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14. ABSTRACT *(Maximum 200 words)*: To develop an LMTS-based tool for predicting small arms, live-fire marksmanship qualification performance, Idaho Reserve Component (RC) soldiers fired for qualification on LMTS and on the live-fire range with either the M16A2 rifle (N = 95) or M9 pistol (N = 81). A statistically significant relation between LMTS and live-fire qualification scores was found and validated for both rifle ($r = .55$) and pistol ($r = .47$) and then used to develop weapon-specific tools for RC trainers to use in predicting the probability of individual soldier, first-run, live-fire, rifle and pistol qualification based on scores fired on LMTS. Use of these prediction tools will enable RC marksmanship trainers to schedule LMTS-based training more efficiently by targeting only those soldiers in need of remediation (i.e., those predicted to be unlikely live-fire qualifiers), as well as to identify when enough training has been provided (i.e., when the predicted likelihood of live-fire qualification is good). These tools also provide the RC unit commander with a set of LMTS-based, empirically derived live-fire performance standards to support (a) implementation of a competency-based rifle, as well as pistol, sustainment training program of instruction using LMTS, and (b) use of LMTS-based qualification firing in place of live-fire qualification firing when outdoor range facilities are not readily available.

15. SUBJECT TERMS
Rifle Marksmanship Training Pistol Marksmanship Training Laser Marksmanship Training System (LMTS) Reserve Component U.S. Army Reserve

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FOREWORD

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

To date, both the rifle and pistol programs have been developed and plans are underway to answer questions about their payoff. A necessary step in the implementation of these plans is to determine the relation between LMTS- and live-fire-based marksmanship performance and, if found to be of sufficient magnitude, develop a tool for trainers to use in predicting the latter from the former. This report describes the research conducted first to assess this relation and then to develop the LMTS-based tools for predicting both rifle and pistol record fire qualification scores.

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

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

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Technical Director

PREDICTING RIFLE AND PISTOL MARKSMANSHIP PERFORMANCE WITH THE LASER MARKSMANSHIP TRAINING SYSTEM

EXECUTIVE SUMMARY

Research Requirement:

To develop a Laser Marksmanship Training System (LMTS)-based tool for predicting live-fire marksmanship qualification performance for both rifle and pistol.

Procedure:

Idaho Reserve Component (RC) soldiers fired for record on LMTS and on the live-fire range with either the M16A2 rifle (N = 95) or M9 pistol (N = 81). Live-fire qualification was fired on the Alternative Qualification Course for rifle (ALT-C) and for pistol (APQC), whereas LMTS-based qualification was fired on simulated versions of the same courses of fire. Separate regression analyses were performed to identify the relation between the LMTS- and live-fire-based qualification scores found for each weapon. The identified relations were then used to develop weapon-specific, LMTS-based tools for predicting the probability of soldier live-fire qualification.

Findings:

A statistically significant relation between LMTS and live-fire qualification scores was found and validated for both rifle ($r = .55$) and pistol ($r = .47$). Based on these obtained relations, weapon-specific tools were developed to enable RC marksmanship trainers to predict the probability of individual soldier, first-run, live-fire qualification based on scores fired on LMTS.

Use of Findings:

Use of the developed rifle and pistol prediction tools will enable RC marksmanship trainers to schedule LMTS-based training more efficiently by targeting only those soldiers in need of remediation (i.e., those predicted to be unlikely first-run, live-fire qualifiers), as well as to identify when enough training has been provided (i.e., when the predicted likelihood of live-fire qualification is good). These tools also provide the RC unit commander with a set of LMTS-based, empirically derived live-fire performance standards to support (a) implementation of a competency-based rifle, as well as pistol, sustainment training program of instruction using LMTS, and (b) use of LMTS-based qualification firing in place of live-fire qualification firing when outdoor range facilities are not readily available.

