can focus on refining gross- and fine-motor responses and develop and test techniques to improve performance. Practice on the task becomes more consistent and speed and accuracy improve over the learning period as coordination between cognitive and motor responses improves. Performance during the practice phase would continue to show improvement over the course of fire. During this phase and the more advanced automaticity phase, knowledge becomes increasingly compiled and broad ability measures and content-specific abilities become less influential on performance for closed-ended skills such as marksmanship (Ackerman, 1987, 1992).

## Presumed Characteristics of Shooters in the Automaticity Phase

Trainees who have reached the last phase can execute the skill automatically. Performance is highest, and is often effortless and requires little overt attention (Ackerman, 1987, 1992; Fitts & Posner, 1967). Performance is consistent and seemingly effortless and knowledge about carrying out the task is “compiled” (Anderson, 1982). The cognitive load on performers with respect to executing the task is lowered (compared to other phases), thus freeing up mental resources. Shooters who have reached the autonomous phase could be expected to be true experts—snipers or members of the rifle team, for example. Performance is consistent and robust against distractions. There may be increases in performance but the rate of improvement slows over time. Few individuals are expected to reach this phase without deliberate, effortful, and consistent practice. Similar characterizations of the development of cognitive skill have been postulated by Anderson (1982). Whether the task is perceptual-motor or verbal, the general idea is that learning occurs in several phases, which may overlap but involve distinctly different learning (Shuell, 1990).

## Understanding Rifle Marksmanship Within the Stages-of-Processing Framework

In this section we update the review of past rifle marksmanship research by Chung, Delacruz, et al. (2006). Table 2, Table 3, and Table 4 summarize the findings of studies that have explicitly examined predictors of record-fire performance with respect to perceptual-motor, cognitive and affective variables.

Table 2

Summary of Perceptual-Motor Variables Related to Performance ($p < .05$)

| Predictor variables | *r* | *n* |
|---|---|---|
| Rifle steadiness (Humphreys, Buxton, & Taylor, 1936) | .72 | 43 |
| Rifle steadiness (McGuigan & MacCaslin, 1955) | .22 | 148 |
| Rifle steadiness (Spaeth & Dunham, 1921) | .61 | 73 |
| Prior shooting experience and aptitude (MacCaslin & McGuigan, 1956) | $R$ = .67 to .72 | |
| Prior shooting experience (Tierney, Cartner, & Thompson, 1979), males | .24 | |
| Prior shooting experience (Tierney et al., 1979), females | .19 | |
| Prior hunting experience (Tierney et al., 1979), males | .21 | |
| Prior experience with a .22 rifle (Thompson, Smith, Morey, & Osborne, 1980), males | .21 to .25 | |
| Prior record-fire performance (McGuigan & MacCaslin, 1955). Repeated qualification course 3 times. | .88 and .84 | |
| Self-reported prior record-fire performance (Schendel et al., 1983) | .29 | 121 |
| Prior record-fire performance (Smith, 2000, Experiment 2) | .37 | 50 |
| Prior record-fire performance (Thompson, Morey, Smith, & Osborne, 1981) | | 388 |

| Predictor variables | $r$ | $n$ |
|---|---|---|
| Weaponeer device-fire (Schendel et al., 1985, Experiment 1) | .37–.74 | 102 |
| Weaponeer device-fire (Schendel et al., 1985, Experiment 2) | .17–.55 | 244 |
| Combat Training Theater device-fire (Marcus & Hughes, 1979) | low | |
| Laser Marksmanship Training System device-fire (Smith & Hagman, 2000) | .55 | 95 |
| Engagement Skills Trainer device-fire (Hagman, 1998) | .68 | 102 |
| Other device-fire (Torre et al., 1987) | .54 | 29 |
| Postural balance, side-to-side and front-to-back (Mononen, Konttinen, Viitasalo, & Era, 2007) | -.45, -.43 | 58 |
| Most recent record-fire performance (Chung et al., 2004, Study 1) | .41 | 121 |
| Most recent record-fire performance (Chung et al., 2004, Study 2) | .34 | 138 |
| Frequency of shooting outside job (Chung et al., 2004, Study 2) | .27 | 138 |
| Years of shooting experience before joining Marines (Chung et al., 2004, Study 2). | .26 | 138 |
| Perceived firing line experience [pre-qualification] (Chung et al., 2004, Study 2) | .33 | 138 |
| Perceived firing line experience [post-qualification] (Chung et al., 2004, Study 2) | .57 | 138 |
| No. of months since last training (Chung et al., 2004, Study 1) | -.26 | 152 |
| Perceived utility of marksmanship knowledge (Chung et al., 2004, Study 1). | .20 | 157 |
| Muzzle wobble (Chung, Nagashima, Espinosa, Berka, & Baker, 2008b)[a, b] | -.44 | 33 |
| Breath control (Chung et al., 2008b)[a, b] | .39 | 33 |
| Trigger control (Chung et al., 2008b)[a, b] | .42 | 33 |
| Perceived firing line experience (Chung et al., 2008b)[a, b] | .38 | 33 |
| Perceived firing line experience (Chung, O'Neil, Delacruz, & Bewley, 2005) | .69 | 42 |

[§]Significance level not reported. [a]Performance was measured using a rifle simulation systerm. [b]During the learning phase but not the practice phase.

Table 3

Summary of Cognitive Variables Related to Performance ($p < .05$ unless otherwise noted)

| Predictor variables | $r$ | $n$ |
|---|---|---|
| ASVAB clerical/administrative (Carey, 1990) | .26[§] | |
| ASVAB general technician (Carey, 1990) | .35[§] | |
| ASVAB electrical repair (Carey, 1990) | .32[§] | |
| ASVAB mechanical maintenance (Carey, 1990) | .38[§] | |
| ASVAB composite (Carey, 1990) | .32[§] | |
| Infantry training GPA (Carey, 1990) | .25[§] | |
| Core job knowledge (Carey, 1990) | .31[§] | |
| Supervisor ratings (Carey, 1990) | .16[§] | |
| Skill Qualification Test, a measure of a soldier's skill achievement (Wisher, Sabol, Sukenik, & Kern, 1991) | .24 | 439 |
| Knowledge of zeroing (Thompson et al., 1980) | .50 | 144 |

| Predictor variables | *r* | *n* |
|---|---|---|
| Knowledge of bullet strikes at greater ranges than the 25m target trainees were practicing on (Thompson et al., 1980) | .33 | 144 |
| Knowledge of distance effects and appropriate sight adjustments (Thompson et al., 1980) | .31 | 144 |
| Knowledge of rifle marksmanship (Chung et al., 2004, Study 1) | .29 | 156 |
| Knowledge of shot group errors (Chung et al., 2004, Study 1) | .27 | 154 |
| Knowledge of shooter positions (Chung et al., 2004, Study 1) | .20 | 156 |
| Perceived level of rifle marksmanship skill (Chung et al., 2004, Study 2) | .26 | 138 |
| Pre-training conceptual knowledge of rifle marksmanship (Chung et al., 2004, Study 3) | .51 | 34 |
| Knowledge of rifle marksmanship (Chung et al., 2004, Study 3) | .38 | 36 |
| Perceived level of rifle marksmanship knowledge (Chung et al., 2004, Study 3) | .41 | 36 |
| Perceived level of rifle marksmanship knowledge (Chung et al., 2005) | .39 | 42 |
| General Classification Test (GCT) (Chung et al., 2005) | .34 | 42 |
| Knowledge of rifle marksmanship (Chung et al., 2008b)[a, b] | .38 | 32 |
| Scientific reasoning (Chung et al., 2008b)[a, b] | .44 | 32 |

[§]Significance level not reported. [a]Performance was measured using a rifle simulation system. [b]During the learning phase but not the practice phase.

Table 4

Summary of Affective Variables Related to Performance ($p < .05$ unless otherwise noted)

| Predictor variables | *r* | *n* |
|---|---|---|
| State anxiety (Chung et al., 2004, Study 2) | -.41 | 138 |
| State worry (Chung et al., 2004, Study 2) | -.42 | 138 |
| Trait worry (Chung et al., 2004, Study 2) | -.29 | 138 |
| State anxiety (Chung et al., 2008b)[b] | -.52 | 32 |
| State anxiety (Chung et al., 2005) | -.51 | 42 |
| State worry (Chung et al., 2005) | -.59 | 42 |
| Trait worry (Chung et al., 2005) | -.44 | 42 |
| Self-reported nervousness (Tierney et al., 1979) | -.19 | |
| Predicted record-fire score for soldiers whose confidence estimates in their prediction were > 90% (Schendel et al., 1983) | .50 | 41 |

[§]Significance level not reported. [a]Performance was measured using a rifle simulation system. [b]During the learning phase but not the practice phase.

## Perceptual-Motor Variables

The perceptual-motor variables under consideration relate to the physical aspects of shooting such as carrying out the different shooting positions, establishing proper sight alignment and sight picture, and maintaining rifle steadiness. Skilled shooters are able to position various body parts to achieve maximum rifle support with minimal fatigue in different positions (prone, sitting, kneeling, standing), and establish and maintain sight alignment (centering the front sight post within the rear sight aperture) and correct sight picture (centering the sights on the target). A shooter's skill in consistently hitting the same spot on a target is determined largely by the extent to which he or she can maintain these factors before, during, and after firing a round.

**Steadiness.** For example, skilled shooters have been found to be able to hold a rifle steadier than unskilled shooters and this steadiness relates positively to shooting performance (Humphreys et al., 1936; McGuigan & MacCaslin, 1955; Spaeth & Dunham, 1921). In general, being able to maintain a steady body position has consistently been found to be related to shooting performance. In novice shooters with poor balance, side-to-side and back-and-forth movement were found to be negatively related to shooting accuracy. In contrast, no such relation was found among shooters with higher balance (Mononen, Konttinen, Viitasalo, & Era, 2007). Similar findings were found with novice shooters, with muzzle wobble negatively related to shot group precision (Chung, Nagashima, Espinosa, Berka, & Baker, 2008b). Compared to novice shooters, expert shooters have been found to perform higher on measures of whole-body stability (e.g., Era, Konttinen, Mehto, Saarela, & Lyytinen, 1996; Gates, 1918) and muzzle wobble (Chung et al., 2008b). While an obvious finding, what is less obvious is that experts have been found to increase their stability during the aiming period preceding the shot (Era et al., 1996).

**Experience with weapons.** Another important variable that has been found related to shooting performance is experience with weapons and prior record-fire performance. MacCaslin and McGuigan (1956) found self-reported shooting experience combined with aptitude scores contributed substantially to record-fire score prediction, with multiple $R$ between .67 and .72, $p < .01$. Similarly, Tierney et al. (1979) found low, positive relationships between self-reported prior rifle experience and record-fire scores for males and females ($r = .24$, $p < .05$; $r = .19$, $p < .05$). In addition, hunting experience also correlated significantly with record-fire scores for males ($r = .21$, $p < .05$). Similarly, significant relations were found between self-reported experience with a .22 caliber rifle and record-fire scores for male entry-level Army trainees ($r$ ranged from .21 to .25, depending on the experimental condition, Thompson et al., 1980).

**Previous record-fire performance.** In addition to experience with weapons, one of the best predictors of a record-fire score is the shooter's previous record-fire score. McGuigan and MacCaslin (1955) reported test-retest reliabilities of unskilled Army trainees on three trials of a slow-fire qualification course. The average reliability of the slow-fire course for samples drawn from two Army bases was .88 and .84. Schendel et al. (1983) report a significant correlation between Army soldiers' self-reported prior record-fire score and actual record-fire score ($r = .29$, $n = 121$, $p < .01$). Smith (2000, Experiment 2) found a correlation of .37 ($p < .05$, $N = 50$) between the prior year's record-fire score and the current year's record-fire score for U.S. Army Reserve soldiers. As part of a study of skill retention, soldiers were retested 6 weeks after completing the basic rifle marksmanship course (Thompson et al., 1981). Soldiers ($N = 388$) repeated the same qualification course six weeks after record qualification. No correlations between record-fire and retest scores were reported; however, compared to the record-fire score, 33% of soldiers scored lower and 60% of soldiers scored higher. Recent investigations with Marines have found similar correlations, with previous qualification score correlating with the current qualification score in the .3 to .4 range (Chung et al., 2004, Study 1 and 2). Interestingly, when five years worth of qualification data were examined for all Marines, for both the enlisted and the officer groups, 75% to 82% of Marines qualify at the same or higher level, over different gap periods between subsequent qualifications. The majority of the sample remained at the same classification level or higher regardless of the time between qualifications, suggesting that sustainment-level classifications are stable (Kim, 2006).

**Device-fire performance.** Device-fire performance, or shooting performance on a rifle simulator, has been one of the strongest predictors of record-fire performance. The use of rifle simulators has received much attention because of the cost-savings potential for sustainment-level training and remediation.

One of the earliest rifle simulator systems was Weaponeer. Schendel et al. (1985, Experiment 1) examined the relationship between device-fire scores on Weaponeer and record-fire scores 1 to 2 days later (foxhole supported position only). Schendel et al. found correlations between .37 and .74, depending on the experimental condition. However, in a follow-up study, the authors found lower correlations, between .17 and .55. Similar results were found for the Laser Marksmanship Training System (LMTS). Smith and Hagman (2000) found a moderate correlation between LMTS device-fire scores and range record-fire scores ($r = .55$, $p < .05$, $N = 95$). Likewise, Hagman (1998) found a strong correlation between record-fire scores and device-fire scores using the Engagement Skills Trainer ($r = .68$, $p < .05$, $N = 102$). Finally, a moderate correlation was found by Torre et al. (1987) in their investigation ($r = .54$, $p < .05$, $n = 29$). Other systems have been investigated (e.g., Combat Training Theater, Marcus & Hughes, 1979), but low correlations between device-fire and record-fire scores have been found, possibly owing to poor live-fire range conditions.

**Summary.** Some of the strongest predictors of shooting performance are experience-related variables. Surprisingly, the magnitude of the relationship is lower than might be expected and the correlation between the experience-related variables and shooting score varies considerably across studies. For example, the test-retest reliability of previous shooting experience is at best in the .80s (McGuigan & MacCaslin, 1955) across the span of a few days. As the time interval increases (e.g., across annual qualifications), the correlation drops to the .30s. Just as surprising are the range of correlations between device-fire and record-fire scores (*r* ranges from .2 to .7) over one or two days. Our interpretation of these results is that in general, shooting performance is very sensitive to many variables. While perceptual-motor variables may be the strongest predictor of shooting performance, cognitive and affective variables may help explain the variation.

## Cognitive Variables

Presumably underlying shooting performance is the knowledge of marksmanship—(a) knowing position-related factors (e.g., what the different positions are, how to properly position limbs, how to control breathing and trigger, how to align the sights on the target), and (b) knowing cause-effect relations (e.g., knowing how yanking the trigger affects the muzzle, knowing why the rifle should be supported by bone instead of muscle, understanding the concept that everything a shooter does position-wise should minimize body movement [and thus rifle movement]).

The importance of knowledge of marksmanship was recognized by early authors on shooting. For example, Whelen (1918, p. 455) asserted that "Rifle shooting is almost entirely a matter of *intelligent* practice. Practice alone, without head work, will not get one very far." Similarly, the 1916 Marine Corps Score Book emphatically stated that Marines should not even be allowed to handle a weapon if they did not know the fundamentals of marksmanship (Harllee, 1916). However, rifle marksmanship research has virtually ignored the simple questions of how much do shooters know about marksmanship and how does their knowledge of marksmanship relate to their shooting performance?

**Training effects.** The available evidence suggests that shooting performance is sensitive to knowledge. Studies of different training programs clearly show group differences in record-fire scores. For example, McGuigan (1953) compared part- and whole-task training methods with Army basic trainees. Those soldiers in the whole-task training condition outperformed soldiers in the part-task training condition on record-fire performance. Further, regardless of training condition, soldiers in general shot higher after receiving training.

Additional evidence of the sensitivity of shooting to instruction is seen in an instructional study by Boyce (1987). In her study, Boyce compared the performance of unskilled (novice) shooters in the prone position across three instructional conditions and a control condition over five days (trials). The experimental conditions received different forms of instruction on marksmanship. The control condition received the minimal instruction required to safely shoot the weapon. In general, conditions with instruction on marksmanship significantly outperformed the control group. In addition, a main effect for trial was found, with the mean score across conditions on the first trial significantly lower than the mean score on subsequent trials. Similarly, higher rifle marksmanship performance was observed in normal versus accelerated training cycles, again suggesting sensitivity to instruction and thus a cognitive component (Cline, Beals, & Seidman, 1960).

Most recently, Chung, Nagashima, Espinosa, Berka, and Baker (2008a) examined whether individualized multimedia-based instruction would influence the development of rifle marksmanship skills in novice shooters. Chung et al. found support for the idea that multimedia-based instruction can be highly effective for novices, with a large increase in shooting performance observed after 10 to 15 minutes of multimedia instruction. Subsequent individualized instruction using very short multimedia instruction appeared to be effective in shaping participants' skills toward an "ideal" state consistent with shooting doctrine. A similar approach for individualized instruction was used by Chung, Delacruz, Dionne, and Bewley (2003), and a close examination of conceptual knowledge changes showed development toward more expert-like knowledge structures (Delacruz, Chung, & Bewley, 2003).

**Knowledge of shooting.** In a study comparing different marksmanship training techniques, Thompson et al. (1980) found that for entry-level male Army trainees, record-fire scores correlated with knowledge of zeroing ($r = .50$, $p < .001$, $n = 144$), knowledge of bullet strikes at greater ranges than the 25m target trainees were trained on ($r = .33$, $p < .001$, $n = 144$), and knowledge of range effects and appropriate sight adjustments ($r = .31$, $p < .001$, $n = 144$). However, this finding was only for the experimental treatment receiving the most training support. A similar pattern of correlations but lower in magnitude (*r* in the low .20s) was found for another experimental condition. However, no such relations were found for the normal training condition or for a third training condition. In a series of studies across sustainment-level enlisted Marines (Chung et al., 2004, Study 1 and 2), entry-level 2LT (Chung et al., 2004, Study 3), and naïve shooters drawn from a university population (Chung et al., 2008b), knowledge of rifle marksmanship was consistently related to performance, although the magnitude of the relations was generally low (*r*s ranging from .2 to .5). In addition, experts and high performers consistently score higher than novices on various measures of knowledge of marksmanship (e.g., Chung et al., 2004, Studies 1, 2, and 3; Chung et al., 2008b).

