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Small Arms Trainer Validation and Transfer of Training: C7 Rifle

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Defence R&D Canada
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In conducting the research described in this report, the investigators adhered to the policies and procedures set out in the *Tri-Council Policy Statement: Ethical conduct for research involving humans* (2010) as issued jointly by the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada.

Abstract

The Canadian Army uses the Small Arms Trainer (SAT) to support the use of infantry weapons. A trial was conducted at CFB Gagetown to validate the simulator and to determine how live and simulated fire should be used to prepare troops for the Personal Weapons Test Level 3 (PWT3). Six infantry platoons completed the range practices using either

- all live fire;
- all simulated fire;
- simulated fire, completing all range practices twice; or
- simulated fire for the first five range practices and live fire for the last three range practices.

Following training, all participants fired the PWT3 using live fire. Results indicated that a mix of live and simulated fire led to the highest scores on the PWT3 and the highest proportion of marksmen.

Résumé

L'Armée canadienne emploie le simulateur de tir aux armes légères (STAL) pour l'entraînement à l'usage des armes de l'infanterie. On a procédé à un essai à la BFC Gagetown pour valider le simulateur et pour déterminer comment se servir des tirs réels et des tirs sur simulateur pour préparer les soldats à l'épreuve de tir avec l'arme personnelle de niveau 3 (ETAP3). Six pelotons d'infanterie ont suivi l'entraînement au tir en employant l'une des méthodes suivantes :

- uniquement des tirs réels;
- uniquement des tirs au simulateur;
- tirs au simulateur, en faisant tous les entraînements deux fois;
- tirs au simulateur pour les cinq premiers entraînements et tirs réels pour les trois derniers entraînements.

Une fois l'entraînement terminé, tous les participants ont été soumis à l'ETAP3 avec des tirs réels. D'après les résultats obtenus, une combinaison de tirs réels et de tirs au simulateur à l'entraînement permet d'obtenir le plus grand nombre de points à l'ETAP3 et la plus grande proportion de tireurs d'élite.

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Executive summary

Small Arms Trainer Validation and Transfer of Training: C7 Rifle

Stuart C. Grant; DRDC Toronto TR 2013-085; Defence R&D Canada, Toronto Research Centre; December 2013.

Introduction: The Canadian Army uses the Small Arms Trainer (SAT) to support the use of infantry weapons. The SAT has characteristics such as low operating cost, instructional aids, and automated performance measurement to assist in the acquisition and maintenance of small arms skills. Accordingly, the Directorate of Army Training (DAT) tasked Defence R&D Canada to conduct validation and transfer of training research on the SAT to support the integration of the SAT in army training. The trial was conducted to answer the following questions:

- What is the optimum balance of live and simulator training to reach the required marksmanship standard?
- What part or parts of training can be conducted in simulation, and what parts require live firing?
- Can soldiers be trained entirely in simulation with a high degree of confidence that they can immediately achieve the standard in live fire?

The trial involved six platoons of the Phase II Common course at the Infantry School at CFB Gagetown. Four possible uses of the SAT to complete the range practices in preparation for the Personal Weapons Test Level 3 (PWT3) were examined:

- completing all range practices using live fire,
- completing all range practices using simulated fire,
- completing all range practices twice using simulated fire, and
- completing the first five range practices using simulated fire and the last three range practices using live fire.

Following training, all participants fired the PWT3 using live fire.

Results: Troops trained using a mix of live and simulated fire achieved significantly higher scores on the PWT3. There was no significant difference between the scores obtained by troops trained entirely in simulation and those trained entirely using live fire. Troops who completed the range practices twice in simulation did not gain an advantage over those who completed the practices once in simulation. Finally, it was observed that troops actively coached using the SAT's instructional support features achieved higher scores than passively coached troops.