PREDICTING RIFLE AND PISTOL MARKSMANSHIP PERFORMANCE WITH THE LASER MARKSMANSHIP TRAINING SYSTEM

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Introduction

The delivery of basic small-arms marksmanship training has been a challenge for the U.S. armed forces since the days of the Continental Army (Government Accounting Office, 1995). Despite modern weaponry and an accumulated body of time-tested training methods (Evans, Dyer, & Hagman, in publication), the challenge today seems no less formidable than at any time in the past. Budget cuts, coupled with increased ammunition costs and reduced access to live-fire ranges, have all but mandated the use of cutting edge technology to meet current marksmanship training standards (Krug & Pickrell, 1996). In the Reserve Component (RC), budget cuts and range access problems are exacerbated by ever-present training time constraints (Hagman & Phelps, 1999), plus the necessity for conducting most training at home station where live-fire range facilities are often not readily available.

These considerations have prompted the U.S. Army Reserve (USAR) to search for more effective and efficient ways to train and evaluate small arms marksmanship through the use of training devices (San Miguel, 1998). The objective of this search is the development and evaluation of indoor (i.e., home station), device-based rifle and pistol marksmanship sustainment training programs that will produce proficiency levels that meet or exceed unit readiness requirements while minimizing the resources needed to do so (Plewes, 1997, Oct 9). This objective is currently being pursued through a partnership involving the U.S. Army Research Institute (ARI) and the U.S. Army Reserve Command's (USARC's) marksmanship executive agent (i.e., the 84th Institutional Training Division [DIVIT]) and Small Arms Training Team (SATT).

Based on a relative capabilities analysis of candidate training devices conducted by USARC (Memorandum for Record, 1997, Dec 14), the device selected to support small arms marksmanship training is the Laser Marksmanship Training System (LMTS; BeamHit™, 1999). LMTS is a laser-emitting device, designed for indoor use, that enables targets to be engaged with Army-issue weapons without the use of live ammunition. Different versions of LMTS have been developed for rifle (M16A1/A2) and pistol (M9). In both versions, the major components include a laser transmitter, a mandrel to which the transmitter is attached/aligned, a variety of laser sensitive targets, and a dedicated computer with optional printer (Figure 1). One end of the mandrel holds the laser transmitter and the other end slips into the barrel of the weapon. For both rifle and pistol, vibrations from the weapons' (mechanical) firing mechanism activate the laser when the weapons are dry fired, and the location of the emitted beam is first "picked up" by the laser-sensitive target(s) (Dulin, 1999) and then recorded and stored on the computer for future analysis and printout.

Current plans call for using LMTS technology to develop device-based rifle and pistol marksmanship sustainment training programs that will accomplish the following: (a) train marksmanship fundamentals for rifle (steady position, aiming, breath control, and trigger squeeze) and pistol (grip, aiming, breath control, trigger squeeze, target engagement, and firing position), as well as support the training of shot grouping and weapon battlesight zeroing procedures associated with the former, (b) ensure training produces proficiency levels that are equal to, or greater than, those produced by traditional training methods, and (c) develop an LMTS-based rifle marksmanship Alternate Qualification Course (ALT-C; Headquarters, Department of the Army,1989) and an LMTS-based Alternate Pistol Qualification Course (APQC; Headquarters, Department of the Army, 1988) that will identify soldiers most in need of sustainment training, signal when enough such training has been provided, and permit LMTS-based qualification firing in place of live-fire qualification firing when outdoor range facilities are not readily available.

Figure 1. LMTS computer/monitor, sample electronic target, and laser transmitter with attached mandrel.

Some of the above objectives have already been met while others are either under development or being planned. Both rifle (Commander, SATT,1999a) and pistol (Commander, SATT, 1999b) programs of instruction (POIs), for instance, have been completed. The rifle POI has undergone field testing and, according to preliminary results (Smith, in publication), is capable of supporting both efficient and effective training. In contrast, the pistol POI, has yet to be formally evaluated. It does, however, closely parallel the POI developed for rifle in both procedure and content and is, therefore, expected to deliver comparable results.