**Aptitude and achievement.** Other studies have examined the relationship between aptitude and achievement measures with record-fire performance. While not measures of marksmanship knowledge, these variables suggest the potential for shooters to acquire the knowledge.

Carey (1990) examined the relationship between a variety of background variables and first-term enlisted Marines' known distance (KD) record-fire performance. Moderate correlations between various subscales of the ASVAB and record-fire scores were found, ranging from .26 for the clerical/administrative subscale to .38 on the mechanical maintenance. The relationship to the overall ASVAB composite was .32. Infantry training GPA was weakly related to record-fire scores ($r$ = .25), as was performance on a core job knowledge test ($r$ = .31) and supervisor ratings ($r$ = .16). Unfortunately, Carey does not report significance levels of these correlations.

Similarly, a significant correlation was found between record-fire score and score ($r$ = .24, $p$ < .01, $n$ = 439) on the Skill Qualification Test, a measure of a soldier's skill achievement (Wisher et al., 1991). However, Wisher et al. found no relationship between soldiers' scores on the Armed Forces Qualification Test (AFQT), a measure of aptitude, and their record-fire scores. As mentioned earlier, MacCaslin and McGuigan (1956) combined aptitude (Aptitude Area I on the Army Classification Battery) and self-reported shooting experience to predict record-fire score with a multiple $R$ in the .70 range.

Finally, Chung et al. (2008b) found that scientific reasoning (aptitude) and knowledge of marksmanship had a dominant influence on task performance during the learning phase and a diminishing one during the practice phase, as predicted by Ackerman's theory (1988). This finding suggests that rifle marksmanship is primarily a cognitive task during the early stages of skill acquisition, consistent with skill development theory. Knowledge appeared to play an important role on breath and trigger control—skills that required instruction and could not be reasoned through. In this case, the influence of knowledge persisted into the practice phase although marginally significant for breath control ($r_s(31) = -.33$ $p < .06$) and trigger control ($r_s(29) = -.30$, $p < .09$).

**Summary.** While knowledge of rifle marksmanship has been recognized as important for nearly a century, there has been virtually no research until recently that examined the relationship between knowledge of rifle marksmanship and shooting performance. When examined, there appears to be a moderate relationship between knowledge of shooting and shooting performance. Training clearly has an impact on shooting performance, and proxy variables for the potential to learn such knowledge are suggestive of a relationship. These findings point to a possible knowledge component to shooting performance.

### Affective Variables

As with knowledge variables, the relationship between affective variables and shooting performance has been largely unexplored. In general, the amount and type of mental thoughts preceding the moment of firing are believed to have an influence on shot quality. For example, EEG frequencies preceding low-scoring shots in an expert shooter were interpreted as resulting from distracting thoughts and increased mental activity (Bird, 1987; Konttinen & Lyytinen, 1992). This interpretation is consistent with an early examination of expert and novice shooters (Gates, 1918), where novice shooters' performance was affected severely by dwelling on steadiness factors (e.g., "I can't seem to control myself" or "There, I moved again"; p. 3). Tierney et al. (1979) found low, negative relationships between self-reported nervousness about firing and record-fire scores for females but not males ($r = -.19$, $p < .05$). Sade, Bar-Eli, Bresler, & Tenenbaum (1990) found that highly skilled shooters reported significantly lower (state) anxiety than moderately skilled shooters when measured 10 minutes prior to competition (seven occasions). Further, shooting performance was negatively related with state anxiety in six of seven competitions. More recent investigations that examined the anxiety-performance relation specifically have found significant and moderate negative correlations between qualification scores and self-reported state anxiety ($r = –.51$, $p < .01$) and state worry ($r = –.59$, $p < .01$) among 2nd lieutenant officers undergoing marksmanship training (Chung, O'Neil, Delacruz, & Bewley, 2005). Similarly, Chung et al. (2004) found significant negative correlations between sustainment-level qualification scores of enlisted members of the armed forces and their self-reports of state anxiety and state worry (*r*s in the range of -.4). In a study of novices using a rifle simulation system, Chung et al. (2008b) found that state anxiety related negatively to shot group precision ($r_s(31) = -.52$, $p < .01$) during the learning phase but not the practice phase.

### Equipment and Environmental Variables

Finally, a third area that has received attention is in investigating equipment aspects. For example, Kemnitz, Rice, Irwin, Merullo, and Johnson (1997) found that shooting performance on an M16A2 (as measured using a rifle simulator) increased with a shorter stock and reduced rifle weight. Early studies of the M16A1 rifle examined performance variables such as accuracy of the rifle, zeroing, shooter error, barrel stress, and ballistics.

Osborne, Morey, and Smith (1980) and later studies compared firing and serviceability characteristics of the M16A1 to M16A2 (Osborne & Smith, 1986).

## Summary and Discussion

In general, the highest correlations with record-fire scores were with steadiness scores and live-fire and device-fire scores. Prior record-fire scores correlated lower with current record-fire scores, possibly owing to skill decay over time periods of 12 months. Prior shooting experience related with record-fire scores, but the correlations were low in magnitude. Knowledge-related variables correlated moderately with record-fire scores, and prior shooting experience scores correlated even lower.

When the data are interpreted within the stages-of-skill-processing framework, several trends appear that are consistent with the framework. First, the overall variability in shooting performance across studies can be interpreted as sensitivity of the act of shooting to different conditions. The strongest evidence that shooting can be consistent is in the test-retest study by McGuigan and MacCaslin (1955). In their studies, the shooters fired the same qualification course three times across three days. The test-retest coefficient was .84 and .88 depending on the sample.

One of the most interesting findings is the low predictability of the most recent record-fire score ($r$ in the .3–.4 range). Again, when interpreted in terms of the stages-of-skill-processing framework, the data are consistent with the idea that shooters were still in the cognitive phase. The sample was young soldiers or Marines who were undergoing sustainment-level training and requalification. The typical time in service was 1-2 years. Performance was varied and inconsistent.

The low to moderate correlations between device-fire and record-fire scores observed across different rifle simulators may reflect a possible effect due to fidelity of the shooting context. That is, the simulator system only approximates shooting conditions. The simulators in the studies reviewed in this report are all intended to be used indoors. Indoor conditions remain stable compared to the outdoors, which can vary considerably over time (e.g., cloud cover, intensity of sunlight [time of day], temperature, and humidity). The act of firing differs as well. Recoil and report are not simulated except for the Engagement Skills Trainer (EST) system, which also found the highest correlations with record-fire scores. Finally, the consequences of poor performance were low for device-fire and relatively high for record-fire. The studies were conducted with volunteers and device-fire scores were not part of the participant's permanent record. One effect of this difference was that the shooters probably did not experience as much "match pressure" during device-fire as they did during record-fire.

Consistent with the idea of more varied performance in the early stages of skill learning compared to later stages, higher correlations between device-fire and record-fire were found for the presumably more experienced sample. The sample in Smith and Hagman (2000) were U.S. Army Reservists whereas other studies used entry-level trainees. In this case, the entry-level trainees would be expected to show inconsistent performance on both the rifle simulator and for record-fire, which may explain the lower correlations. In a study that explicitly examined shooter performance across phases of skill development, Chung et al. (2008b) found evidence that the development of rifle marksmanship follows a skill development framework. The patterns of performance, variation, and the errors and remediation were remarkably consistent with the skill development framework. Shooters demonstrated initially very poor and varied performance, with most shooters committing gross position errors and receiving remediation. This initial state was followed by a rapid rate of improvement over three trials (which included targeted instruction). Performance continued to improve over the remaining three trials, but at a slower rate than the previous trials. A few participants continued to have position errors but the errors were not severe enough to require remediation. While such a finding is unsurprising, what is interesting is how fast the skill can be learned and how quickly participants move from the learning phase to the practice phase. For 80% of shooters, position errors were eliminated within three trials. On average, shooters went from a 20-inch shot group radius to a 13-inch shot group radius, a 35% improvement over seven trials (or 35 shots).

Overall, the research reviewed on predicting shooting performance suggests a deceptively complex task sensitive to a variety of variables. There appears to be a strong perceptual-motor component that includes motor control and experience variables. Further, shooting performance also appears to be sensitive to affective variables via the influence of anxiety on motor control. There also appears to be an aptitude and knowledge component associated with shooting performance; however, this area appears to be largely unexplored beyond examination of shooting performance across groups receiving different training and instruction.

## SECTION II: COMBAT MARKSMANSHIP

In this section we describe the current USMC Combat Marksmanship Program (CMP). To our knowledge, there has been little research conducted specifically examining combat marksmanship. The purpose of this section then is to provide an overview of the CMP to identify the critical skills the program is intended to develop in shooters.

### Combat Mindset

The CMP is designed to prepare a Marine to develop a combat mindset to react instinctively in a combat environment without "hesitation, fear, or uncertainty of action" (USMC, 2008, p. 9-1). Unlike Table 1 which focuses on precision shooting at known distances, the Table 2 portion of CMP is designed to begin training these skills. During the Table 2 portion, reaction time is of critical importance. The combat mindset requires that a Marine can engage an enemy rapidly. However, speed is not the only critical factor in combat. Doctrine stresses that a Marine "should fire only as fast as he can fire accurately" (USMC, 2008, p. 9-1).

The relation between speed and accuracy is contingent upon a Marine's ability to execute the physical skills of target engagement. These include marksmanship skills such as presenting the weapon as well as assuming appropriate shooting positions. A combat mindset requires that these physical skills have reached a level of automaticity, which will free the Marine to focus on the cognitively demanding skills of searching and assessing the combat environment.

### Target Acquisition

Target acquisition includes the detection and identification of the target, and range estimation.

#### Target Detection

Detection of targets is often based on indicators such as movement, sound, improper camouflage, shine, outline, and contrast with background.

#### Identifying Target Location

Locating a target requires attaining a good observation position and searching an area (to look for target indicators). Two ways to conduct a search would be to do a hasty search (quickly check for enemy activity, glancing at various points rather than sweeping the eyes across the terrain in one continuous movement). With the hasty search, the Marine should examine the area nearest to him because that poses the greatest threat. Hasty search takes advantage of peripheral vision.

In contrast, the detailed search is a systematic examination of either a specific target indicator or a sweeping search of the entire area. Procedure requires that the search take place from top to bottom, or side to side. The difference between a detailed search and a hasty search is that the former requires that the search examine the area closely. A detailed search may take place after a hasty search to examine the threat indicator that poses the greatest threat.

### Range Estimation

Determining the distance from one's location to a known point assists in the process of successfully engaging targets at unknown distances, especially because it often requires the shooter to adjust rifle sight settings or attain a new point of aim.

The process of range estimation uses methods such as the use of the RCO bullet drop compensator (i.e., aligning the chevron of the sights on the width of the target to determine the range), using the rifle front sight post (i.e., examining the amount of the target covered by the front size post), unit of measure method (visualizing a distance and then estimating the number of these units between Marine and the target), and the visible detail method.

The factors that would affect the accuracy of range estimation may include the nature of the target (e.g., a poorly contrasted target make appear closer), the nature of the terrain (e.g., upward slopes give the illusion of a shorter distance), and limited visibility.

## Engagement Techniques

For each process of target engagement, a Marine is required to complete a series of actions that is referred to as the Target Engagement Cycle. The cycle involves acquiring the target, presenting the weapon, engaging the target, and taking post-engagement actions. Acquiring the target involves threat identification and range estimation. These factors determine the engagement technique, aiming point, and firing position to be used. Presenting the weapon must take place while assuming the proper position, and acquiring and maintaining stability and proper sight picture. The engagement technique used once the weapon is presented is based on the size and distance to the target. Finally, the Marine must assess the situation and then determine the appropriate next course of action. If the situation changes at any step of the cycle, the Marine must go back to acquiring the target because the rest of the cycle is dependent upon the observation of the target.

## Rifle Presentation

To deal with a combat environment in which targets may appear without warning, the Marine must carry his weapon in a manner that allows for easy and quick presentation. There are various carries, and choosing which way to carry one's weapon is dependent upon the situation. The alert carry is used when enemy contact is likely or imminent. The controlled carry is used when no immediate threat is present.

## Close-Range Engagement

Close-range engagement is likely to take place in close terrain such as an urban or jungle environment. The targets are estimated to be 50 meters or closer. The types of marksmanship skills required would be a quick presentation and compression of the fundamentals. Ability to react quickly is far more critical than during precision shooting. For instance, because sight alignment is not as critical at close ranges, quick acquisition of sight picture is ideal. Likewise, the negative effects of jerking or slapping the trigger are reduced at these distances. The stability of the hold is also not as critical at close-range engagements because the area on the target covered by the sights is larger.

In close-range engagements, Marines employ various shot delivery techniques. For instance, a two-shot technique in which Marines deliver multiple shots to the body in rapid succession is used when it is not possible to eliminate the target in a single engagement. There are two types of two-shot techniques that are used: the controlled pair and the hammer pair.

The controlled pair is one in which two aimed shots are fired in rapid succession with sight picture being acquired for both shots. In training, Marines are given about 2-3 seconds to deliver a controlled pair. The factor that contributes to the speed of delivering the successive shot is the ability of the Marine to reacquire his front sight, which is dependent upon how well recoil is managed. Controlled pairs are the preferred technique when engaging targets at ranges greater than 15 yards.

When employing the hammer pair technique, two aimed shots are fired in rapid succession with sight picture only being acquired for one shot. The aiming point is the center of the upper torso and often used at close ranges.

When target engagement fails to incapacitate the target (e.g., when a pair fired to the torso fails to stop the target), a Marine is to use a failure-to-stop technique in which a single shot is fired to alternate aiming areas. Failure-to-stop techniques are typically aimed at two places. One aim point is the "T-box" of the head, which is located from the brow to the bottom of the nose and from eye to eye, aiming to penetrate the head with minimal deflection or energy loss. The other aim point is the pelvic girdle which causes the target to fall. A shot to the pelvic girdle does not ensure that the target will be eliminated but it will incapacitate the target. It should be used if there is no chance of engaging the T-box. Finally, at short ranges, firing a three-round burst can be an effective engagement technique.

### Mid- to Long-Range Engagement

With mid- to long-range engagement, the known-distance/precision shooting applies. Proper fundamentals are far more important, requiring proper aiming, trigger control, stability, and body positioning. Typically, a single precision shot is employed.

### Post-engagement

After an engagement, the Marine must immediately search the area and assess the results of engagement. The purpose of searching and assessing is to determine if a Marine needs to reengage the target, engage a new target, take cover, assume a more stable position, or cease engagement.

## Multiple Target Engagement Techniques

Multiple target engagement requires decision making based on prioritizing and planning one's shots. Situation awareness is key to successfully engaging multiple targets because as one target is successfully engaged, the Marine must immediately concentrate on engaging the next target. For each target, the target engagement cycle of acquiring the target, presenting the weapon, engaging the target, and taking post-engagement action is employed. Situation awareness also requires that the Marine must continually engage in search and assess techniques to be properly attuned to his surroundings. Factors that contribute to prioritizing targets include proximity, threat, and opportunity. The technique of engagement for multiple targets is called the Box Drill. The procedure is, from USMC (2008):

- The first threat is engaged with a pair to the torso. Then, while utilizing the recoil of the second shot, guide the weapon over to the next target and also fire a pair to the torso.
- Follow through immediately up to the same target's head using the recoil of the last shot to move the weapon. Pause to get a clear sight picture and fire an incapacitating shot to the head.
- Again, using the recoil of the last shot, guide back over to the first target's head, aim in, and fire an incapacitating shot.
- This last shot is the completion of a failure-to-stop drill, because you would not need to fire the last shot if your first pair to the torso had incapacitated the first

target. The reason the second target is engaged with the box drill is to ensure that it will not be able to engage you while you are transitioning back to the target.

- After firing the final shot on the first target, follow through and assess the situation for further action.

The more restrictive the firing position, the longer it will take a Marine to eliminate multiple targets. For example, the prone position limits left and right lateral movement and is not recommended for short-range dispersed targets. The sitting position limits lateral movement. Engagement of widely dispersed multiple targets is difficult. The kneeling position offers a wider, lateral range of motion because only one elbow is used for support. A Marine moves from one target to another by rotating at the waist to move the forward arm in the direction of the target, either right or left. The standing position allows maximum lateral movement. Multiple targets are engaged by rotating the upper body to a position where the sights can be aligned on the desired target. If severe or radical adjustments are required to engage widely dispersed targets, a Marine moves his feet to establish a new position rather than give up maximum stability of the rifle.

## Moving Target Engagement Techniques

There are two types of moving targets: steady moving targets (move in a consistent manner and remain in a Marine's field of vision) and a stop-and-go target (presents itself for only a short time before reestablishing cover). Moving targets involve leading the aim point, range, speed, and angle of the target.

### Lead

Leading a target is the process of a Marine aiming in front of the target. Because the target moves during the time the bullet is in flight, aiming in front of the target ensures that the target will be engaged. If the Marine aims at the target while it is moving, the shot will fall behind the target. The factors that affect the amount of lead are the target's range, speed, and angle of movement. Table 5 shows the relation among distance of target, speed of target, and how far the target will move during the flight of the bullet.

Table 5

Distance (inches) a Target Will Move During the Flight of Bullet (USMC, 2008)

| Distance of target (yards) | Slow walking (2 – 2.5mph) | Jogging (5mph) | Running (10mph) |
|---|---|---|---|
| 50 | 2 | 4 | 9 |
| 100 | 4 | 9 | 18 |
| 200 | 8 | 19 | 38 |

### Range

Distance is a factor because the time of flight increases as range to the target increases. When considering how far in front of the target a Marine must fire, one must consider that the lead increases as the distance to the target increases.

### Speed

Speed is an issue as it relates to range. A target running will move a greater distance than a target walking, and thus will require a greater lead.

### Angle

Angle of movement across the line of sight relative to the flight of the bullet determines the amount of lead.