Significance: The trial found that completing the first five range practices on the SAT and the final three range practices on the live fire range led to the best performance on the PWT3 relative

to training with exclusively live or simulated fire. This mix is not necessarily optimal, however, because not all blends of live and simulated fire could be investigated. Nevertheless, while soldiers can prepare for the PWT3 using only simulated fire, their probability of success will be moderate and comparable to those trained using only live fire. Before training rifle marksmanship entirely in simulation can be recommended, however, the effect on confidence and motivation should be considered.

Sommaire

Validation du simulateur de tir aux armes légères et transfert de l'instruction : fusil C7

Stuart C. Grant; RDDC Toronto TR 2013-085; R & D pour la défense Canada – Toronto; decembre 2013.

Introduction ou contexte : L'Armée canadienne utilise le simulateur de tir aux armes légères (SMART) pour soutenir le maniement d'armes d'infanterie. Le simulateur SMART présente des caractéristiques telles qu'un faible coût d'exploitation, du matériel d'instruction et des mesures de rendement automatisées pour favoriser l'acquisition et le maintien d'habiletés avec des armes légères. Par conséquent, la Direction – Instruction de l'Armée de terre (DIAT) a chargé R & D pour la défense Canada de valider le simulateur SMART et d'effectuer de la recherche sur le transfert de l'instruction. Ce mandat vise à intégrer le simulateur à l'instruction de l'Armée de terre. L'essai a été mené pour répondre aux questions suivantes :

- Quel est l'équilibre optimal entre l'instruction réelle et la simulation pour atteindre la norme requise d'adresse au tir?
- Quelles parties de l'instruction peuvent être simulées et quelles parties doivent être réelles?
- Un soldat peut-il suivre une instruction entièrement simulée et atteindre le niveau de confiance élevé nécessaire pour respecter immédiatement la norme d'adresse au tir réel?

Six pelotons du cours commun de phase II de l'École d'infanterie, située sur la BFC Gagetown, ont participé à cet essai. RDDC a examiné quatre utilisations possibles du simulateur SMART pour compléter les exercices de tir en vue de l'épreuve de tir avec l'arme personnelle (ÉTAP) de niveau 3. Des soldats ont pratiqué uniquement des exercices de tir réel ou de tir simulé, alors que d'autres ont effectué tous les exercices de tir simulé en double. Certains participants ont quant à eux réalisé cinq exercices de tir simulé, suivi de trois exercices de tir réel. Après l'instruction, tous ont passé l'ÉTAP de niveau 3 avec tirs réels.

Résultats : Les troupes dont l'instruction combinait des tirs réels et des tirs simulés ont obtenu des résultats nettement plus élevés lors de l'ÉTAP de niveau 3. L'écart n'était pas important entre le pointage des troupes ayant suivi une instruction entièrement simulée et celui des soldats ayant effectué que des tirs réels. Les participants ayant complété les exercices de tir simulé en double n'ont pas obtenu de meilleurs résultats que ceux l'ayant effectué une seule fois. Enfin, il a été observé que la façon dont les instructeurs de tir utilisent le simulateur SMART a une grande influence sur l'instruction.

Importance : L'essai a révélé que l'utilisation du simulateur SMART pour les cinq premiers exercices de tir, suivi de trois exercices sur le champ de tir offrait un meilleur rendement lors de l'ÉTAP de niveau 3, comparativement à l'instruction entièrement simulée ou réelle. Cependant, cette combinaison n'est pas nécessairement optimale puisqu'un mélange de tous les tirs réels et simulés n'a pas pu être examiné. Néanmoins, les soldats peuvent se préparer pour l'ÉTAP de niveau 3 uniquement avec le simulateur SMART, mais leur probabilité de réussite sera modérée et comparable à celle de ceux pratiquant uniquement le tir réel. Avant que l'instruction du tir de précisions entièrement simulé soit recommandée, il faudrait prendre en considération l'incidence sur la confiance et la motivation.

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Acknowledgements

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1. Introduction

The Canadian Army operates the Small Arms Trainer (SAT) to support the use of infantry weapons. As a simulator, the SAT has characteristics such as low operating cost, instructional aids, and automated performance measurement that suggest it assists considerably in the acquisition and maintenance of small arms skills. Accordingly, the Directorate of Army Training (DAT) tasked Defence R&D Canada to conduct validation and transfer of training research on the SAT to support the integration of the SAT in army training.