LMTS-based training has received other quantitative support as well. A recent investigation conducted at Fort Benning, GA (Hagman, 2000), has shown that LMTS is superior to traditional devices (i.e., the dime [washer], target [shadow] box, Multi Purpose Arcade Combat Simulator [MACS] [e.g., Evans, 1988; Purvis & Wiley, 1990; Schroeder, 1986], and the Weaponeer [Schendel, 1985; Schendel, Heller, Finley, & Hawley, 1985]) in training certain aspects of basic rifle marksmanship (BRM). Hagman reported that LMTS-based instruction during the early stages of BRM training significantly reduced the number of rounds expended during subsequent live-fire shot grouping and weapon zeroing exercises, and increased the number of hits on known-distance targets.

While other research is examining the long-term retention benefits of LMTS-based training and the relative effectiveness of this training compared to that of traditional marksmanship training methods (See Smith, in publication, for the research design.), the present investigation sought to determine the degree of correspondence between LMTS- and live-fire-based marksmanship performance for both rifle and pistol. If found to be sufficiently strong, this relation can be used to (1) identify which soldiers are most in need of sustainment training (i.e., those predicted to be unlikely live-fire qualifiers), (2) determine when sufficient sustainment training has been provided (i.e., when the predicted likelihood of live-fire qualification is good), and (3) predict live-fire qualification results on the basis of LMTS scores.

Experiment 1: Rifle

Method

Participants

Ninety-five soldiers from an Idaho Army National Guard armor brigade voluntarily participated in the research as part of their yearly rifle qualification firing at Orchard Range near Boise, Idaho. None of these soldiers had prior experience firing LMTS.

Procedure

To control for possible sequence effects[1], approximately half the soldiers fired live-fire ALT-C first, and then LMTS ALT-C. The other half fired this sequence in reverse, with no more than an hour occurring between the two firings under either sequence.

Live-fire ALT-C Qualification. M16A2 rifle qualification firing was conducted in accordance with procedures stipulated in FM 23-9 (Headquarters, Department of the Army, 1989) with shot grouping and weapon zeroing accomplished immediately beforehand. Soldiers shot at paper targets placed 25m downrange (Headquarters, Department of the Army, 1989; Appendix G). Each target contained 10 silhouettes, scaled to represent distances of from 50m to 300m. Soldiers first assumed the prone supported firing position and were given two 10-round magazines with instructions to fire two rounds at each silhouette. Two minutes were given to fire these 20 rounds (including the magazine change) and no more than two hits could be scored on any silhouette. Soldiers then assumed the prone unsupported firing position and were given two additional 10-round magazines and instructed to fire two more rounds at each silhouette. Again, 2 min were allowed for firing (including the magazine change) and no more than two hits could be scored on any silhouette. All scoring was done by members of the participating unit and verified by the range noncommissioned officer (NCO) in charge before being entered for record. Hit numbers associated with specific shooting classifications were as follows: 0-25, Unqualified; 26-32, Marksman; 33-37,

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[1] All potential sequence effects for rifle and pistol (see Experiment 2) were subsequently found to be statistically nonsignificant ($p > .05$) and, therefore, no mention of their analysis is provided hereafter.

Sharpshooter; 38-40 Expert. All statistical analyses were based on first-run hit scores (i.e., the number of hits obtained on the soldiers' first qualification attempt).

LMTS-based ALT-C Firing. LMTS ALT-C firing was conducted in a tent set up next to the live-fire range and followed the same procedures used for live fire. All LMTS rounds were fired under a dry-fire mode wherein shooters used their trigger-pulling hand to re-cock the weapon after each round by recycling the charging handle located at the rear of the upper receiver assembly. A total of seven officers and NCOs from the 84th DIVIT and SATT supervised the conduct of LMTS-based ALT-C firing procedures, whereas target scoring was done automatically by the device.

Analytic Approach

The objective of the current research was to determine the relation between LMTS- and live-fire-based rifle ALT-C scores. To do so, a split-group, cross-validation design (Tatsuoka, 1969) was followed whereby the sample of 95 soldiers was initially divided randomly into two subgroups (Norusis, 1993). Group 1 was used to develop a prediction equation between device and live-fire scores. This equation was then applied to Group 2 soldiers to see if their live-fire scores could be predicted successfully from an equation based on Group 1 data.