### Types of Leads

There are three types of leads: Full, Half, and No. As stated in doctrine (USMC, 2008):

- **Full Lead.** The target is moving straight across a Marine's line of sight with only one arm and half the body visible. This target requires a full lead because it will move the greatest distance across a Marine’s line of sight during the flight of the bullet.
- **Half Lead.** The target is moving obliquely across a Marine's line of sight (at a 45-degree angle). One arm and over half the back or chest are visible. This target requires half of a full lead because it will move half as far as a target moving directly across a Marine’s line of sight during the flight of the bullet.
- **No Lead.** The target is moving directly toward or away from a Marine and presents a full view of both arms and the entire back or chest. No lead is required. A Marine engages this target as if it were a stationary target because it is not moving across his line of sight.

## Leading a Moving Target

A lead is held in front of a moving target to compensate for the distance the bullet will travel while the target is moving. Figure 3, Figure 4, and Figure 5 present leads for slow walking, jogging, and running (USMC, 2008).

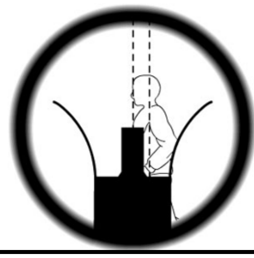
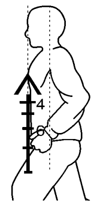
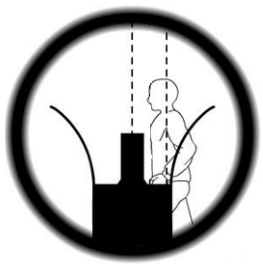
| Slow Walking (2 – 2.5 mph) | | | |
|---|---|---|---|
| **Iron Sights** | **RCO** | **Range** | **Lead** |
|  |   | 100 meters or less | ½ body width (leading edge of target) |
|  |   | 200 meters | 1 body width |

*Figure 3.* Lead for slow walking (USMC, 2008).

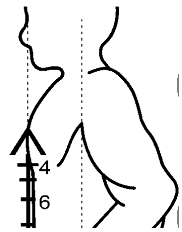
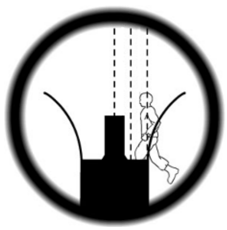
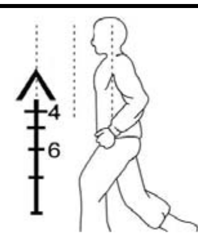
| Jogging (5 mph) | | | |
|---|---|---|---|
|  |  | 50 meters or less | ½ body width (leading edge of target) |
| | | 100 meters | 1 body width |
|  |  | 200 meters | 2 body widths |

*Figure 4.* Lead for jogging (USMC, 2008).

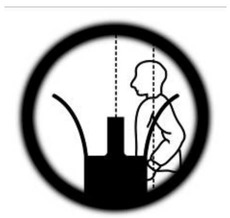
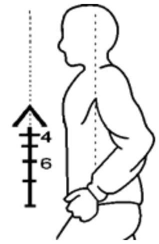
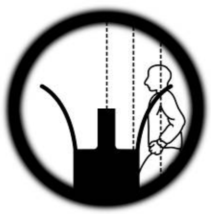
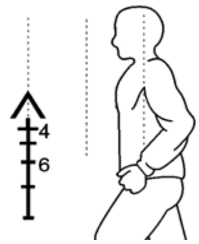
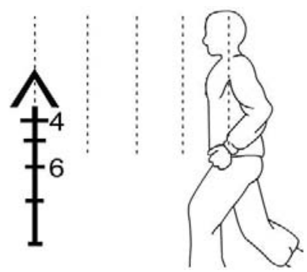
| Running (10 mph) | | | |
|---|---|---|---|
|  |  | 50 meters or less | 1 body width |
|  |  | 100 meters | 2 body widths |
|  |  | 200 meters | 4 body widths |

*Figure 5.* Lead for running (USMC, 2008).

## Engaging a Moving Target

**Tracking.** The two methods of engaging a moving target are tracking and ambush. In the tracking method, the Marine tracks the target with the rifle's front sight post while maintaining sight alignment and a point of aim on or ahead of the target until the shot is fired. The rifle sights are not centered on the target but are held on a lead in front of the target. When engaging moving targets using the tracking method, the rifle must be moved smoothly and steadily as the target moves. A stable position steadies the rifle sights while tracking. Additional rearward pressure may be applied to the pistol grip to help steady the rifle during tracking and trigger control. Elbows may be moved from the support so the target can be tracked smoothly.

**Ambush.** The ambush method is used when it is difficult to track the target with the rifle (e.g., while in the prone or sitting position). The lead required to effectively engage the target determines the engagement point. With the sights settled, the target moves into the predetermined engagement point and creates the desired sight picture. The trigger is pulled simultaneously with the establishment of sight picture.

There are a few modifications to the fundamentals of marksmanship when engaging moving targets. Rather than aiming at the target's center of mass, sight picture is based on target's range, speed, and angle of movement (i.e., in front of target). Trigger control is modified in that a Marine can apply pressure on the trigger prior to establishing sight picture, but there should be no rearward movement of the trigger until sight picture is established. Interrupted trigger control is not recommended because the lead will be lost or have to be adjusted to reassume proper sight picture. When using the tracking method, the Marine continues tracking as trigger control is applied to ensure the shot does not impact behind the moving target. Finally, if a Marine uses the tracking method to engage moving targets, he continues to track the target during follow-through so the desired lead is maintained as the bullet exits the muzzle. Continuous tracking also enables a second shot to be fired on target if necessary.

**General considerations for firing during lateral movement.** Several factors should be considered when engaging moving targets. These are:

- Movement must be smooth and steady. Place your feet heel to toe and drop your center mass by consciously bending the knees. This will make your thighs act as "shock absorbers" and steady your movement so as to maintain the stability of your upper body so the rifle sight(s) can be stabilized on the target.
- Bend forward at your waist to put as much mass as possible behind your weapon for recoil management.
- Roll the foot heel to toe as you place your foot on the deck and lift it up again to provide for as smooth a motion as possible. Your feet should almost fall in line during movement. This straight-line movement will keep your sights from bouncing excessively and will allow a good stationary stance when needed.
- While moving, your weapon should be at the alert or ready carry. Do not aim in on the target until ready to engage. You should maintain awareness of your surroundings and to your left and right at all times during movement.
- Aiming in prematurely is incorrect. When there are targets to aim in at while in a combat situation, those shots should be delivered immediately. If a Marine is moving already aimed in, he will not be aware of his surroundings. Most importantly, he will not be constantly aware of the positions of friendlies and/or other threats.

## Assessment Issues

In contrast to known-distance rifle marksmanship, the USMC combat marksmanship program is new and thus there has been little assessment research conducted to develop measures that can capture the processes underlying skilled performance on CMP tasks, much less lead to prediction of performance.

A first step is to conduct a cognitive task analysis to determine the set of cognitive, motor, and affective variables that bear on performance. For example, the base knowledge needs to be identified from subject matter experts and doctrine (e.g., as was done for known-distance as shown in Appendix A, Appendix B, and Appendix C). Second, the knowledge, skills, and abilities required for successful performance on the various components of CMP should be framed within a theoretical model such as the general skill development model of Ackerman (1987, 1992). Finally, validity studies need to be conducted to evaluate the quality of the measures.

In contrast to known-distance marksmanship, combat marksmanship emphasizes a different set of skills. For example, rapid presentation of the weapon, quick engagements with multiple rounds fired within one or two seconds, imprecise aiming, and moving targets are all skills that are not covered or opposite to skills developed during known distance. For example, a rapid trigger pull is appropriate for short-range engagements but not for mid- or long-range engagements. Thus, knowing the conditions when seemingly conflicting procedures apply is an important cognitive skill. While preliminary, Table 6 shows the set of skills and possible measures. Note that some measures will be appropriate only for some settings (e.g., shoot house vs. range vs. laboratory setting).

Table 6

Important CMP Skills and Potential Measures

| Skill | Measure |
| --- | --- |
| Weapons presentation | • Knowledge of presentation forms<br>• Speed of presentation<br>• Accuracy of form |
| Target acquisition | • Knowledge of target acquisition process<br>• Identification of target<br>• Range of target |
| Engagement techniques (close-range, multiple targets, moving targets) | • Knowledge of engagement techniques and the conditions under which different techniques apply<br>• Appropriate use of different techniques across a range of engagement scenarios (e.g., shoothouse, virtual simulation) |

One promising development that will aid the measurement of these various techniques has been the use of sensors to measure marksmanship skills. In the next section, we describe research conducted on the use of sensors for known-distance rifle marksmanship.

## SECTION III: THE USE OF SENSORS IN THE ASSESSMENT OF RIFLE MARKSMANSHIP SKILL

The use of sensors to directly assess shooter skill is one of the promising areas of development. For example, the use of EEG and neurophysiological measures has been promising, particularly for measuring aspects of the skill that are difficult to observe such as trigger control, breath control, muzzle wobble, and the brain states of the shooter (e.g., Berka et al., 2008; Espinosa, Nagashima, Chung, Parks, & Baker, 2008; Nagashima, Chung, Espinosa, Berka, & Baker, 2008). In this report we focus on the use of sensors for measuring the behavioral dimensions of marksmanship skill.

Exploratory work by Chung, Dionne, and Elmore (2006) and recent work by Espinosa et al. (2008) and Nagashima et al. (2008) have focused on gathering validity evidence of assessments intended to measure the fundamentals of rifle marksmanship (trigger control, breath control, aiming, and steadiness). For example, Espinosa et al. describe the development of measures of rifle marksmanship skill and performance using a prototype instrumented laser-based training system (LaserShot, 2008). Measures of performance were derived from laser strikes on a video-projected target. Measures of rifle marksmanship skill—breath control, trigger control, and muzzle wobble—were developed from shooters' breathing and trigger squeeze patterns. Existing marksmanship doctrine and expert shooters' breath and trigger control profiles guided the development of the skill measures. A shooter's breath control was described by where and how long into the respiratory cycle the trigger broke. A shooter's trigger control was described by the duration of the trigger squeeze. A shooter's muzzle was described by the total acceleration during the two seconds prior to the shot. The use of sensor-based measures provides insight into exactly how a shooter is executing two of the three skills considered to be the fundamentals of rifle marksmanship.

In the following section we report in detail the work of Espinosa et al. (2008) and Nagashima et al. (2008) on (a) the sensor-based measures developed for measuring breath control, trigger control, and muzzle wobble, and (b) a pilot study and main study gathering validity evidence of the measures using expert and novice shooters.

### Sensor-based Measures of Rifle Marksmanship Skill

In the Espinosa et al. (2008) study, shooting performance was captured by shot group precision, which reflects how well a shooter can *consistently* apply the fundamentals of rifle marksmanship. Such measures have been found to correlate with shooting performance (Taylor, Dyer, & Osborne, 1986). Johnson (2001) defined precision as dispersion of shots within a shot group ($D_{SG}$) as shown in Table 7. Higher values of $D_{SG}$ indicate greater dispersion of shots within a trial and poorer performance.

Table 7

Shot Group Precision Measures (modified from Johnson, 2001)

| Measure | Symbol | Formula | Interpretation |
|---|---|---|---|
| Center of shot group | $SG_x$ | $\frac{\sum_{i=1}^{N} x_i}{N}$ | Center of *N* shots, *x* coordinate. |
| | $SG_y$ | $\frac{\sum_{i=1}^{N} y_i}{N}$ | Center of *N* shots, *y* coordinate. |
| Distance of each shot to the center of the shot group | $d_{SG}$ | $\sqrt{(x_i - SG_x)^2 + (y_i - SG_y)^2}$ | |
| Mean distance of *N* shots to the center of the shot group | $D_{SG}$ | $\frac{\sum_{i=1}^{N} d_{SG_i}}{N}$ | This is the measure of precision and reflects the mean dispersion across all shots with respect to the center of the shot group. |

*Note.* $N$ = number of shots. $x_i$ and $y_i$ = location of *i*th shot.

## Breath Control Measures

**Respiration location at trigger break.** Firing while breathing can cause rounds to disperse vertically on the target due to the muzzle being displaced as the lungs expand and contract during the breathing cycle. To determine where the breath was located during the shot, the minimum and maximum values of the respiration data were determined. The minimum and maximum values were identified by analyzing the respiration data starting from the first trigger squeeze onset to the last trigger break in the trial. Finding the trigger squeeze onset is described in the next section. A simple peak detection algorithm was used to find the extrema. An example of this is shown in Figure 6. The delimited region specifies the range of breath data examined.

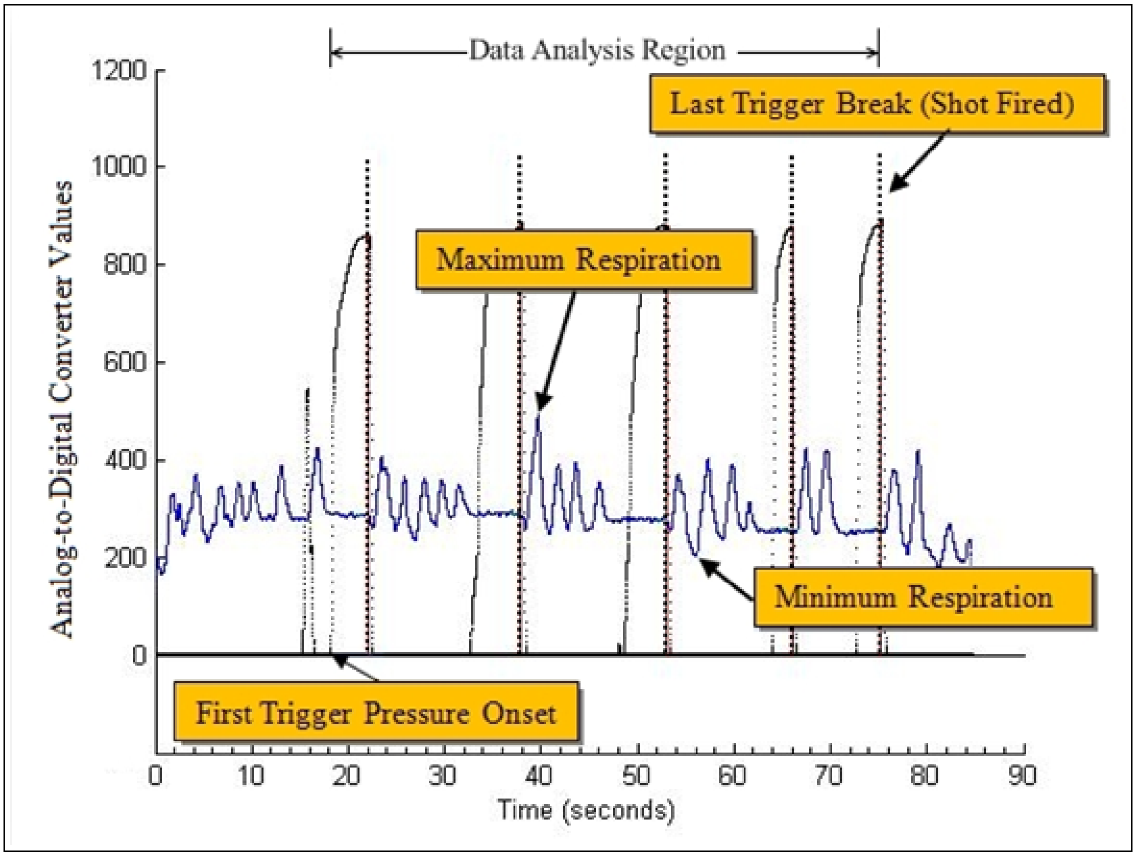



*Figure 6.* Example of trigger squeeze, respiration, and shot markers.

Once the minimum and maximum respiration values were found, the respiration data were scaled to lie between 0 and 1 on the y-axis as shown in Figure 7. The equation used to scale the data is given as: 1/((*maximum – minimum*)(*Respiration Data – minimum*)).

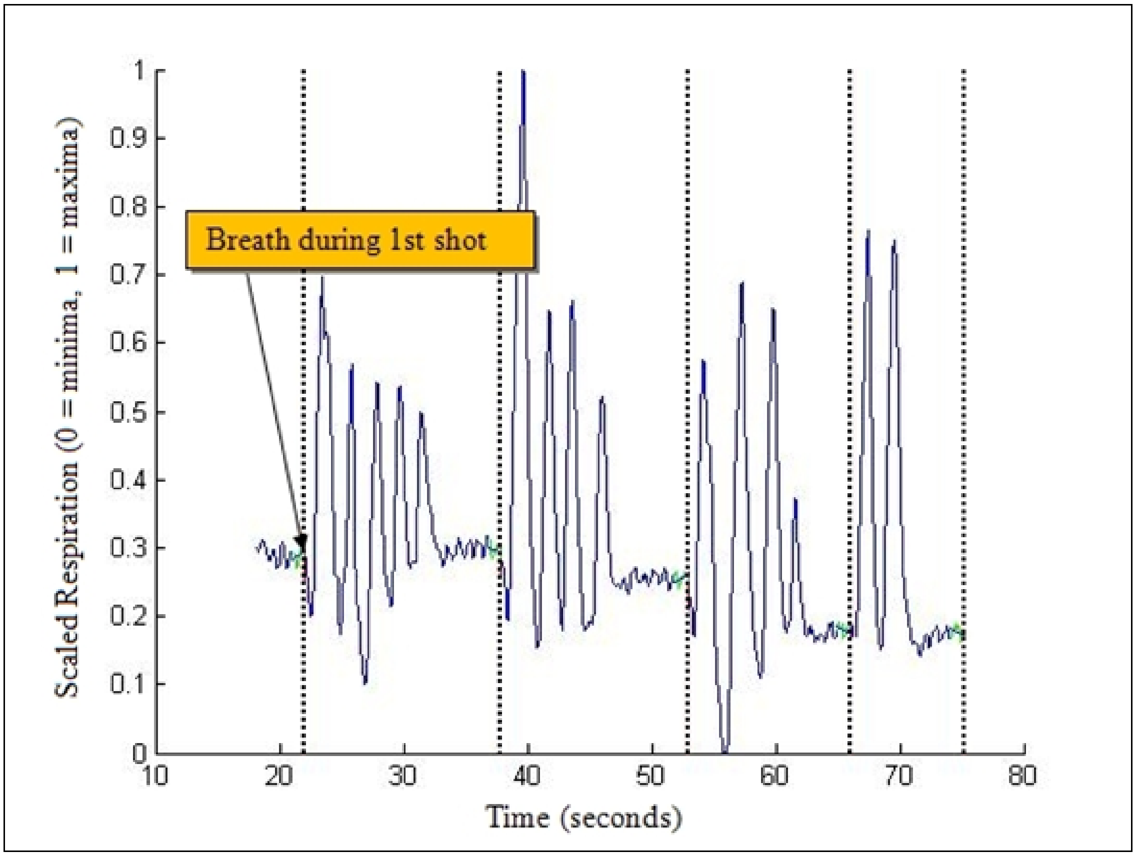



*Figure 7.* Scaled respiration data with trigger break markers.