To aid integration of the SAT into Canadian Armed Forces (CAF) use, DAT requested answers to a series of questions (1). The following questions were addressed by this trial:

- What is the optimum balance of live and simulator training to reach the required marksmanship standard?
- What part or parts of training can be conducted in simulation, and what parts require live firing?
- Can soldiers be trained entirely in simulation with a high degree of confidence that they can immediately achieve the standard in live fire?

The interest in considering a mix of live and simulated fire is an acknowledgement that current simulation technology may not be suitable or sufficient for the entire training problem and that some live fire training may also be necessary. Prior research within Canada and allied nations bears on some of these issues. An Australian study (2) on the balance of live and simulated fire was inconclusive. It did not detect a training effect under any condition examined owing in part to the large variability in individual marksmanship performance and the small sample size obtained. In the United Kingdom (UK) (3), recruits were trained using either all live fire or a mix of live and simulated fire. The mixed training group used simulation for six serials and live fire for two familiarization serials, two training serials, and a practice of the Annual Personal Weapons Test (Phase 1) (APWT1). The result was that both groups successfully completed the final APWT1 with equal probability. The pass rates were sufficiently high (approximately 98%) that any superiority of one method over the other was undetectable. Nevertheless, the sufficiency of the mix of live and simulated fire was demonstrated for the UK's APWT1. When the performances of the two groups were compared on the two live fire serials and the two familiarization serials, they were not statistically different. This suggests that a mix of live and simulated fire may be a successful approach to training Canada's Personal Weapons Test. These results are not conclusive, however, because there are differences between Canada's and the UK's weapons, doctrines, and tests. Collecting data in a Canadian context was therefore warranted.

Questions regarding the balance of live and simulated fire must be answered within the context of a training program with explicit training standards. A transfer of training ratio relating the efficacy of training time in a simulator to training time with the operational equipment can change considerably depending on whether the trainees are expected to achieve familiarity, basic competence, or mastery. The Personal Weapons Test was therefore used to provide a well-defined set of parameters for answering DAT's questions relating to the SAT.

To determine the optimal mix of live and simulated fire, a large number of plausible mixes would have to be investigated, requiring an impractically large data collection effort. Instead, a small set of mixes were explored. These mixes included the two extreme possibilities (all simulated fire and all live fire) and a mix where live fire was used to train the serials involving the 300 m targets—which are the most challenged by the limited resolution of the SAT's visual display—and those requiring running. Another condition was also examined: the option of completing all serials twice (given that the training serials can be completed more quickly in the simulator than on the range). The results obtained in the various training conditions were compared to determine their differences.

2. Method

Subjects

The experiment was conducted using six platoons on the Phase II Common course at the Infantry School at CFB Gagetown. The number of firers in each platoon for whom complete datasets are available ranged from 11 to 40.

Apparatus

SAT systems used were the Fire Arms Trainer Version 4, manufactured by Firearms Training Systems Inc. and incorporating Canadian Army weapons and instructional features. SAT users fire simulated weapons, including the C7A1, at targets projected on a screen. When fired, the simulated weapon produces recoil and report similar to the firing of the actual weapon. A laser beam emitted from the weapon and detected by a shot camera is used to determine whether the firer would have hit the target during live fire. The system displays imagery that depicts a variety of targets at whatever range is required.

Live firing on the range was conducted using the C7A1 rifle. Training occurred on CFB Gagetown's Mons and Vimy ranges. The Personal Weapons Test was conducted on the Mons, Vimy, and Batouche ranges.