Results

Group 1 Data (N = 48)

For Group 1, LMTS hit scores ranged from 5 to 39 (M = 27.96, SD = 9.08). Live-fire hit scores ranged from 14 to 39 (M = 29.33, SD = 7.32. A least squares regression-based prediction equation of the form $Y' = B_o + B_1(X_1)$ was developed in which Y' was the predicted live-fire criterion score, B_o was the intercept (or theoretical live-fire score when the LMTS score equals zero), B_1 was the empirically derived regression coefficient linking changes in the live-fire criterion variable with changes in the LMTS predictor variable, and X_1 was the obtained LMTS ALT-C score. A significant linear relation, $Y' = 16.44 + .46(X_1)$, SE = 6.07 was found between LMTS and live-fire performance, $F(1, 46) = 22.39$, with the rejection region for this and all other analyses equal to .05. In addition, the correlation (r = .57) between predicted and actual live-fire scores was significant. Thus, Group 1 LMTS scores were both linearly related to, and reasonably good predictors of, ALT-C live-fire performance.

Group 2 Data (N = 47)

For Group 2, LMTS hit scores ranged from 14 to 40 (M = 29.13, SD = 7.71. Live-fire hit scores ranged from 13 to 40 (M = 31.17, SD = 6.59). Following cross-validation procedures described by Tatsuoka (1969), the Group 1 regression equation was used to predict Group 2 live-fire scores, and then the relative amount of variance accounted for in each group was compared. A significant linear relation, $Y' = 2.57 + .96(X_1[\text{predicted}])$, SE = 5.70, was found between actual and predicted (from Group 1) live-fire scores for

Group 2, $F(1, 45) = 16.49$. The resulting correlation ($r = .52$) was significant, and the associated Group 2 r^2 of .27 did not differ significantly from the r^2 of .33 found for Group 1, indicating that the Group 1 prediction equation accounted for a comparable amount of live-fire ALT-C score variance in the two groups. Thus, the predictive model was found to be valid and, therefore, likely to maintain similar efficiency when used to predict the live-fire scores of other RC samples.

Pooled Data

The results of the individual group analyses identified and confirmed the presence of a positive linear relation between LMTS and live-fire performance. For this relation to be of practical value, however, it should afford marksmanship trainers the capability to predict which soldiers will fire the minimum ALT-C qualification scores of 26 for Marksman, 33 for Sharpshooter, and 38 for Expert. To provide the best possible basis from which to make such predictions, and given the similar outcome of the separate group analyses, scores from the two groups were pooled (N = 95) and an overall regression equation was computed.

Regression-Based Prediction Model. For the pooled sample, LMTS scores ranged from 5 to 40 ($M = 28.54$, $SD = 8.40$), with 70.5% of soldiers (67 of 95) firing at least the minimum qualification score of 26 on their first run (Q1). Live-fire scores ranged from 13 to 40 ($M = 30.24$, $SD = 6.99$), with 74 out of 95 soldiers (77.9%) firing Q1. A least-squares regression analysis revealed a significant linear relation, $Y' = 17.16 + .46(X_1)$, $SE = 5.86$, $F(1, 93) = 40.61$, between the predictor variable (LMTS ALT-C score) and the criterion variable (live-fire ALT-C score). The correlation ($r = .55$) between LMTS and live-fire scores was significant, with the former accounting for almost a third of the variance in the latter ($r^2 = .303$; adjusted $r^2 = .296$).

Based on the obtained regression equation, a trainer can predict that soldiers with an LMTS ALT-C score (X_1) of 19, for example, will, on the average, fire a minimum qualification score (Y') of 26. Similarly, it can be predicted that, on the average, an LMTS score of 34 will be associated with the minimum Sharpshooter qualification score of 33, and an LMTS score of 38 will be associated with the minimum Expert qualification score of 40[2], and so forth. Assuming that the actual probability of firing these predicted qualification scores will follow a normal distribution, with $M = 26$ and $SE_{ind}\ Y' = 5.91$ (Marksman), $M = 33$ and $SE_{ind}\ Y' = 5.89$ (Sharpshooter), and $M = 38$ and $SE_{ind}\ Y' = 5.92$ (Expert; see Hays, 1963, p. 523), the probability of an individual soldier shooting a qualification score greater than or equal to 26, 33, and 38 was calculated for a selected range of LMTS scores by using the ARI Live-Fire Prediction Tool (Hagman, 1998, in publication).