After scaling the respiration data, the location of the shooter's breath is found by taking the point that corresponds to when the shot was fired. Figure 7 points out the location of the shooter's breath when the first shot was fired.

**Breath duration.** The algorithm used to determine the breath duration uses the scaled respiration data (as shown in Figure 7). The algorithm works by locating the maximum peak to the left and right of a trigger break. The locations of the peaks represent start and end times for a single respiratory cycle. Figure 8 points out the peak values that are used to determine the breath duration of shot number two. The algorithm also detects cases when peaks cannot be found. There are two special checks for the first and last trigger break to account for incomplete breath data or for cases when a peak cannot be found. Whenever peaks cannot be found, the default breath duration will be set to 0.

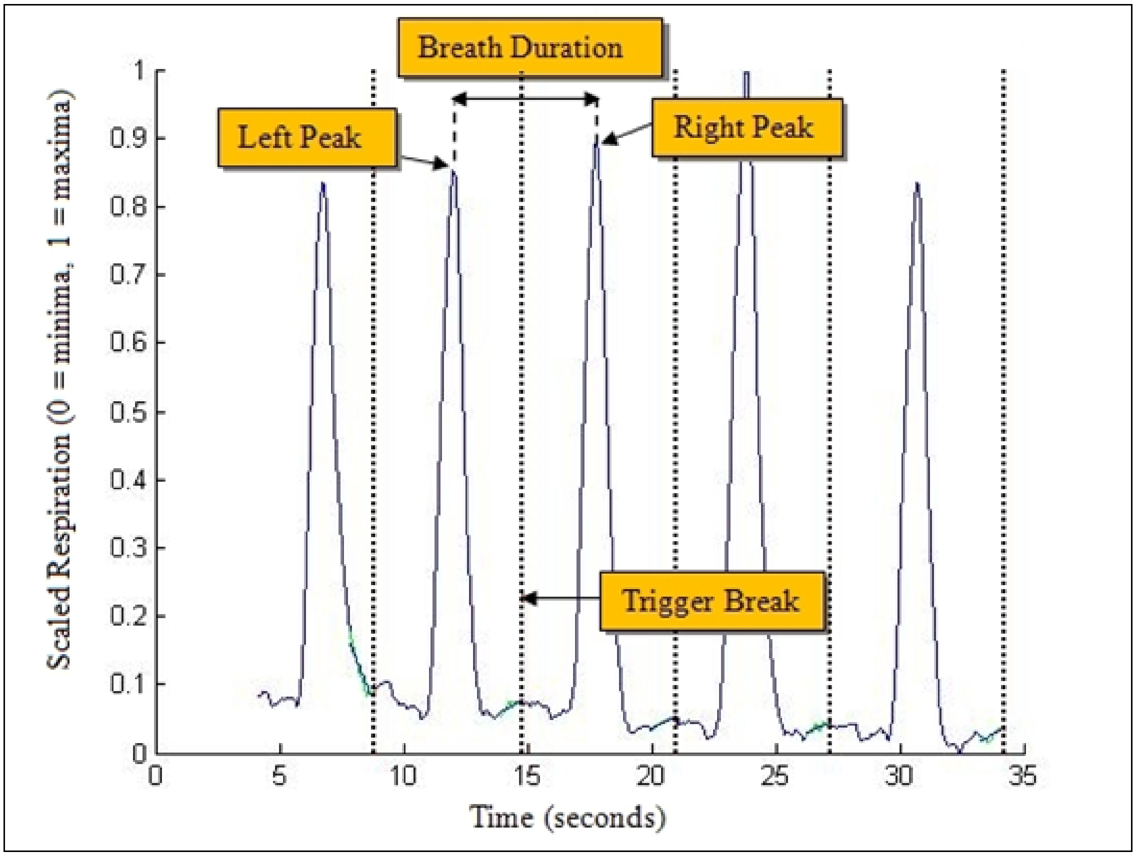



*Figure 8.* Breath duration (focused on 2nd trigger break).

**Shot percent in breath.** This calculation relies on the breath duration in conjunction with the trigger break time. Shot percent in breath represents a ratio relating the time of the trigger break to the breath duration. For trigger break at time $T_{TB}$, breath duration right peak at time $T_{RP}$, and breath duration left peak at time $T_{LP}$, the shot percent in breath is defined as $\frac{T_{TB}-T_{LP}}{T_{RP}-T_{LP}}$. This translates roughly to the time of trigger break divided by time between two inhales. This value represents the relative location of a trigger break within the respiratory cycle.

## Trigger Control Measures

Proper trigger control during slow fire is important because yanking the trigger will cause the weapon to sway laterally.

**Trigger squeeze onset.** The trigger squeeze onset value was recognized using a sliding window technique. The algorithm works backwards from the trigger break using a 0.25-second sliding window until the average of the data falls below 2 as shown in Figure 9. The count value of 2 was chosen empirically after examining trigger squeeze data visually for many trials. Inherent noise from the data signal prevented absolute indications of no activity.

Figure 9 demonstrates the algorithm. The dark rectangle in the middle of the figure represents the 0.25-second sliding window. When the sliding window calculates a mean below 2, the location of the right border, or trailing edge, of the sliding window is identified as the trigger pull onset.

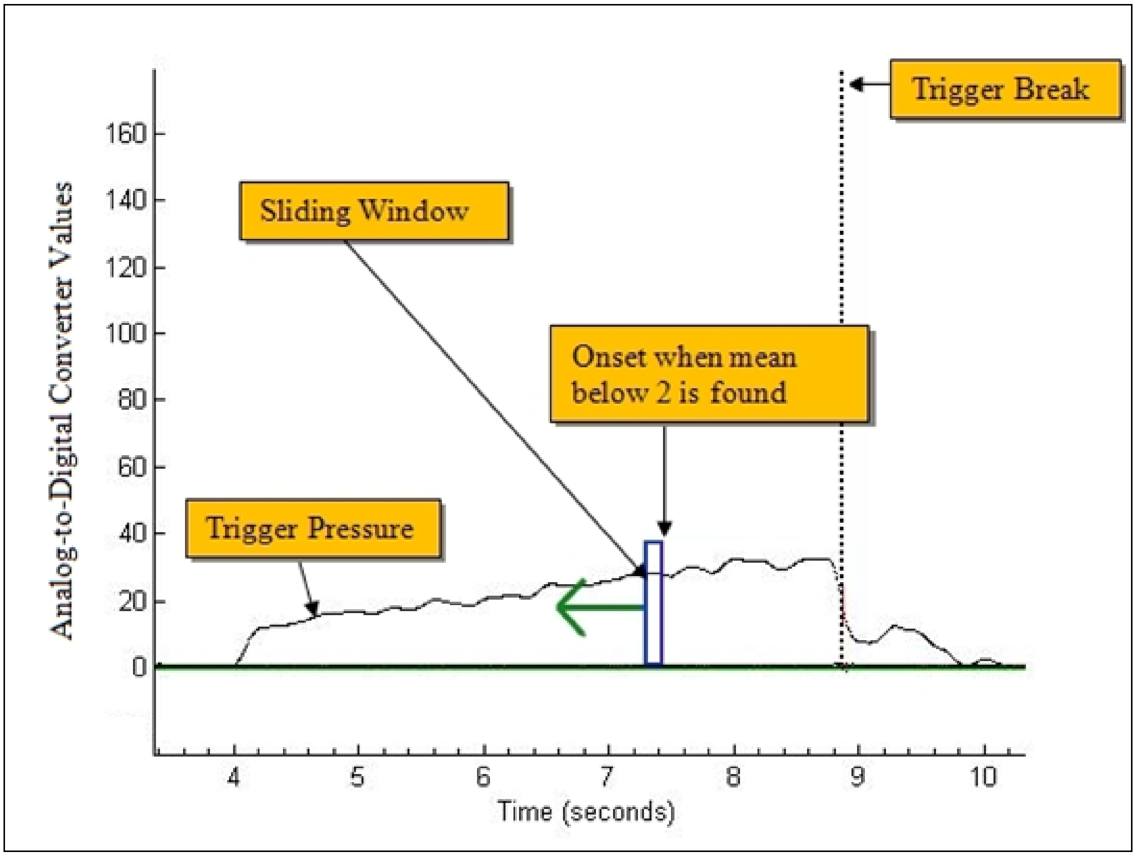



*Figure 9.* Trigger pull onset algorithm.

Two safety checks were used in the algorithm to ensure accurate identification of trigger pull onset. If the sliding window has reached the beginning of the trial and fails to identify a mean less than 2, the onset is set to the beginning of the trial at time 0. Second, if the sliding window has reached the previous trigger break and fails to find a mean less than 2, the onset is set to the data point after the previous trigger break.

**Trigger squeeze duration.** Once the trigger squeeze onset was established, duration was calculated. The knowns at this point are the trigger break time, $T$, and the trigger squeeze onset, $P$. Thus, trigger squeeze duration is simply $T - P$.

### Muzzle Wobble

The wobble is simply the mean of the acceleration's magnitude data two seconds prior to trigger break. For trigger break at time $T$, the range of data used was [$T - 2$ seconds, $T$].

The accelerometer used was a 3-axis accelerometer. Magnitude was calculated as the Euclidean norm.

## Pilot Study: Experts' Breath and Trigger Control Profiles

We tested the sensing apparatus with rifle marksmanship coaches currently serving in the armed forces. The purpose of the study was to test the feasibility of the system and to gather skill data—trigger control, breath control, and steadiness—from acknowledged experts. The skill data would then be used to establish performance ranges for each measure, which could then be used to compare novice performance. Shot group precision data were not collected.

### Sample

Thirteen expert marksmanship coaches were recruited to provide reference performance data. Our sample of expert shooters have on average 5 years of armed forces experience, come from infantry units, frequently fire a rifle as part of their armed forces duties, and rarely fire a rifle for recreation. All experts completed the marksmanship coaches course and all experts are currently full-time marksmanship coaches. Twelve of the 13 experts qualified "expert" in their most recent armed forces qualification, and the average qualification score for the sample is 231 ($SD$ = 6.6), with a range of 219-240 (the score range for "expert" is 220-250).

### Task

Using the instruments described below, sensor data were collected from expert marksmen. Shots were taken in the kneeling position, with five shots constituting a single trial. Five trials worth of data were collected.

**Trigger control.** To determine the range of trigger squeeze durations, experts' trigger squeeze data were examined. The scaling procedure began with first scaling all the trigger squeeze data so that they all have the same value at the time of the trigger break. This was done by multiplying each trigger squeeze, $i$, by $300/m(i)$ where $m(i)$ is the value of each trigger squeeze at the time of the trigger break. The value 300 was chosen empirically. Next, we dropped the shots that either had extremely low values (possibly caused by the touch pad's loss of sensitivity) or extremely high values (possibly caused by a glitch). Finally, we eliminated trigger squeezes that had spiked only at the trigger break, again possibly due to the sensor's loss of sensitivity. After filtering out extreme trigger squeeze profiles, about 100 expert trigger squeezes remained. Figure 10 shows the set of trigger squeezes, sorted by trigger squeeze onset time. The longest trigger squeeze is shown at the top of the plot (approximately 11 seconds) and the shortest trigger squeeze is shown at the bottom of the plot (approximately 1 second). The axis perpendicular to the plane represents the magnitude of the pressure on the trigger sensor.

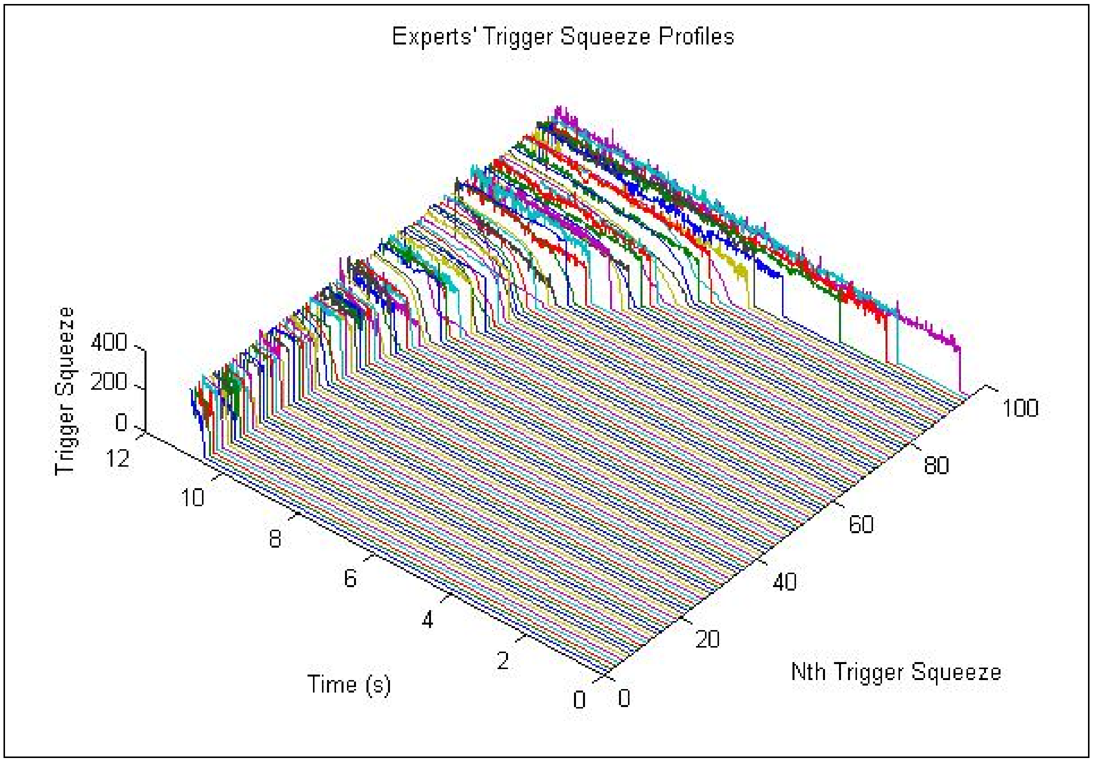



*Figure 10.* Trigger control sensor.

**Breath and trigger control.** Another view of experts' trigger control is seen in Figure 11 (bottom set of signals). Figure 11 shows an overlay of experts' breathing and trigger squeeze signals. Note the extremely high consistency in experts' breathing—*always* firing during the natural respiratory pause.

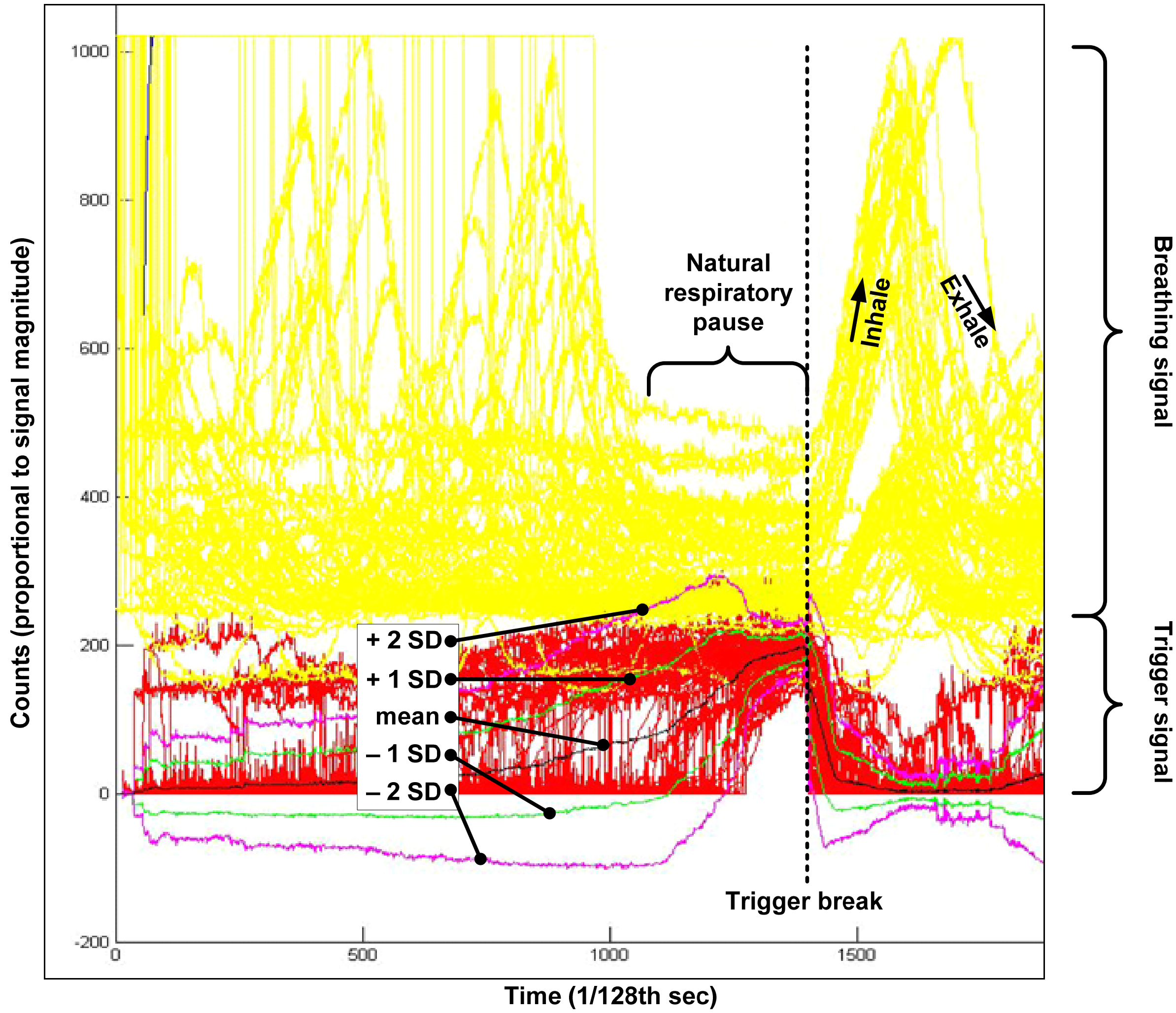



*Figure 11*. Overlay of experts' breath and trigger sensor signals, aligned to trigger break.

## Discussion

Qualitatively, experts' breath control and trigger control appear consistent with existing relevant marksmanship instructional materials (USMC, 2001). That is, proper breath control is firing during the natural respiratory pause, and proper trigger control involves squeezing rather than jerking the trigger. The regularity of experts' breath and trigger control sensor signals suggested to us several measures that might discriminate between experts and novices, and guided the development of the specific measures. For example, for breath control we focused on measuring when in the breathing cycle the shot was taken and the duration between inhales. For trigger control, we focused on the start of the trigger squeeze and duration of the trigger squeeze. Taken together, we expected these measures to provide sufficient information to describe novices' breath control and trigger control.

## Validation Study: Modeling Expert and Novice Shots

### Summary

Nagashima et al. (2008) examined the use of sensor-based skill measures in evaluating performance differences in rifle marksmanship. Ten shots were collected from 30 novices and 9 experts. Three measures for breath control and one for trigger control were used to predict skill classification. The data were fitted with a logistic regression model using holdout validation to assess the quality of model classifications. Individually, all four measures were significant; when considered together, only three measures were significant predictors for level of expertise ($p < .05$). Overall percent correct in shot classification for the testing data was 90.0%, with a sensitivity of 67.5%, and 96.0% specificity.

### Participants

Shots were collected from 39 participants, 30 novices and 9 experts. Novices ranged in age from 19 to 29 years ($M = 22.20$, $SD = 2.57$). Of the 30 novices, 23 (77%) were male, and 7 (23%) were female. Twelve (40%) reported having prior experience shooting a rifle. Of those reporting prior experience, 3 (25%) reported having shot a rifle within the last year, 3 (25%) within 3 to 5 years, and 6 (50%) reported firing a rifle over 5 years ago. None of the novices reported experience with competitive shooting and 2 (7%) reported having coached rifle shooting. All nine experts selected for study were active-duty members of the armed forces with a primary military occupation specialty (MOS) as marksmanship coaches. All were male and ranged in age from 21 to 25 years ($M = 23.33$, $SD = 1.41$). Coaching experience ranged from 1 to 24 months ($M = 12.44$, $SD = 7.52$). In addition to being rifle marksmanship coaches, five (56%) were also qualified as rifle marksmanship instructors.

### Design

Holdout validation was used to assess the quality of shot classifications based on estimated model parameters (Kerlinger & Pedhazur, 1973). Participants were randomly assigned to two groups, model training and model testing. Cases in model training were used to estimate model parameters, while observations in model testing were held back from the estimation procedure and later fitted to the data.

### Measures

Four performance skill measures were evaluated for each shot, three related to breath control (*breath location*, *breath duration*, and *shot-percent breath*) and one for trigger control (*trigger duration*) as described in the previous section.

### Modeling Expert and Novice Shots

A logistic regression model was developed to test the extent to which shots can be classified as originating from a novice or expert using the skill measures as predictors. An extension of simple logistic regression is used to account for multiple predictors as follows:

$$\text{logit}(Y) = \ln(\pi/(1-\pi)) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p$$

$$\pi = \text{Probability}\ (Y = \text{outcome of interest} \mid X_1 = x_1, X_2 = x_2, \ldots, X_p = x_p)$$

$$= ((e^{\alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta p X p})/(1 + e^{\alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta p X p}))$$

where $\pi$ is the probability of the classification, $\alpha$ is the Y intercept, $\beta$s are regression coefficients, and Xs are the set of predictor variables. The value of the coefficient $\beta$ determines the direction of the relationship between X and the logit of Y. When $\beta$ is greater than zero, larger X values are associated with larger logits of Y. Conversely, if $\beta$ is less than zero, larger X values are associated with smaller logits of Y. $\alpha$s and $\beta$s are estimated using the maximum likelihood (ML) procedure designed to maximize the likelihood of reproducing the data given the parameter estimates.

The outcome variable (Y) is expertise status (*status*) and was used to designate cases as either expert or novice (1 = expert, 0 = novice). The logistic procedure predicts the "1" category of the dependent variable, making the "0" category the reference category. The skill measures were used as four continuous predictor variables—*breath location, breath duration, trigger duration,* and *shot-breath location*.

### Results

The overall model significantly differentiates between expert and novice skill performance relative to the null model, $\chi^2 = 188.18$, d.f. = 4, $p < .001$. The variables *breath location*, *breath duration*, and *trigger duration* are significant ($p < .05$). The variable *shot-percent breath*, while a significant predictor when used alone, was not a significant predictor when used concurrently with all four variables.

The log odds of expert classification is as follows:

$$\log(\pi/1-\pi) = -6.381 - 0.148*(\text{breath location}) + 2.111*(\text{breath duration}) + 2.241*(\text{shot-percent breath}) - 0.540*(\text{trigger duration})$$

When interpreting the logistic regression results, an odds ratio greater than 1.0 implies a positive association between the skill measure and status, while an odds ratio less than 1.0 implies a negative association. Odds ratios close to 1.0 indicate that unit changes in that skill variable do not affect the odds of predicted status. The variable *breath location* with an odds ratio of .862 indicates that as *breath location* increases, the odds of expert skill diminish. Specifically, the odds of expert classification diminished by a factor of .137, for one unit increase in location, controlling for other variables in the model. Additionally, for *breath duration*, a one-second increase in *breath duration* results in an 8.26 times greater chance of expert classification. Lastly, the odds ratio of .583 for *trigger duration* signifies that for every one-second increase in *trigger duration*, the odds of expert classification decreases by a factor of .417. The variable *shot-percent breath* was not a significant predictor.

**Discussion**

The validation study was designed to test whether sensor-based skill measures provided discriminatory power in differentiating novice and expert skill performance. A key finding in the analysis is that sensor-based skill measures, considered jointly, provide a reliable method of discriminating differences in expert-novice marksmanship performance. Specifically, breath location, breath duration, and trigger duration were significant predictors in expert-novice shot classification. Although we are confident in the results of sensor-based measures in differentiating skill performance, we remain cautious in extending the generalizability of these results to live-fire environments. Additional studies are needed to assess the reliability of sensor-based assessment of skill performance in live-fire environments in supporting skill diagnosis.

## Implications for Measuring Combat Marksmanship Skills

The known-distance application of sensing technology can be used as a model for the assessment of combat marksmanship skills. Table 8 shows a list of how various sensors could be employed on a weapon and on the individual, and how the sensing information could be used.

Table 8

Use of Sensors to Assess Various Rifle Marksmanship Skills

| Measure | Source | Usage |
|---|---|---|
| **Instrumented Weapon** | | |
| Precision | Shots | Degree of dispersion of shots. |
| Accuracy | Shots | Distance from intended target. |
| Trigger break | Switch | Synchronization point for measures. |
| Trigger squeeze | Pressure sensor | Quality of trigger squeeze—slow or rapid. |
| Muzzle wobble | Accelerometer | Degree of movement in the muzzle of the weapon. Can be used to measure steadiness and also speed of weapon presentation. |
| Sight picture | Beam splitter or digital scope | Image shooter is looking at. Used to examine whether shooter is aiming appropriately at the right target. |
| **Physiological** | | |
| Buck | Accelerometer | Whether shooter is bucking prior to shot. |
| Flinch | Rail mounted camera facing shooter | Whether shooter is flinching prior to shot. Can also be used to view shooter's eye movement. |
| Anxiety | Heartbeat | High anxiety indicates existence of stress. Given identical tasks, a trend from high to low stress is taken as an indication that the shooter is becoming conditioned to task demands. |
| **Behavioral** | | |
| Weapon carry position | Tilt sensor | Carry position the weapon is in. The three conditions of interest are tactical (no immediate threat, muzzle pointing upward), alert carry (enemy contact likely, muzzle tilt is slightly below horizon), and ready carry (contact imminent, muzzle tilt is near horizon). |
| Grip | Pressure sensor | Whether shooter has firing hand on grip. Shooter must maintain firing hand on grip while changing magazine. |
| Scan | Compass | Direction of muzzle. Used to examine whether shooter is carrying out area scan. |
| Head orientation | Head mounted compass | Direction of head. Used to examine where shooter is oriented to. |
| Gaze | Head mounted compass | Direction of gaze. Used to examine where shooter is looking. |

## SECTION IV: TRAINERS FOR RIFLE MARKSMANSHIP

This section presents trainers related to rifle marksmanship for live training and virtual training. The set of systems is based on released USMC information (USMC, 2006). Each trainer has been examined with respect to the following features:

Table 9

Use of Sensors to Assess Various Rifle Marksmanship Skills

| Feature | Definition |
|---|---|
| Can use own weapon? | Whether system allows the use of the person's actual weapon. |
| What is instrumented? | What modifications or inserts are needed to integrate weapon into training system. |
| Recoil? | Whether there is recoil in the weapon. |
| Blanks or SESAMS | Type of blanks, if any. |
| Live rounds | Whether live rounds are permitted. |
| Software | Type of software supplied. |
| Virtual target | Whether a virtual target is supplied. |
| Video | Whether there are video-based scenarios. |
| Video reacts to shots fired | Whether there is branching video. |
| Branching video authoring | Whether there is branching video authoring. |
| Real time editing of scenario | Whether there is real-time editing of scenarios. |
| Real people | Whether real people are involved in trainer. |
| Tracking of shot results | Whether hits on target are recorded by the system for printout. |
| How scored | Statistics available for hits. |
| AAR | Whether after-action reports are available. |
| Replay of performance | Whether the system can "replay" performance. |
| Shoot/no-shoot scenarios | Whether there are judgmental scenarios. |
| Basic marksmanship training | Whether there is basic marksmanship training. |
| Add own scenarios? | Whether system allows addition of scenarios. |

Appendix D summarizes the features and capabilities of the training systems for marksmanship. They are a mixture of live and virtual training environments and range from individual to group training situations. Below is a brief description of the various training systems.

## Live Training Scenarios

**Range Modernization and Transformation (RM/T)**. This system updates ranges to a "dynamic training system capable of real time and post mission battle tracking, data collection and the deliverance of value added After Action Review (AAR)" (p. 14). The instrumentation tracks vehicles, aircraft, and tactical voice and data communications. It includes 2D/3D exercise monitoring capability, near real-time dynamic-multimedia/replay AAR, and range/exercise controller situation awareness displays.

**MOUT (military operations in urban terrain)/ UWTC (Urban Warfare Training Center).** The MOUT/UWTC training environment includes non-live and live fire configurations that train team performance on force-on-force fire and maneuver training (day and night in a simulated urban environment-modular building) using SESAMs ammunition (low velocity marking rounds) for non-live and 5.56mm and 7.62mm ball ammunition for live fire scenarios. MILES (multiple laser engagement system) 2000 may be used as well to determine target hits (laser-instrumented weapons and detection devices on individuals and vehicles).

**CAMOUT (combined arms military operation in urban terrain).** Similar to the MOUT training but includes simulated urban context with live actors. Scenarios can include humanitarian relief efforts, peacekeeping, and law enforcement to direct combat, also known as the "three block war."

### Virtual Trainers

**Indoor Simulated Marksmanship Trainer – Enhanced (ISMT-E).** Laser instrumented rifles used with video-projected targets, simulated tactical scenarios (judgment of shoot/no-shoot) as well as the replicate marksmanship qualification ranges. The system provides "comprehensive diagnostic, replay, feedback and scoring capabilities." New scenarios can be generated. Currently contracted upgrades include field optics (RCO).

**DVTE (Deployable Virtual Training Environment).** Composed of two components: the infantry tool kit (ITK) which contains various tactical decision making scenarios, and combined arms network(CAN). This system utilizes a semi-autonomous force model.

**FOPCSim is a Call for Fire Simulator built by NPS with Delta 3D.** Simulates actual 29 Palms terrain. User must "correctly identify and then determine the correct munitions to engage the target."

**Close Combat Marine (CCM).** Squad, platoon, and company-level tactical decision making trainer.

**MPRI Beamhit.** Beamhit has a number of systems and devices used by the Marines Corps. It is a laser-based system that can record number of hits on target.

**LaserShot.** The Lasershot training systems allow for indoor live fire and non-live fire training. Modular rooms can be built including multiple levels. System benefits are being able to use live/SESAM rounds and walls of buildings can absorb impact without richocheting.

## Assessment Issues

One critical shortcoming from many trainers is that they do not typically provide the capability to export data in an easily readable format. This property is important because for research purposes, being able to access data at the shot level (e.g., coordinates on the target) is essential to be able to link shot performance data to an individual.

# SECTION V: RESEARCH PLAN

In this section we describe the research plan. The research design is guided by the following research questions:

1. What are the critical knowledge, skills, and abilities related to rifle marksmanship (known distance, combat marksmanship)?
2. What is the quality of assessments (sensor-based and other measures) used to measure known distance rifle marksmanship skills and combat marksmanship skills?

These research questions will be addressed across three phases of the project. Phase I will extend the work of Nagashima et al. (2008) for known distance. The findings from Phase I will be used to guide the development of sensing measures in Phase II and Phase III. Phase II will focus on identifying the knowledge, skills, and abilities (KSAs) associated with combat marksmanship, including task scenarios that will exercise the range of KSAs. Phase III will focus on the validation work to establish the technical quality of the measures.

## Phase I: Validation of Human Performance Model for Known Distance Rifle Marksmanship

The primary objective for Phase I is to gather additional validity evidence regarding the efficacy of the sensor-based human performance model for known distance rifle marksmanship. Nagashima et al. (2008) developed a model based on naïve participants (college students) and the model needs to be verified on military personnel.

### Methodology

Two methods will be used to generate validity evidence regarding the efficacy of the sensor-based model of skill performance in known distance rifle marksmanship (a) multitrait-multimethod matrix, and (b) predictive validity.

The multitrait-multimethod matrix (MTMM) is an approach to assessing the construct validity of a single or a set of measures in a study (Campbell & Fiske, 1959). Using MTMM, measures of convergent and divergent validity are examined to assess the degree to which the skill model converges with related measures (e.g., USMC marksmanship classification, rifle qualification scores) and diverges from unrelated measures. The MTMM matrix will be constructed using correlation analysis to test the null hypotheses of no relationship between external measures of marksmanship skill (e.g., USMC marksmanship classification, qualification scores) and sensor-based skill measures. Modest to high correlations between the measures will indicate coherence between external measures and model estimates, while low values indicate little coherence.

Predictive validity assesses a model's ability to accurately predict proper classification (Cronbach & Meehl, 1955). Evidence of predictive validity will be collected by comparing the sensor-based model outputs against levels of expertise to test the null hypothesis of no relationship between level of expertise and model classification. The degree of accuracy in model prediction (overall % correct) is an indication of the degree to which the model successfully reproduces the actual level of expertise and indicates the predictive validity of the model. Given the inherent variability in skill performance across experts and non-experts, perfect prediction (i.e., 100% correct classification) is untenable. Nagashima et al. (2008) provide an example of such a methodology for measuring rifle marksmanship skill based on sensor data.

## Phase II: Knowledge Acquisition for Combat Marksmanship Skills

Leveraging work on USMC-basic rifle marksmanship (known distance) in Phase I, Phase II will address the transition of known distance sensing technology (e.g., CRESST's current sensing system or NPS project-developed system) for use in moving-target marksmanship and close combat tactical maneuvering. There are four objectives in Phase II:

1. Define knowledge, skills, and abilities specific to moving-target combat rifle marksmanship and close combat tactical maneuvering.
2. Define the scenario-based tasks aligned to desired outcomes for moving-target combat rifle marksmanship and close combat tactical maneuvering.
3. Identify strengths and weaknesses in current sensing system in relation to moving-target combat rifle marksmanship and close combat tactical maneuvering skills.
4. Define requirements for sensing system to accommodate measurement of moving-target combat rifle marksmanship and close combat tactical maneuvering skills.

### Methodology

Defining the knowledge, skills, and abilities (KSA) related to moving-target marksmanship and close combat tactical maneuvering will be carried out through interviews, observations, questionnaires, and task analysis of content area experts (e.g., coaches, instructors). Once requisite skills are cataloged, a framework will be developed to link scenarios to each skill. An alignment study will be conducted to assess the level of agreement between scenario and skill using multiple experts. Table 10 summarizes the design. Multiple experts will rate the required skills of a particular scenario and the level of agreement will be calculated (Cohen's kappa). Scenarios which fall below a critical value will be reassessed.