Table 1 shows this range of LMTS scores along with their predicted mean live-fire scores and the associated probability of scoring greater than or equal to 26, 33, and 38

[2] Because the actual predicted live-fire score of 45 is outside the range of possible scores, the maximum possible score of 40 is reported.

during qualification firing. With this table, a unit trainer can predict that a soldier with an LMTS score of 26 (Column 1), for instance, will, on the average, fire 29 on the live-fire range (Column 2) and have a 70% chance of successful qualification at the Marksman level (Column 3), a 20-30% chance of qualification at the Sharpshooter level (Column 4), and less than a 10% chance of qualification at the Expert level (Column 5). A soldier with an LMTS score of 30 would be predicted to fire 31 on the range and have an 80% chance of qualifying Marksman, a 30-40% chance of qualifying Sharpshooter, and a 10-20% chance of qualifying Expert, and so forth.

Table 1.
LMTS-Based Predicted Chances of First-Run Qualification at Marksman (≥26 hits), Sharpshooter (≥33 hits), and Expert (≥38 hits) Levels on ALT-C.

LMTS Score	Predicted Qualification Score	Chances of a Live-Fire Score of …		
		≥ 26 (Marksman)	≥ 33 (Sharpshooter)	≥ 38 (Expert)
3	19	10	--	--
8	21	20	--	--
13	23	30	--	--
16	25	40	--	--
18	25	--	10	--
19	26	50	--	--
23	28	60	--	--
24	28	--	20	--
26	29	70	--	--
28	30	--	30	--
29	30	--	--	10
30	31	80	--	--
31	31	--	40	--
34	33	--	--	20
35	33	--	50	--
36	34	90	--	--
38	35	--	60	--
39	35	--	--	30

Experiment 2: Pistol

Experiment 2 examined the relation between LMTS- and live-fire-based qualification scores fired with the M9 pistol. The investigative paradigm was similar to that used in Experiment 1.

Method

Participants

Eighty-one soldiers from an Idaho Army National Guard armor brigade voluntarily participated in the research as part of their yearly pistol qualification firing at Orchard Range near Boise, Idaho. None of these soldiers had ever fired with LMTS.

Procedure

Live-fire APQC Qualification. M9 pistol qualification firing was conducted in accordance with procedures stipulated in FM 23-35 (Headquarters, Department of the Army, 1988). Soldiers fired four separate tables involving the use of paper targets placed 25m downrange. Each target contained an E-type silhouette with scoring rings (Headquarters, Department of the Army, 1988; Appendix G).

On each APQC table, the first round was fired double action with the remaining rounds fired single action. On Table 1, which was shot from the standing position, seven rounds were fired from a single magazine within 21 s. Tables 2-4 used two magazines and, therefore, required a rapid magazine change. Table 2 was fired from the kneeling position, with six rounds in the first magazine and seven in the second, and had a time limit of 45 s. Table 3 used two magazines, each with five rounds, and was fired from the crouch position with a time limit of 35 s. The fourth table, also limited to 35 s, was fired from the prone unsupported position and also used two magazines, each with five rounds.

A total of 40 rounds were fired during the APQC (7, 13, 10 and 10 on Tables 1-4, respectively). Each round could earn up to five points, depending upon which ring on the target was impacted, yielding a possible score range on the entire test of 0 to 200. Number of hits could range from 0 to 40. Qualification required a score of at least 80, plus 24 or more hits. One hundred sixty (or more) points were required for an Expert rating, 120-159 for a Sharpshooter rating, and 80-119 for a Marksman rating. All scoring was done by members of the participating unit and verified by the range NCO in charge before being entered for record. Again, only first-run scores were analyzed.