Table 10

Summary of Alignment Study of Scenario Versus Task

| Scenario | Expert rating | | | Level of agreement |
|---|---|---|---|---|
| | E1 | E2 | E3 | |
| a | a1 | a2 | a3 | $\kappa_a$ |
| b | b1 | b3 | b3 | $\kappa$b |
| c | c1 | c3 | c3 | $\kappa_c$ |
| d | d1 | d3 | d3 | $\kappa_d$ |
| e | e1 | e3 | e3 | $\kappa_e$ |
| f | f1 | f3 | f3 | $\kappa_f$ |
| a | a1 | a3 | a3 | $\kappa_a$ |
| b | b1 | b3 | b3 | $\kappa_b$ |
| c | c1 | c3 | c3 | $\kappa_c$ |
| d | d1 | d3 | d3 | $\kappa_d$ |
| e | e1 | e3 | e3 | $\kappa_e$ |
| . | . | . | . | . |
| . | . | . | . | . |
| . | . | . | . | . |

## Phase III: Validation of Combat Marksmanship Skills Assessment Tasks

Phase III involves the development of an assessment ontology and the validation of sensor-based measures and assessment tasks. The assessment ontology will align the scenario-based tasks developed in Phase III with sensor-based estimates of skill performance for moving-targets and close combats tactical maneuvering. There are four objectives for Phase III:

1. Definition of measurement scales linking scenario-based tasks to sensing data.
2. Development of an assessment ontology for moving-target combat rifle marksmanship and close combat tactical maneuvering.
3. Validation of the assessment measures and tasks for moving target marksmanship and close combat tactical maneuvering.
4. Specification of sensing requirements.

### Methodology

Table 11 outlines the tentative analytical approach. The different scenarios along with requisite skill defined in Phase II will be tested on a small sample ($n$ = 5) to fit a preliminary model of expert performance. Given that a scenario may require multiple skills, data from across subjects and across scenarios will be pooled to establish parameter estimates (β's) for individual skill types resulting in a single model for every skill.

Table 11

Summary of Tentative Modeling Design

| | | | Sensor | | | | | |
|---|---|---|---|---|---|---|---|---|
| Participant | Scenario | Task | A | B | C | D | … | Model estimate of performance |
| 1001 | 1 | Controlled pair | $\beta_{A1}$ | $\beta_{B1}$ | $\beta_{C1}$ | $\beta_{D1}$ | ˜ | Y1 |
| 1002 | 2 | Failure drill | $\beta_{A2}$ | $\beta_{B2}$ | $\beta_{C2}$ | $\beta_{D2}$ | ˜ | Y2 |
| 1003 | 3 | Speed reload / controlled pairs | $\beta_{A3}$ | $\beta_{B3}$ | $\beta_{C3}$ | $\beta_{D3}$ | ˜ | Y3 |
| . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . |

With a tentative skill model for moving targets and close combat tactical maneuvering defined, validity evidence will be collected. As in Phase I, a MTMM matrix will be constructed using correlation analysis to test the null hypotheses of no relationship between external measures of marksmanship skill (e.g., USMC marksmanship classification, qualification scores) and sensor-based skill measures. Additionally, evidence of predictive validity will be collected for the new models (for each skill) by comparing the sensor-based model outputs against levels of expertise to test the null hypothesis of no relationship between level of expertise and model classification. However, unlike known distance marksmanship, a model for moving targets and close combat tactical maneuvering must attend to inherent interdependencies between context and skill. For example, in known distance marksmanship training, the target is static with relatively little change in the environment from shot to shot; on the other hand, moving targets and tactical maneuvering situations are never the same. As a result, a statistical approach must be employed that captures intrinsic differences in difficulty across various scenarios. One such approach is with the use of item response theory (IRT). IRT analysis enables the estimation of difficulty level of each scenario so that scenarios can be weighted resulting in increased accuracy in model building and estimation (Embretson & Reise, 2000).

Data collection will involve experts as the criteria with non-experts as the test group. Comparison of expert performance against non-expert performance will highlight skill differences that can be measured and evaluated to provide evidence regarding the validity and reliability of sensor-based measures.

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# APPENDIX A:
# KEY KNOWLEDGE COMPONENTS

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Weapons condition:<br>Readiness for firing | Condition 1: Safety on, magazine inserted round in chamber, bolt forward, ejection port cover closed.<br><br>Condition 2: Not applicable to the M16A2 rifle.<br><br>Condition 3: Safety on, magazine inserted, chamber empty, bolt forward, ejection port cover closed.<br><br>Condition 4: Safety on, magazine removed, chamber empty, bolt forward, ejection port cover closed. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 3<br>Section 3002<br>Page 3-1 |
| Determining a weapon's condition: Preparing a weapon for firing | • Determine if a magazine is present.<br>• Ensure the rifle is on safe.<br>• Conduct a chamber check.<br>• Bring the left hand back against the magazine well.<br>• Extend the fingers of the left hand and cover the ejection port…<br>• Grasp the charging handle with the index and middle fingers of the right hand.<br>• Pull the charging handle slightly to the rear and visually and physically inspect the chamber… Right-handed Marines, insert one finger of the left hand into the ejection port and feel whether a round is present. Left-handed Marines, insert the thumb of the right hand into the ejection port and feel whether a round is present.<br>• CAUTION: Pulling the charging handle too far to the rear while inspecting the chamber may cause double feed or ejection of one round of ammunition.<br>• Release the charging handle and observe the bolt going forward.<br>• Tap the forward assist.<br>• Close the ejection port cover (if time and the situation permit).<br>• Remove the magazine (if present) and observe if ammunition is present. If time permits, count the rounds. Reinsert the magazine into magazine well. | Procedural (knowledge of subject-specific skills)<br><br>[Procedural Explanation]<br><br>Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3003<br>Page 3-1 & 3-2 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Weapons commands:<br>Commands for loading and unloading the rifle | Six commands are used in weapons handling:<br><br>Load. This command is used to take the weapon from Condition 4 to Condition 1.<br><br>Make Ready. This command is used to take the weapon from Condition 3 to Condition 1.<br><br>Fire. This command is used to specify when a Marine may engage targets.<br><br>Cease-Fire. This command is used to specify when a Marine must stop target engagement.<br><br>Unload. This command is used to take the weapon from any condition to Condition 4.<br><br>Unload and Show Clear. This command is used when an observer must check the weapon to verify that no ammunition is present before the rifle is placed in Condition 4. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 3<br>Section 3004<br>Page 3-2 |
| Loading the rifle | • Ensure the rifle is on safe.<br>• Withdraw the magazine from the magazine pouch.<br>• Observe the magazine to ensure it is filled.<br>• Fully insert the magazine in the magazine well. Without releasing the magazine, tug downward on the magazine to ensure it is seated.<br>• Close the ejection port cover.<br>• Fasten the magazine pouch. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3004<br>Page 3-3 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Making the rifle ready | • Pull the charging handle to the rear and release. There are two methods of doing this:<br>Grip the pistol firmly with the right hand and pull the charging handle with the left hand to its rearmost position and release…<br>Or grip the handguards firmly with the left hand and pull the charging handle with the right hand to its rearmost position and release…<br>• To ensure ammunition has been chambered, conduct a chamber check (see para. 3003) to ensure a round has been chambered.<br>• Check the sights (to ensure proper battlesight zero [BZO] setting, correct rear sight aperture, etc.).<br>• Close ejection port cover. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3004<br>Page 3-3 |
| Fire:<br>Knowing when to fire | On the command "Fire," aim the rifle, take the rifle off safe, and pull the trigger. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3004<br>Page 3-3 |
| Cease fire | On the command "Cease Fire," perform the following steps:<br>• Place your trigger finger straight along the receiver.<br>• Place the weapon on safe. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3004<br>Page 3-3 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Unloading the rifle | • Ensure the weapon is on safe.<br>• Remove the magazine from the rifle and retain it on your person.<br>• Cup the left hand under the ejection port, rotate the weapon until the ejection port faces down.<br>• Pull the charging handle to the rear and catch the round in the left hand…<br>• Lock the bolt to the rear.<br>• Put the weapon on safe if the selector lever would not move to safe earlier.<br>• Ensure the chamber is empty and that no ammunition is present.<br>• Depress the bolt catch and observe the bolt moving forward on an empty chamber…<br>• Close the ejection port cover.<br>• Check the sights (for proper BZO setting, correct rear sight aperture, etc.).<br>• Place any ejected round into the magazine and return the magazine to the magazine pouch and close the magazine pouch. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3004<br>Page 3-3 & 3-4 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Unloading & showing the rifle clear | The Marine–<br>• Ensures the weapon is on safe.<br>• Removes the magazine from the rifle and retains it.<br>• Cups the left hand under the ejection port, rotates the weapon until the ejection port faces down.<br>• Pulls the charging handle to the rear and catches the round in the left hand.<br>• Locks the bolt to the rear and ensures the chamber is empty and that no ammunition is present.<br>• Has another Marine inspect the weapon to ensure no ammunition is present.<br><br>The observer–<br>• Visually inspects the chamber to ensure it is empty, no ammunition is present, and the magazine is removed.<br>• Ensures the weapon is on safe.<br>• Acknowledges the rifle is clear.<br><br>The Marine, after receiving acknowledgement that the rifle is clear–<br>• Depresses the bolt catch and observes the bolt moving forward on an empty chamber.<br>• Closes the ejection port cover.<br>• Checks the sights (for proper BZO setting, correct rear sight aperture, etc.).<br>• Places any ejected round into the magazine and returns the magazine to the magazine pouch and closes the magazine pouch. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3004<br>Page 3-4 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Reloading the rifle:<br>Condition 1 (replacing the magazine before it runs out of ammunition) | • Withdraw a filled magazine from the magazine pouch. With the same hand, press the magazine button and remove the partially filled magazine so it can be retained in the remaining fingers.<br>• Fully insert the filled magazine into the magazine well and tug downward on the magazine to ensure it is properly seated.<br>• Store the partially filled magazine in the magazine pouch with rounds up and projectiles pointing away from the body.<br>• Fasten the magazine pouch. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3006<br>Page 3-7 |
| Reloading the rifle:<br>Dry reload (magazine in the weapon has been emptied and the bolt has locked to the rear) | • Press the magazine release button.<br>• Remove the empty magazine and retain it on your person when time permits.<br>• Fully insert a filled magazine into the magazine well and tug downward on the magazine to ensure it is properly seated.<br>• Depress the bolt catch to allow the bolt carrier to move forward and observe the round being chambered. This places the rifle in Condition 1. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3006<br>Page 3-7 |
| Remedial action | If the rifle fails to fire, a Marine performs remedial action. Remedial action is the process of investigating the cause of the stoppage, clearing the stoppage, and returning the weapon to operation.<br><br>Observe for Indicators<br>Once the rifle ceases firing, the Marine must visually or physically observe the ejection port to identify the problem before he can clear it. The steps taken to clear the weapon are based on observation of one of the following three indicators:<br><br>Indicator: The bolt is forward to the ejection port cover is closed….<br>To return the weapon to operation—<br>• Seek cover if the tactical situation permits.<br>• Tap–Tap the bottom of the magazine.<br>• Rack–Pull the charging handle to the rear and release it.<br>• Bang–Sight in and attempt to fire. | Declarative, factual (knowledge of terminology)<br><br>Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 3<br>Section 3007<br>Page 3-7 & 3-8 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| | Indicator: Brass is obstructing chamber area (usually indicating a double feed or failure to eject)…<br>To return the weapon to operation–<br>• Seek cover if the tactical situation permits.<br>• Attempt to remove the magazine.<br>• Attempt to lock the bolt to the rear. | | |
| | If the bolt will not lock to the rear, rotate the rifle so the ejection port is facing down; hold the charging handle to the rear as far as it will go and shake the rifle to free the round(s). If the rounds do not shake free, hold the charging handle to rear and strike the butt of the rifle on the ground or manually clear the round. Conduct and reload. Sight in and attempt to fire. | | |
| | Indicator: The bolt is locked to the rear…. To clear return the weapon to operation–<br>Note: Although a dry weapon is not considered a true stoppage or mechanical failure, the Marine must take action to return the weapon to operation.<br>• Seek cover if the tactical situation permits.<br>• Conduct a dry reload.<br>• Sight in and attempt to fire. | | |
| | Audible Pop or Reduced Recoil<br>An audible pop occurs when only a portion of the propellant is ignited. It is normally identifiable by reduced recoil and is sometimes accompanied by excessive smoke escaping from the chamber area. To clear the rifle in a combat environment:<br>• Place the rifle in Condition 4.<br>• Move take down pin from left to right as far as it will go to allow the lower receiver to pivot.<br>• Remove the bolt carrier group. | Declarative, factual (knowledge of terminology)<br><br>Procedural (knowledge of subject-specific skills) | |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| | • Inspect the bore for an obstruction from the chamber end.<br>• Insert a cleaning rod into the bore from the muzzle end and clear the obstruction.<br>• Reassemble the rifle.<br>• Conduct a reload.<br>• Sight in and attempt to fire. | | |
| Fundamentals of Marksmanship | • The fundamentals of marksmanship are aiming, breathing, and trigger control.<br>• For rifle fire to be effective, it must be accurate.<br>• The fundamentals of marksmanship, when applied correctly, form the basis for delivering accurate fire on enemy targets.<br>• These skills must be developed so that they are applied instinctively.*<br>• The fundamentals are more critical to accurate engagement as the range to the target increases. | Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 4<br>Introduction<br>Page 4-1 |
| Physical preparation | *To be effective in combat, the Marine must train to perfect the physical skills of shooting so those skills become second nature. Mastery of physical skills allow the Marine to concentrate on the mental aspects of target engagement; e.g., scanning for targets, detection of targets, selection and use of cover. The more physical skills that a Marine can perform automatically, the more concentration he can give to the mental side of target engagement. | Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 1<br>Section 1003<br>Page 1-2 |
| Aiming<br>Sight alignment | • Sight alignment is the relationship between the front sight post and rear sight aperture and the aiming eye. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-1 |
| Sight alignment<br><br><br><br>Insert Fig. 4-4 | This relationship is the most critical to aiming and must remain consistent from shot to shot.<br>A sight alignment error results in a misplaced shot.<br><br><br>This error grows proportionally greater as the distance to the target increases. | Conceptual (knowledge of principles and generalizations)<br><br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-2 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Sight alignment<br>Insert Fig.4-1 | • Center the tip of the front post vertically and horizontally in the rear sight aperture.<br>• Imagine a horizontal line drawn through the center of the rear sight aperture. The top of the front sight post will appear to touch the line.<br>• Imagine a vertical line drawn through the center of the rear sight aperture. The line will appear to bisect the front sight post. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-1 |
| Sight picture<br>Insert Fig. 4-2 | Sight picture is the placement of the tip of the front sight post in relation to the target while maintaining sight alignment. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-1 |
| Sight picture<br>Insert Fig. 4-4 | Correct sight alignment but improper sight placement on the target will cause the bullet to impact the target incorrectly on the spot where the sights were aimed when the bullet exited the muzzle. | Conceptual (knowledge of principles and generalizations)<br><br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-1 |
| Sight picture<br>Insert Fig. 4-3 | To achieve correct sight picture, place the tip of the front sight post at the center of the target while maintaining sight alignment… | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-1 & 4-2 |
| Sight picture | Center mass is the correct aiming point so that point of aim/point of impact is achieved. | Declarative, factual (knowledge of terminology)<br><br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-1 & 4-2 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Sight picture | An error in sight picture…remains constant regardless of the distance to the target. | Declarative, factual (knowledge of specific details and elements)<br>Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-2 |
| Stock weld | Stock weld is the point of firm contact between the cheek and the stock of the rifle. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-2 |
| Stock weld | The head should be as erect as possible to enable the aiming eye to look straight through the rear sight aperture…..<br>The eye functions best in its natural forward position. Changing the placement of the cheek up or down on the stock from shot to shot may affect the zero on the rifle due to the perception of the rear sight aperture.<br><br>A consistent and proper stock weld is critical to the aiming process because it provides consistency in eye relief, which affects the ability to align the sights. | Declarative, factual (knowledge of specific details and elements)<br><br>Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-2 |
| Eye relief | Eye relief is the distance between the rear sight aperture and the aiming eye. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-2 |
| Eye relief | Normal eye relief is two to six inches from the rear sight aperture. The distance between the aiming eye and the rear sight aperture depends on the size of the Marine and the firing position. While eye relief varies slightly from one position to another, it is important to have the same eye relief for all shots fired from a particular position. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-2 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Eye relief | If the eye is too close to the rear sight aperture, it will be difficult to line up the front sight post in the rear sight aperture… Moving the eye back form the rear sight aperture will make the aperture appear smaller and allow the tip of the front sight post to be easily lined up inside the rear sight aperture. If the eye is too far from the rear sight aperture, it will be difficult to acquire the target and to maintain a precise aiming point. | Declarative, factual (knowledge of specific details and elements)<br><br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-2 & 4-4 |
| Acquiring and maintaining sight alignment and sight picture | For accurate shooting, it is important to focus on the tip of the front sight post. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-4 |
| Acquiring and maintaining sight alignment and sight picture | As rifle sights become level with the aiming eye, a Marine visually locates the target through the rear sight aperture. As the rifle settles, a Marine's focus shifts back to the front sight post to place the tip of the post on the target and obtain sight alignment and sight picture. To maintain sight alignment and sight picture, the Marine's focus should shift repeatedly from the front sight post to the target until correct alignment and sight picture are obtained. This enables the detection of minute errors in sight alignment and sight picture. | Procedural (knowledge of subject-specific skills)<br><br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 4<br>Section 4001<br>Page 4-4 |
| Breath control | Proper breath control is critical to the aiming process. Breathing causes the body to move. This movement transfers to the rifle making it impossible to maintain proper sight picture. Breath control allows the Marine to fire the rifle at the moment of least movement. | Conceptual knowledge<br>(knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 4<br>Section 4002<br>Page 4-5 |
| Breath control during long-range or precision fire (slow fire) | It is critical that Marines interrupt their breathing at a point of natural respiratory pause before firing a long-range shot or a precision shot from any distance. A respiratory cycle lasts 4 to 5 seconds. Inhaling and exhaling each require about 2 seconds. A natural pause of 2 to 3 seconds occurs between each respiratory cycle. The pause can be extended up to 10 seconds. | Declarative factual (knowledge of terminology)<br><br>Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4002<br>Page 4-5 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Breath control during long-range or precision fire (slow fire) | During the pause, breathing muscles are relaxed and the sights settle at their natural point of aim. To minimize movement, Marines must fire the shot during the natural respiratory pause. | Conceptual knowledge (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 4<br>Section 4002<br>Page 4-5 |
| Breath control during long-range or precision fire (slow fire) | The basic technique is as follows:<br>• Breathe naturally until the sight picture begins to settle.<br>• Take a slightly deeper breath.<br>• Exhale and stop at the natural respiratory pause.<br>• Fire the shot during the natural respiratory pause. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 4<br>Section 4002<br>Page 4-5 |
| Trigger control | Trigger control is the skillful manipulation of the trigger that causes the rifle to fire without disturbing sight alignment or sight picture. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |
| Trigger control | Controlling the trigger is a mental process, while pulling the trigger is a physical process. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |
| Grip | A firm grip is essential for effective trigger control. The grip is established before starting the application of trigger control and it is maintained through the duration of the shot. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |
| Grip | To establish a firm grip on the rifle, position the “V” formed between the thumb and index finger on the pistol grip behind the trigger. The fingers and the thumb are placed around the pistol grip in a location that allows the trigger finger to be placed naturally on the trigger and the thumb in a position to operate the safety. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
| --- | --- | --- | --- |
| Grip | Once established, the grip should be firm enough to allow manipulation of the trigger straight to the rear without disturbing the sights. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |
| Trigger finger placement | Correct trigger finger placement allows the trigger to be pulled straight to the rear without disturbing sight alignment. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |
| Uninterrupted trigger control | After obtaining sight picture, the Marine applies smooth, continuous pressure rearward on the trigger until the shot is fired. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |
| Interrupted trigger control | Interrupted trigger control is used at any time the sight alignment is interrupted or the target is temporarily obscured. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |
| Interrupted trigger control | To perform interrupted trigger control:<br>• Move the trigger to the rear until an error is detected in the aiming process.<br>• When this occurs, stop the rearward motion on the trigger, but maintain the pressure on the trigger, until sight picture is achieved.<br>• When the sight picture settles, continue the rearward motion on the trigger until the shot is fired. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |
| Resetting the trigger | During recovery, release the pressure on the trigger slightly to reset the trigger after the first shot is delivered (indicated by an audible click). Do not remove the finger from the trigger. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
| --- | --- | --- | --- |
| Resetting the trigger | This places the trigger in position to fire the next shot without having to reestablish trigger finger placement. | Conceptual knowledge (knowledge of principles and generalizations)<br><br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 4<br>Section 4003<br>Page 4-6 |
| Follow-through | Follow-through is the continued application of the fundamentals until the round has exited the barrel. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 4<br>Section 4004<br>Page 4-7 |
| Follow-through | In combat, follow-through is important to avoid altering the impact of the round by keeping the rifle as still as possible until the round exits the barrel. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4004<br>Page 4-7 |
| Recovery | It is important to get the rifle sights back on the target for another shot. This is known as recovery. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 4<br>Section 4004<br>Page 4-7 |
| Recovery | Shot recovery starts immediately after the round leaves the barrel. To recover quickly, a Marine must physically bring the sights back on target as quickly as possible. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 4<br>Section 4004<br>Page 4-7 |
| Rifle firing positions | There are four basic firing positions: prone, sitting, kneeling, and standing. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5001<br>Page 5-1 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Rifle firing positions | Any firing position must provide stability, mobility, and observation of the enemy. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5001<br>Page 5-1 |
| Stability | A firing position must provide a stable platform for accurate and consistent shooting. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 5<br>Section 5001<br>Page 5-1 |
| Stability | If the position is solid, the front sight can be held steady and the rifle sights should recover after recoil to the same position on the target. This allows for rapid engagement of the enemy.<br><br>The prone position provides the most stability for firing, while the standing position provides the least stability. | Declarative, factual (knowledge of specific details and elements)<br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 5<br>Section 5001<br>Page 5-1 |
| Types and uses of the rifle web sling | The rifle sling, when adjusted properly, provides maximum stability for the weapon, and helps hold the front sight still and reduce the effects of the rifle's recoil. Once a sling adjustment is found that provides maximum control of the weapon, the same sling adjustment should be maintained. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5001<br>Page 5-1 |
| Types and uses of the rifle web sling | Varying the sling tension extensively will affect the strike of the bullet, which will make maintaining a BZO difficult. Using the same sling adjustment will ensure the accuracy of rounds on target. | Conceptual knowledge (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 5<br>Section 5001<br>Page 5-1 |
| Types and uses of the rifle web sling | There are two basic types of rifle sling adjustments: the hasty sling and loop sling. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5001<br>Page 5-1 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Factors common to all shooting positions | There are seven factors that are common to all shooting positions that affect the ability to hold the rifle steady, maintain sight alignment, and control the trigger. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-4 |
| Left hand | Placement of the left hand affects placement of left elbow, eye relief, stock weld, and sling tension. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-4 |
| Hasty sling | In a hasty sling configuration, the sling is attached to the upper and lower sling swivels of the rifle. | Declarative (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-4 |
| Hasty sling | When the left arm is placed in the hasty sling, tension created by the sling travels from side to side. The tension created by the sling affects how the position is established. | Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-4 |
| Grip of the right hand | Proper placement of the right hand high on the pistol grip allows the trigger to be moved straight to the rear without disturbing sight alignment. | Conceptual (knowledge of principles and generalizations)<br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-6 |
| Right elbow | The right elbow should be positioned naturally to provide balance to the position and create a pocket in the shoulder for the rifle butt. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-6 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Right elbow | The exact placement of the elbow varies with each shooting position but should remain consistent from shot to shot, ensuring the resistance to recoil remains constant. | Declarative, factual (knowledge of specific details and elements)<br><br>Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-6 |
| Stock weld | The placement of the shooter's cheek against the stock should remain firm and consistent from shot to shot. Consistency of stock weld is achieved through proper placement of the rifle butt in the pocket of the shoulder. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-6 |
| Stock weld | A firm contact between the cheek and the stock enables consistent eye relief and enables the head and rifle to recoil as a single unit. Stock weld provides quick recovery between rapid fire shots, keeps the aiming eye centered in the rear sight aperture, and prevents the head from bouncing off the stock during recoil. | Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-6 |
| Breathing | Breathing causes chest movement and a corresponding movement in the rifle and its sights. Applying breath control will minimize this movement and the effect it has on aiming. | Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-6 |
| Muscular Tension-<br>Hasty sling | With the hasty sling donned, the shooter must apply an amount of controlled muscular tension in the left arm to keep the sling taut and stabilize the weapon sights. Resistance against the hasty sling controls the point at which the rifle sights will settle. The muscular tension is applied outward against the sling rather than in an effort to hold the rifle up. However, muscular tension should not be excessive to cause the shooter to shake, tremble, or experience fatigue. | Declarative, factual (knowledge of specific details and elements)<br><br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-6 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Muscular relaxation–<br>Loop sling | When using the loop sling, the muscles should be relaxed. Relaxation prevents undue muscle strain and reduces excessive movement. If proper relaxation is achieved, natural point of aim and sight alignment are more easily maintained. | Declarative, factual (knowledge of specific details and elements)<br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-6 & 5-7 |
| Elements of a good shooting position | There are three elements of a good shooting position that apply when using a loop sling: bone support, muscular relaxation, and natural point of aim. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-7 |
| Bone support | The body's skeletal structure provides a stable foundation to support the rifle's weight. A weak shooting position will not withstand a rifle's repeated recoil when firing at the sustained rate or buffeting from wind. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-7 |
| Bone support | To attain a correct shooting position, the body's bones must support as much of the rifle's weight as possible. Proper use of the sling provides additional support. The weight of the weapon should be supported by bone rather than muscle because muscles fatigue whereas bones do not. By establishing a strong foundation for the rifle utilizing bone support, the Marine can relax as much as possible while minimizing weapon movement due to muscle tension. | Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-7 |
| Muscular relaxation | Once bone support is achieved, muscles are relaxed. Muscular relaxation helps to hold the rifle steady and increase the accuracy of the aim. Muscular relaxation also permits the use of maximum bone support to create a minimum arc of movement and consistency in resistance to recoil. Muscular relaxation cannot be achieved without bone support. During the shooting process, the muscles of the body must be relaxed as much as possible. Muscles that are tense will cause excessive movement of the rifle, disturbing the aim. When proper bone support and muscular relaxation are achieved, the rifle will settle onto the aiming point, making it possible to apply trigger control and deliver a well-aimed shot. | Declarative, factual (knowledge of specific details and elements)<br>Conceptual (knowledge of principles and generalizations)<br>[Procedural Explanation] | (MCRP) 3-01A<br>Chapter 5<br>Section 5003<br>Page 5-7 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Natural point of aim | The point at which the rifle sights settle when in a firing position is called the natural point of aim. | Declarative (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 5<br>Section 5004<br>Page 5-7 |
| Natural point of aim | When in a shooting position with proper sight alignment, the position of the tip of the front sight post will indicate the natural point of aim. When completely relaxed, the tip of the front sight post should rest on the desired aiming point. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5004<br>Page 5-7 |
| Natural point of aim | One method of checking for natural point of aim is to aim in on the target, close the eyes, take a couple of breaths, and relax as much as possible. When the eyes are opened, the tip of the front sight post should be positioned on the desired aiming point while maintaining sight alignment. | Procedural (knowledge of subject-specific skills and algorithms) | (MCRP) 3-01A<br>Chapter 5<br>Section 5004<br>Page 5-7 |
| Natural point of aim | In all positions, the natural point of aim can be adjusted by–<br>• Varying the placement of the left hand in relation to the handguards.<br>• Moving the left hand forward on the handguards to lower the muzzle of the weapon, causing the sights to settle lower on the target.<br>• Moving the left hand back on the handguards to raise the muzzle of the weapon, causing the sights to settle higher on the target.<br>• Varying the placement of the stock in the shoulder.<br>• Moving the stock higher in the shoulder to lower the muzzle of the weapon, causing the sights to settle lower on the target.<br>• Moving the stock lower in the shoulder to raise the muzzle of the weapon, causing the sights to settle higher on the target.<br>• Natural point of aim can be adjusted right or left by adjusting body alignment in relation to the target. | Procedural (knowledge of subject-specific skills and algorithms) | (MCRP) 3-01A<br>Chapter 5<br>Section 5004<br>Page 5-7 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Prone position | The prone position provides a very steady foundation for shooting and presents a low profile for maximum concealment. However, the prone position is the least mobile of the shooting positions and may restrict a Marine’s field of view for observation. In this position, the Marine’s weight is evenly distributed on the elbows, providing maximum support and good stability for the rifle. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5005<br>Page 5-8 |
| Sitting position | There are three variations of the sitting position: crossed ankle, crossed leg, and open leg. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5006<br>Page 5-12 |
| Kneeling position | The kneeling position is quick to assume and easy to maneuver from….A tripod is formed by the left foot, right foot, and right knee when the Marine assumes the position, providing a stable foundation for shooting. The kneeling position also presents a higher profile to facilitate a better field of view as compared to the prone and sitting positions. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5007<br>Page 5-15 |
| Standing position | The standing position is supported by the shooter’s legs and feet and provides a small area of contact with the ground. In addition, the body’s center of gravity is high above the ground. Therefore, maintaining balance is critical in this position. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 5<br>Section 5008<br>Page 5-18 |
| Effects of weather | Wind, temperature, and precipitation can affect the trajectory of the bullet. In addition, all weather conditions have a physical and psychological effect on Marines. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 8<br>Introduction<br>Page 8-1 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Physical effects of wind on the bullet | The weather condition that presents the greatest problem to shooting is the wind. Wind affects a bullet's trajectory. The effect of wind on the bullet as it travels down range is referred to as deflection. The wind deflects the bullet laterally in its flight to the target…<br><br>The bullet's exposure time to the wind determines the amount the bullet is deflected from its original trajectory. Deflection increases as the distance to the target increases. There are three factors that affect the amount of deflection of the bullet:<br><br>• Velocity of the wind–The greater the velocity of the wind, the more the bullet will be deflected.<br>• Range to the target–As the distance to the target increases, the speed of the bullet slows allowing the wind to have a greater effect on shot placement.<br>• Velocity of the bullet–A bullet with a high muzzle velocity will not be affected by the wind as much as a bullet with a low muzzle velocity. | Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 8<br>Section 8001<br>Page 8-1 |
| Determining windage adjustments to offset wind effects | The velocity and direction of the wind in relationship to the bullet must be determined to offset the wind's effects. | Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 8<br>Section 8001<br>Page 8-1 |
| Wind direction | Determine wind direction by observing direction vegetation is moving, by feeling the wind blow against the body, or by observing direction of a flag (in training). | Procedural (knowledge of subject-specific skills and algorithms) | (MCRP) 3-01A<br>Chapter 8<br>Section 8001<br>Page 8-1 |
| Wind value classifications | Winds are classified according to the direction from which they are blowing in relation to the direction of fire. The clock system indicates wind direction and value… Winds can be classified as half value, full value, or no value. The target is always located at 12 o'clock. | Conceptual (knowledge of classifications and categories) | (MCRP) 3-01A<br>Chapter 8<br>Section 8001<br>Page 8-1 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Wind velocity | There are two methods used to determine wind velocity : observation and flag. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 8<br>Section 8001<br>Page 8-2 |
| Flag method | The flag method is primary method used on the KD range. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 8<br>Section 8001<br>Page 8-2 |
| Flag method | To estimate wind velocity in miles per hour:<br>Estimate the angle created between the flagpole and the flag in degrees.<br>• Divide the angle by four to estimate wind velocity in miles per hour. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 8<br>Section 8001<br>Page 8-2 |
| Windage adjustments | After identifying wind direction, wind classification, and wind velocity, windage adjustments needed to enable the bullet to strike the target are estimated in the following ways:<br><br>Observation Method. Using the windage chart provided in figure 8-4, match the wind velocity, wind direction, and range to the target to the information in the chart to estimate the correct number of clicks to apply to the windage knob.<br><br>Flag Method. Using the windage chart provided in figure 8-5, match the wind velocity, wind direction, and range to the target to the information in the chart to determine the correct number of clicks to apply to the windage knob.<br><br>Once the number of windage clicks is determined, turn the windage knob causing the rear sight aperture to move into the direction of the wind. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 8<br>Section 8001<br>Page 8-2 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
| --- | --- | --- | --- |
| Wind: physical and psychological effects | The Marine can combat the wind in a number of ways:<br>• Make subtle changes to the basic shooting positions, such as increasing muscular tension, to reduce movement of the rifle sights.<br>• Select a more stable firing position.<br>• Seek support to stabilize the rifle.<br>• Hold the shot and apply the fundamentals during a lull in the wind. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 8<br>Section 8003<br>Page 8-4 |
| Zeroing | Zeroing is adjusting the sights on the weapon to cause the shots to impact where the Marine aims. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Introduction<br>Page 8-5 |
| Elements of zeroing | There are five basic elements involved in zeroing a rifle: line of sight, aiming point, centerline of the bore, trajectory, and range. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 9<br>Section 9001<br>Page 9-1 |
| Line of sight | The line of sight is a straight line, which begins with the shooter's eye, proceeds through the center of the rear sight aperture, and passes across the tip of the front sight post to a point of aim on a target. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9001<br>Page 9-1 |
| Aiming point | The aiming point is the precise point where the tip of the front sight post is placed in relationship to target. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9001<br>Page 9-1 |
| Centerline of the bore | Centerline of the bore is an imaginary straight-line beginning at the chamber end of the barrel, proceeding out of the muzzle, and continuing indefinitely. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9001<br>Page 9-1 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Trajectory | In flight, a bullet does not follow a straight line but travels in a curve or arc, called trajectory. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9001<br>Page 9-1 |
| Trajectory | As the bullet exits the muzzle, it travels on an upward path, intersecting the line of sight (because the sights are above the muzzle). As the bullet travels farther, it begins to drop and intersects the line of sight again. | Declarative, factual (knowledge of specific details and elements)<br><br>Conceptual (knowledge of principles and generalizations) | (MCRP) 3-01A<br>Chapter 9<br>Section 9001<br>Page 9-1 |
| Range | Range is the KD from the rifle muzzle to the target. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9001<br>Page 9-2 |
| Battlesight zero | A BZO is the elevation and windage settings required to place a single shot, or the center of a shot group, in a predesignated location on a target at 300 yards/meters, under ideal weather conditions (i.e., no wind). | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9002<br>Page 9-2 |
| Zero | A zero is the elevation and windage settings required to place a single shot, or the center of a shot group, in a predesignated location on a target at a specific range, from a specific firing position, under specific weather conditions. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9002<br>Page 9-2 |
| True zero | A true zero is the elevation and windage settings required to place a single shot, or the center of a shot group, in a predesignated location on a target at a specific range other than 300 yards/meters, from a specific firing position, under ideal weather conditions (i.e., no wind). | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9002<br>Page 9-2 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
| --- | --- | --- | --- |
| M16A2 sighting system | The sighting system of the M16A2 service rifle consists of a front sight post and two rear sight apertures windage and elevation knob. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9003<br>Page 9-2 |
| Front sight | The front sight post is used to adjust for elevation. The front sight consists of a square, rotating sight post with a four-position, spring-loaded detent… | Declarative, factual (knowledge of terminology)<br><br>Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 9<br>Section 9003<br>Page 9-2 |
| Front sight | To adjust for elevation, use a pointed instrument (or the tip of a cartridge) to depress the detent and rotate the front sight post… To raise the strike of the bullet, rotate the post clockwise (in the direction of the arrow marked UP) or to the right. To lower the strike of the bullet, rotate the post counter-clockwise (in the opposite direction of the arrow) or to the left. | Procedural (knowledge of subject-specific skills) | (MCRP) 3-01A<br>Chapter 9<br>Section 9003<br>Page 9-2 |
| Rear sight | The rear sight consists of two sight apertures, a windage knob, and an elevation knob. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9003<br>Page 9-2 |
| Elevation knob | The rear sight elevation knob is used to adjust the sight for a specific range to target. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 9<br>Section 9003<br>Page 9-2 |
| Windage knob | The windage knob is used to adjust the strike of the round right or left. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 9<br>Section 9003<br>Page 9-2 |

| Keywords | Knowledge | Type of Knowledge | Source/Citation |
|---|---|---|---|
| Windage and elevation rules | Moving the front sight post, elevation knob or windage knob one graduation or notch is referred to as moving one "click" on the sight. | Declarative, factual (knowledge of terminology) | (MCRP) 3-01A<br>Chapter 9<br>Section 9004<br>Page 9-3 |
| Windage and elevation rules | The windage and elevation rules define how far the strike of the round will move on the target for each click of front and rear sight elevation or rear sight windage for each 100 yards/meters of range to the target. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 9<br>Section 9004<br>Page 9-3 |
| Front sight elevation rule | One click of front sight elevation adjustment will move the strike of the round on target approximately 1.25 inches for every 100 yards of range to the target or 3.5 centimeters for every 100 meters of range to the target. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 9<br>Section 9004<br>Page 9-3 |
| Rear sight elevation rule | One click of rear sight elevation adjustment will move the strike of the round on the target approximately 1 inch for every 100 yards of range to the target or 2.5 centimeters for every 100 meters of range to the target. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 9<br>Section 9004<br>Page 9-4 |
| Windage rules | One click of windage adjustment will move the strike of the round on the target approximately 0.5 inch for every 100 yards of range to the target or 1.25 centimeters for every 100 meters of range to the target. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 9<br>Section 9004<br>Page 9-4 |
| Uniform | The wearing of full battle gear changes eye relief, placement of the rifle in the shoulder pocket, and the way the rifle is supported on the handguard. Marines must establish their BZOs while wearing the uniform and equipment they will be wearing while engaging targets. | Declarative, factual (knowledge of specific details and elements) | (MCRP) 3-01A<br>Chapter 9<br>Section 9008<br>Page 9-6 |