LMTS-based APQC Firing. The LMTS APQC was conducted in a tent set up next to the pistol live-fire range and followed the same procedures used for live fire. Electronic targets, scaled to simulate a 25m distance, were placed 10 ft from the firing line. All rounds were fired under a dry-fire mode, using a two-hand (fist) grip, wherein shooters used their support-hand thumb to sweep up and manually re-cock the pistol's external hammer after the first round was fired). A total of seven officers and NCOs from the 84th DIVIT and SATT supervised the conduct of LMTS-based APQC firing procedures, whereas target scoring was done automatically by the device.

Analytic Approach

As with the rifle investigation, a split-group, cross-validation approach (Tatsuoka, 1969) was used to test for generalizability of the results. To this end, the sample of 81 soldiers was divided randomly into two subgroups (Norusis, 1993). Group 1 was used to develop a prediction equation between device and live-fire scores. This equation was then applied to Group 2 soldiers to see if their live-fire scores could be predicted successfully from an equation based on Group 1 data.

Results

Group 1 Data (N = 40)

For Group 1, LMTS scores ranged from 97 to 195 (*M* = 158.73, *SD* = 23.05), whereas live-fire scores ranged from 73 to 186 (*M* = 141.03, *SD* = 29.92). A least squares regression-based prediction equation of the form $Y' = B_o + B_1(X_1)$ was developed in which Y' was the predicted live-fire criterion score, B_o was the intercept, B_1 was the empirically derived regression coefficient linking changes in the live-fire criterion variable with changes in the LMTS predictor variable, and X_1 was the obtained LMTS APQC score. A significant linear relation, $Y' = 30.25 + .70(X_1)$, *SE* = 25.56 was found between LMTS and live-fire scores, $F(1, 38) = 15.45$. In addition, the correlation (r = .54) between predicted and actual live-fire scores was significant. Thus, Group 1 LMTS scores were both linearly related to, and reasonably good predictors of, APQC live-fire performance.

Group 2 Data (N = 41)

For Group 2, LMTS scores ranged from 81 to 184 (*M* = 149.39, *SD* = 25.04), whereas live-fire scores ranged from 75 to 193 (M = 144.44, SD = 31.23). Following the same cross-validation procedure used for rifle, the Group 1 regression equation was used to predict Group 2 live-fire scores, and then the relative amount of variance accounted for in each group was compared. A significant linear relation, $Y' = 38.32 + .79(X_1[\text{predicted}])$, *SE* = 28.37, was found between actual and predicted (from Group 1) live-fire scores for Group 2, $F(1, 39) = 9.44$. The resulting correlation ($r = .44$) was significant, and the associated Group 2 adjusted r^2 of .17 did not differ significantly from the adjusted r^2 of .27 found for Group 1, indicating that the Group 1 prediction equation accounted for a comparable amount of live-fire APQC score variance in the two groups. Thus, the predictive model was found to be valid and, therefore, likely to maintain similar efficiency when used to predict live-fire scores of other RC samples.

Pooled Data

The results of the individual group analyses identified and confirmed the presence of a positive linear relation between LMTS and live-fire performance. For this relation to be of practical value, however, it should afford marksmanship trainers the capability to predict which soldiers will fire the minimum qualification scores of 80 for Marksman, 120 for Sharpshooter, and 160 for Expert. To provide the best possible basis from which to make such predictions, and given the similar outcome of the separate group analyses, scores form the two groups were pooled (N = 81) and an overall regression equation was computed.

Regression-Based Prediction Model. For the pooled sample, LMTS scores ranged from 81 to 195 (M = 154.00, SD = 24.38) with all soldiers firing a score of at least 80, for a Q1 rate of 100%. Live-fire scores ranged from 73 to 193 (M = 142.75, SD = 30.45) with 93.8% of all soldiers achieving Q1 (see Table 2). A least squares regression analysis revealed a significant linear relation, $Y' = 53.31 + .58(X_1)$, $SE = 27.12$, $F(1, 79) = 21.81$, between the predictor variable (LMTS APQC score) and the criterion variable (live-fire APQC score). The correlation ($r = .47$) between LMTS and live-fire scores was significant, with the former accounting for a little more than a fifth of the variance in the latter ($r^2 = .216$; adjusted $r^2 = .206$).

Table 2.
Marksmanship Ratings Obtained on LMTS and Live-Fire APQC.