# APPENDIX B:
# KEY RIFLE MARKSMANSHIP FACTS

| Topic | Description |
|---|---|
| Weapons handling | A Marine carries the rifle at Tactical Carry when there is no immediate threat present. |
| Weapons handling | Definition of remedial action<br>Remedial action is investigating the cause of the stoppage, clearing the stoppage, and returning the weapon to operation. |
| Weapons handling:<br>Weapon condition | Different weapons conditions (could be graphic)<br>CONDITION 1: Magazine inserted, round in chamber, bold forward, safety on, ejection port cover closed<br>CONDITION 2: Not Applicable<br>CONDITION 3: Magazine inserted, chamber empty, bolt forward, safety on, ejection port cover closed<br>CONDITION 4: Magazine removed, chamber empty, bold forward, safety on, ejection port cover closed |
| Weapons handling:<br>Remedial Action | Three indicators of remedial action and their corresponding actions<br>(1)Bolt is forward or ejection port cover is closed. ACTION Tap, rack, bang<br>(2)Bolt is locked to the rear. ACTION Conduct a dry reload,<br>(3)Brass is obstructing chamber area (usually indicates double feed or failure to eject) ACTION Remove magazine. Lock bolt to rear. Shake rounds out. Conduct a reload. |
| Weapons handling:<br>Rifle transfer | Two procedures to use to transfer a rifle from one Marine to another<br>Clear transfer<br>Condition Unknown Transfer |
| Weapons handling: Safety Rules | Four safety rules that most strongly enforce muzzle awareness.<br>Treat every weapon as if it were loaded.<br>Never point a weapon at anything you do not intend to shoot.<br>Keep your finger straight and off the trigger until you are ready to fire.<br>Keep the weapon on safe until you intend to fire. |
| Fundamentals of Marksmanship | The three fundamentals of marksmanship<br>Aim<br>Breathing Control<br>Trigger control |
| Fundamentals of Marksmanship:<br>Aiming | Obtaining a natural point of aim<br>Align sights, breathe in, close your eyes, exhale, and open your eyes. |
| Fundamentals of Marksmanship:<br>Aiming | Achieving a correct sight picture.<br>Place the tip of the front sight post at the center of the target while maintaining sight alignment. |
| Fundamentals of Marksmanship:<br>Aiming | Definition of center mass.<br>The correct aiming point so that point of aim/point of impact is achieved. |
| Fundamentals of Marksmanship:<br>Aiming | Where the shooter's main point of focus should be when he/she fires a shot<br>Center mass or center of target |

| Topic | Description |
|---|---|
| Fundamentals of Marksmanship:<br>Breath control | The technique for breath control is as follows:<br>Breathe naturally until the sight picture begins to settle.<br>Take a slightly deeper breath<br>Exhale and extend your natural respiratory pause<br>Stop breathing at your point of NRP before firing a long-range shot |
| Fundamentals of Marksmanship:<br>Trigger control | Definition of uninterrupted Trigger Control. Definition of interrupted Trigger Control<br>Uninterrupted Trigger Control: After the initial slack of the trigger is taken up, the trigger is pulled with a single, smooth motion straight to the rear with no interruption<br>Interrupted Trigger Control: After the initial slack is taken up, the trigger is moved to the read unless an error is detected in the aiming process. When this occurs, rearward motion is topped until sight picture is achieved. Then the rearward motion continues until the shot breaks. |
| Fundamentals of Marksmanship:<br>Trigger Control | Use of interrupted trigger control<br>In extremely windy conditions when the weapon will not settle, forcing the Marine to pause until the sights return to his aiming point. |
| Fundamentals of Marksmanship:<br>Trigger Control | Uninterrupted trigger control is the preferred method in a combat environment |
| Fundamentals of Marksmanship:<br>Trigger Control | Definition of a follow-through<br>The continued applications of the fundamentals until the round has exited the barrel. |
| Rifle firing positions:<br>Stability | The most stable position is the prone position. The least stable position is the standing position |
| Rifle firing positions: Mobility | The least mobile of the shooting positions<br>Prone |
| Rifle firing positions:<br>Observation of the enemy | The best firing position that normally provides the best field of view is standing |
| Rifle firing positions:<br>Types and uses of Rifle web sling | The two basic types of rifle sling adjustments<br>Hasty Sling and Loop Sling |
| Rifle firing positions:<br>Types and uses of Rifle web sling | If body alignment is correct, the weapon's recoil is absorbed by the whole body |
| Rifle firing positions: Types and uses of Rifle web sling | The rifle sling provides maximum stability for the weapon and helps stabilize the front sight and reduce the effects of the rifle's recoil. |

| Topic | Description |
|---|---|
| Rifle firing positions: Elements of a good shooting position | Three elements of a good shooting position.<br>Bone support<br>Muscular Relaxation<br>Natural Point of Aim |
| Rifle firing positions: Elements of a good shooting position | Seven factors that are common to all shooting positions as they apply with the Hasty Sling<br>Left hand<br>Rifle Butt in the Pocket of the Shoulder<br>Grip of the Right Hand<br>Right Elbow<br>Stock Weld<br>Breathing<br>Muscular Tension |
| Rifle firing positions: Elements of a good shooting position | In the kneeling position, a right-handed shooter should have his/her right elbow supported. |
| Effects of weather:<br>On marines | Weather factors that affect the shooter<br>Wind<br>Temperature<br>Precipitation |
| Effects of weather:<br>On the bullet | Wind affect the bullet's trajectory laterally |
| Zeroing:<br>Elements of zeroing | Five basic elements involved in zeroing the rifle<br>Line of sight<br>Point of aim<br>Centerline of the bore<br>Trajectory<br>Range |
| Zeroing:<br>Types of zeros<br>Battlesight Zero | A BZO is the elevation and windage setting that is used in combat to engage point targets from 0-300 yards/meters under now wind conditions. |
| Zeroing:<br>Battlesight Zero | Factors that affect the accuracy of a BZO<br>Forward hand, grip, right elbow, stock weld, rifle butt in the pocket of the shoulder, relaxation, breathing<br>Sling tension, trigger control, slight picture |
| Zeroing:<br>Reconfirmation of BZO | Some factors that cause a BZO to be reconfirmed.<br>Rifle maintenance, temperature, climate, ground elevation, and uniform |
| Zeroing:<br>Sight alignment | Front sight is used to adjust for elevation |

| Topic | Description |
|---|---|
| Zeroing:<br>Sight alignment | The direction to rotate the front sight post in order to move the strike of the round up. And down.<br>To move it up, move it right (or clockwise)<br>To move it down, move it left (or counterclockwise) |
| Zeroing:<br>Sight alignment | During the zeroing process, all elevation adjustments should be made on the front sight post |
| Zeroing:<br>Sight alignment | The direction to turn the rear sight windage knob in order to move the strike of the round to the right.<br>To the right or clockwise |
| Zeroing:<br>Sight alignment | The rear sight elevation should be set on 8/3 - 2 when firing at the 200-yd line |
| Engagement techniques:<br>Target indicators | Three target indicators<br>Movement<br>Sound<br>Improper Camouflage |

# APPENDIX C:
# KEY RIFLE MARKSMANSHIP CAUSE-EFFECT RELATIONS

| Fundamental | Impacts | Explanation |
|---|---|---|
| Stock weld | Sight picture and alignment | Maintains an erect head position, which places the eye in its natural forward position, enabling the aiming eye to look straight through the rear sight picture. If the position of the Marine's head causes him to look across the bridge of his nose or out from under his eyebrow, the eye will be strained. |
| Varying the stock weld placement | Perception of the rear sight aperture | Changes eye relief |
| Eye relief (eye is too close to the rear sight aperture) | Sight picture and alignment | Makes it difficult to line up the front sight post if the eye is too close to the rear sight aperture. |
| Eye relief (eye is too far from the rear sight aperture) | Sight picture and alignment | Makes it difficult to acquire the target and to maintain a precise aiming point. |
| Focus of eye on front sight post | Sight picture and alignment | Enables detection of minute errors in sight alignment and sight picture. Marine's focus should shift repeatedly from the front sight post to the target until correct sight alignment and sight picture are obtained. |
| Focus of eye on front sight post when shot is fired | Sight alignment | Distorts the image when staring at the front sight post for longer than a few seconds, making it difficult to detect minute errors in sight alignment. |
| Increasing distance to the target | Ability to aim at center of mass and maintain a center mass sight picture | Front sight post covers more of the target making it difficult to establish a center of mass. |
| Looking at the target | Impact of shots | Lowers the tip of the front sight post, which causes shots to impact low or miss the target completely. |
| Breath control | Sight picture | Allows the Marine to fire the rifle at the moment of least movement since breathing causes the body to move which transfers to the rifle, making it impossible to maintain proper sight picture |
| Trigger control (firm grip) | Sights | If it is firm enough, it should allow manipulation of the trigger without disturbing the sights. |
| Trigger control (finger placement) | Sight alignment | If the trigger finger contacts the trigger naturally, it should allow the trigger to be pulled straight to the rear without disturbing sight alignment |
| Follow-through | Impact of the round | Keeps rifle as still as possible until round exits the barrel. |
| Stable firing position | Sights | Front sight can be held steady and the rifle sights should recover after recoil to the same position on the target. |
| Mobile firing position | Engagement | Standing allows the most lateral movement for engagement of widely dispersed targets. |

| Fundamental | Impacts | Explanation |
|---|---|---|
| Rifle sling | Sight alignment and rifle recoil | Provides maximum stability for the weapon, which reduces the effects of rifle recoil and offers resistance against the sling, which enables the rifle sights to be held steady. |
| Varying of sling tension | BZO | Changes the strike of the bullet. |
| Controlled muscle tension of hasty sling | Sights | Offers resistance against the sling, keeping sights steady. |
| Forward hand placement | Stability of rifle | A straight and locked forward hand's wrist creates resistance on the sling close to the muzzle, stabilizing the rifle.<br>If the rifle rests across the palm of the hand, the only resistance created is where the sling meets the triceps.<br>Resistance is further from the muzzle, making stabilizing the rifle more difficult. |
| Excessively tightened loop sling | Rifle sights | Restricting blood flow causes an excessive pulse beat to be transmitted through the rifle sling to the rifle, and causes a rhythmic movement of the rifle sights. |
| Tension on the rifle sling | Rifle recoil | Causes the rifle butt to be forced rearward into the pocket of the shoulder, keeping butt plate in the shoulder pocket during recoil. |
| Bone support | Weapon movement | Provides a stable foundation to support the rifle's weight because muscles fatigue whereas bones do not. |
| Muscular relaxation | Accuracy of aim | Creates a minimum arc of movement and consistency in resistance to recoil by permitting the use of maximum bone support. Tense muscles cause excessive movement of the rifle, which disturbs aim. |
| Velocity of wind | Deflection of the bullet | The greater the velocity of the wind, the more the bullet will be deflected. |
| Rifle chamber's pressure (cold weather) | Point of aim | In cold weather, the rifle chamber's pressure decreases, which causes the bullet to exit the muzzle at a lower velocity, which impacts the target below the point of aim. |
| Rifle chamber's pressure (extreme heat) | Point of aim | In extreme heat, the rifle chamber's pressure increases, which causes the bullet to exit the muzzle at a higher velocity, which impacts the target above the point of aim. |
| Rapid fatigue | Sight alignment | Rapid fatigue causes muscle cramps, heat exhaustion, heat stroke, blurred vision, and reduced concentration, which results in inaccurate shooting. |
| Sweat running into the eyes | Sights | Sweat running into the eyes can cause irritation, which makes it difficult to see the sights. |
| Heat waves or mirages | Sights | Distorts the target shape or the appearance of the front sight post, reducing the Marine's ability to see the sight clearly. |
| Extreme cold | Trigger control | If hands are numb, the Marine will have difficulty holding a rifle and executing effective trigger control. |
| Precipitation | Sight alignment and picture | When it collects on rear sight aperture, it can make it difficult to establish sight alignment and sight picture. |

| Fundamental | Impacts | Explanation |
|---|---|---|
| Bright light | Appearance of a target | Makes a target appear smaller and farther away. |
| Overcast | Appearance of a target | Makes the target appear larger and closer. |
| Haze | Sight picture | Makes a target appear indistinct. |
| Temperature | BZO | Causes chamber pressure to increase or decrease, causing the shots to impact the target high or low (respectively). |
| Climate | BZO | Changes air density, moisture content, temperature or barometric pressure. |
| Ammunition | BZO | Inconsistencies in the production of ammunition affects BZO. |
| Ground elevation | BZO | Creates changes in air density, moisture content, temperature, or barometric pressure. |
| Uniform | BZO | Changes eye relief, placement of the rifle in the shoulder pocket, and the way the rifle is supported on the handguard. |

# APPENDIX D:
# RIFLE MARKSMANSHIP TRAINING SYSTEMS (USMC, 2006)

| Product | Can use own weapon? | What is instrumented? | Recoil? | Blanks or SESAMS | Live Rounds | Software | Virtual Target | Video | Video Reacts to shots fired | Branching Video Authoring | Real Time editing of scenario | Real People | Tracking of Shot results | Scoring | AAR | Replay of Performance | Shoot/no-shoot scenarios | Basic Marksmanship training | Add own scenarios? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LaserShot** | | | | | | | | | | | | | | | | | | | |
| Thermal Shot CQB Shoot House (MSH-modular shoot house) | Y | not needed | Natural | | | | Y | Y | Y | Y | | N | Y | | Y | Y | Y | Y | Y |
| Mobile Range (LSMR) | Y | not needed | Natural | | | | Y | | | | | | Y | | | | | | |
| (Military Skills Engagement Trainer) MSET-CT (Classroom Trainer) | Y/N | inert recoil or own weapon with laser inserts | Drop in recoil kit | | | | | | | | | | | | | | | | |
| (Military Skills Engagement Trainer) MSET-DT (Deployable Trainer) | Y/N | | | | | Running Man | Y | Y | Y | | | | | | | | | | |
| Running Man | Y | | Y | | | | | | | | | | Y | Hit/Hit locations | Y | Y | | Moving Targets | |
| Virtual Battlespace 2 | Y | | | | | | | | | | Y | | | | | | | | |
| **BEAMHIT** | | | | | | | | | | | | | | | | | | | |
| LMTS (Laser Marksmanship Training System) | Y | Y[1] | Y[2] | 2 way blanks | N | Y[3] | | | | | | N | Y[4] | Y[5] | | | | Y | N |
| TR900 | Y | Y[1] | Y[2] | 2 way blanks | N | Y[3] | | | | | | N | Y[4] | Y[5] | | | | Y | N |
| Mini-RETS TR-700 Target | Y | Y[1] | Y[2] | 2 way blanks | N | Y[3] | | | | | | N | Y[4] | Y[5] | | | | Y | N |
| Alt C course | Y | Y[1] | Y[2] | 2 way blanks | N | Y[3] | | | | | | N | Y[4] | Y[5] | | | | Y | N |
| 130-1E Warrior Kit | Y | Y[1] | Y[2] | 2 way blanks | N | Y[3] | | | | | | N | Y[4] | Y[5] | | | | Y | N |
| Laser Collective Combat Advanced Training System | Y | Y[1] | Y[2] | 2 way blanks | N | Y[3] | | | | | | N | Y[4] | Y[5] | | | | Y | N |
| 390 System | Y | Y[1] | Y[2] | SafeShot Blanks and barrels | N | Y[3] | Y | Y | coming | coming | N | | Y[4] | Y[5] | Y | | | Y | |
| ExpeditionDI | Y | Y[1] | | | | | Y | Y | Y | | | | | | | | | | |
| Infantry Immersive Trainer (IIT) | | | | SESAMs | | | | | | | | | | | | | | | |
| Non-Live Fire MOUT (Military Operations in Urban Terrain) | | | | SESAMs | | | | | | | | | | | | | | | |
| Live Fire MOUT | Y | | | | | | | | | | | | | | | | | | |

| Product | Can use own weapon? | What is instrumented? | Recoil? | Blanks or SESAMS | Live Rounds | Software | Virtual Target | Video | Video Reacts to shots fired | Branching Video Authoring | Real Time editing of scenario | Real People | Tracking of Shot results | Scoring | AAR | Replay of Performance | Shoot/no-shoot scenarios | Basic Marksmanship training | Add own scenarios? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Combined Arms (CAMOUT) | Y | | | SESAMs | | | | | | | | | | | | | | | |
| Multiple Integrated Laser Engagement System (MILES) - 2000 | | | | | | | | | | | | | | detection system records hits | | | | | |

*Notes.* Blank cells indicate presence or absence is not confirmed. No information on Indoor Simulated Marksmanship Trainer (ISMT)-E (Enhanced).

[1] muzzle or replaced upper receiver

[2] replaced upper receiver and via safeShot round

[3] to record and analyze data

[4] printout/electronic

[5] point-of-impact, shot number, group center, dispersion, time, and score