	LMTS APQC			Live-Fire APQC		
	Number	%	Cumulative %	Number	%	Cumulative %
Expert	40	49.4	49.4	34	42.0	42.0
Sharpshooter	34	42.0	91.4	27	33.3	75.3
Marksman	7	8.6	100.0	15	18.5	93.8
Did Not Q1	0	0.0		5	6.2	100.0
Total	81	100.0		81	100.0	

Based on the obtained regression equation, a trainer can predict that soldiers with an LMTS ALC-C score (X_1) of 46, for example, will, on the average, fire a minimum Marksman qualification score (Y') of 80. Those with and LMTS score of 115 will, on the average, fire a Sharpshooter qualification score of 120. And finally, those with an LMTS score of 184 will, on the average, fire the minimum Expert qualification score of 160, and so forth. Assuming that the actual probability of firing these predicted qualification scores will follow a normal distribution, with $M = 46$ and $SE_{\text{ind}} = 27.61$ (Marksman), $M = 120$ and SE_{ind} Y = 27.3 (Sharpshooter), and $M = 160$ and SE_{ind} Y = 27.45 (Expert; see Hays, 163, p. 523), the probability of an individual soldier shooting a qualification score greater than or equal to 80, 120, and 160 was calculated for a selected range of LMTS scores by using the ARI Live-Fire Prediction Tool.

Table 3 shows this range of LMTS scores along with their predicted mean qualification scores and the associated probabilities of shooting greater than, or equal to, 80 (Marksman), 120 (Sharpshooter), and 160 (Expert) during qualification firing. With this table, a unit trainer can predict that a soldier with an LMTS score of 139 (Column 1), for instance, would be predicted to fire a qualification score of 134 (Column 2) and have better than a 90% chance of firing Marksman (Column 3), a 70% chance of firing Sharpshooter (Column 4), and a 10-20% chance of firing Expert (Column 5). A soldier with an LMTS score of 155 would be predicted to fire 143 on the live-fire range and have better than a 90% of firing Marksman, an 80% chance of firing Sharpshooter, and a 20-30% chance of firing Expert, and so forth.

Table 3.
LMTS-Based Predicted Chances of First-Run Qualification at Marksman (≥ 80 score), Sharpshooter (≥ 120 score), and Expert (≥ 160 score) Levels on APQC.

LMTS Score	Predicted Qualification Score	Chances of a Live-Fire Score of …		
		≥ 80 (Marksman)	≥ 120 (Sharpshooter)	≥ 160 (Expert)
6	57	20	--	--
21	66	30	--	--
34	73	40	--	--
46	80	50	--	--
55	85	--	10	--
58	87	60	--	--
71	94	70	--	--
75	97	--	20	--
86	103	80	--	--
90	106	--	30	--
103	113	--	40	--
107	115	90	--	--
115	120	--	50	--
123	125	--	--	10
127	127	--	60	--
139	134	--	70	--
144	137	--	--	20
155	143	--	80	--
159	146	--	--	30
172	153	--	--	40
175	155	--	90	--
184	160	--	--	50
196	167	--	--	60

Discussion

These findings indicate that (a) a positive linear relation exists between simulated rifle, as well as pistol, marksmanship performance on LMTS and live-fire marksmanship performance on the range, and (b) this relation is both consistent and of sufficient magnitude to support development of an easy-to-use LMTS-based tool for predicting the probability of first-run, live-fire qualification at the Marksman, Sharpshooter, and Expert levels for both rifle and pistol.

Application.

The rifle and pistol LMTS-based prediction tools can serve as diagnostic instruments for meeting the current research objectives of (a) identifying soldiers most in need of remediation/sustainment training, (b) signaling when enough such training has been provided, and (c) providing device-based, live-fire performance standards for enabling the substitution of LMTS-based qualification firing for live-fire qualification firing when outdoor range facilities are not readily available. In doing so, these tools can form the basis for competency-based delivery of the USAR's newly developed rifle and pistol marksmanship POIs.

Figure 2 shows, in flowchart format, how this competency-based delivery approach would work. Soldiers would first be pretested by firing LMTS ALT-C (for rifle) or LMTS APQC (for pistol). Based on their obtained pretest scores, soldiers would receive either a "Go" or "NoGo" depending upon the LMTS-based cutoff score fired, with this cutoff score set beforehand by the unit commander. Say, for instance, that the cutoff score on the LMTS pretest is set at 30, the score associated with an 80% probability of live-fire qualification at the Marksman level for rifle, or at 86, the score associated with an 80% probability of live-fire qualification at the Marksman level for pistol. Soldiers firing at or above these cutoff scores would receive a Go and be considered device-qualified. Soldiers firing below the cutoffs would be identified as needing remediation (to be delivered via the USAR's LMTS-based rifle or pistol sustainment training POI). Thus, remediation is provided only for those in need of it, thereby, making the most of valuable training time while saving range time and ammunition in the process. Those completing remediation would then be posttest on LMTS ALT-C for rifle or LMTS APQC for pistol. Those receiving a Go on the posttest would be considered device-qualified, whereas those receiving a NoGo would undergo further remediation until they are able to meet the posttest cutoff score and its associated live-fire expectancy standard of 80% probability of live-fire qualification.

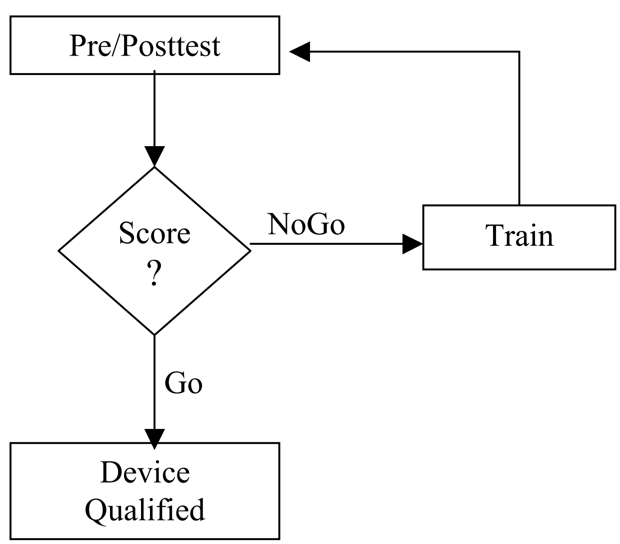

Figure 2. Flowchart of delivery strategy

The rifle and pistol prediction tools also provide empirically derived sets of marksmanship performance probabilities for use in determining live-fire qualification standards on LMTS. Such standards, in the form of cutoff scores, would be required to support a decision to use LMTS scores in lieu of live-fire scores for purposes of yearly qualification. It might be decided, for example, that for soldiers to receive a live-fire qualification rating of Marksman, they must shoot an LMTS ALT-C (for rifle), or LMTS APQC (for pistol), score associated with a predicted 80% probability of successful qualification on the range (i.e., 30 for rifle; 86 for pistol). Analogous standards could also be set for Sharpshooter and Expert for each weapon.

Given the apparent lack of live-fire AQPC difficulty, it should be noted that for pistol shooters a Go/NoGo qualification prediction can be made without the use of LMTS APQC scores and still achieve about a 94% degree of predictive accuracy, as shown in Table 2 for our sample. Thus, an LMTS-based prediction would not be warranted unless a commander's unit pistol marksmanship qualification goal is higher than 94%. If this were the case, then LMTS-based predictions would be necessary to identify the specific soldiers in need of remedial/sustainment training. Caution is recommended in the use of pistol predictions associated with the Marksman level because these predictions extend well beyond the lower end of the obtained pistol score distribution. Although it is assumed that the obtained relation between LMTS-based and live-fire scores for pistol extends to areas of the distribution in which data are lacking, such an assumption can be risky (Hays, 1963) and, therefore, in need of further examination.

Until then, the suggested competency-based delivery strategy for LMTS-based rifle and pistol marksmanship training, with empirically derived live-fire performance standards serving as its basis, should enable the USAR to take a substantial step forward in its ongoing commitment to meeting the Total Army readiness challenge through more productive home-station small arms marksmanship training and evaluation while saving precious time and ammunition in the process.

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