Procedure

The experiment used a between-subjects design where platoons of firers were first trained according to their assigned method and then tested using live fire. All platoons completed Shoot To Live (4) Range Practices 1 through 8, as is customary during the Phase II Common course. The serials are presented in Annex 1. The means of completing the range practices varied between platoons to compare simulator to range training. The assignment of a training condition to a platoon was determined by the ability to schedule those platoons on the available SAT systems and by the capacity of the SAT systems themselves. 7, 10, and 12 Platoons conducted all training on the range. This was the normal course of instruction and therefore provided a baseline and control group. 9 Platoon completed all range practices using the SAT. 13 Platoon completed the range practices twice using the SAT. 8 Platoon completed the first five range practices on the SAT and the final three range practices on the range.

The decision that the platoon employing the mix of simulated and live fire would conduct the advanced range practices on the range was driven by the reduced ability of the SAT to simulate those range practices. Specifically, Range Practice 6 requires the firers to run 50 m before engaging the targets. The SAT version of the serial delays presentation of the targets for several seconds, allowing firers to run in place and thereby simulating the 50 m run. This very simple approach has merit in providing and maintaining familiarity with the conduct of the serial, but it has shortcomings in actual training and prediction. Because the time delay is fixed, the effort expended running in place has no bearing on when the firer can engage the target. Firers on the SAT appear to exert themselves less than those on the range and thereby lose the opportunity to practice control of their breathing. The simulation also denies them the opportunity to learn the trade-off between running hard and having a relatively long time to

engage the targets while breathing heavily versus running at a slower pace and having a shorter time to fire with less laboured breathing. Furthermore, the advanced range practices contain more long-range shots. Limitations in the SAT visual system's resolution mean that longer range targets are less well depicted, making these serials more promising for live fire.

The experimental conditions are summarized in Table 1.

Table 1: Training and Test Schedule

		Monday	Tuesday	Wednesday	Thursday
June 5-9	10 Platoon Live Fire	Range	Range	Range	Range Test
	11 Platoon Simulation	SAT	SAT	SAT	Range Test
June 12-16	7 Platoon Live Fire	Range		Range	Range Test
	8 Platoon Mix	SAT	SAT	Range	Range Test
	9 Platoon Simulation	SAT	SAT	SAT	Range Test
June 19-23	12 Platoon Live Fire	Range	Range	Range	Range Test
	13 Platoon 2 × Simulation	SAT	SAT	SAT	Range Test

All platoons using the SAT were provided with trained SAT operators. The instructional staff assigned to the platoons by the Infantry School provided coaching for their assigned platoons. This meant that not only did the instructional medium differ between platoons; so did the instructors. To mitigate the effect of confounding instructor and training medium, a small arms instructor from the Small Arms Cell of the Infantry School met with the instructors to review instructional principles and emphasize the importance of consistency in instruction across the platoons. During actual training and testing, experimental staff and the instructor from the Small Arms Cell intermittently visited the platoons to observe conduct of the serials.

During the testing phase, all platoons fired live to complete the Personal Weapons Test Level 3 for Infantry (4) (reproduced in Annex 1). Following the common practice at the Infantry School, soldiers who did not pass the PWT3 were retested until they passed, subject to time limitations. Only data from first attempts are used in this report, however.

3. Results

Weather

The weather was generally favourable on the ranges, and the Infantry School instructional staff did not believe it differentially affected the platoons' performances. Daily high temperatures ranged from 16º C to 27º C, with winds up to 30 km/h, and no rain. Daily weather reports are presented in Annex 2.

Data Losses

11 Platoon was able to record scores on Range Practices 3, 4, and 5 only. Consequently, data from 11 Platoon will not be included in the analysis. Range Practice 4 data were also missing for 7 and 8 Platoons. During analysis, rather than try to estimate missing data, cases were deleted from the analysis as necessary.

Training Data

The training data for each platoon are presented in Table 2. In the case of 13 Platoon, only the results from the first completion of the range practices by the actively coached platoon are included. Also, the results from Range Practice 8 differ from the Shoot To Live scoring direction. Shoot to Live indicates that, for Range Practice 8, two points should be awarded for each target hit for some serials whereas other serials are unscored. For this analysis, we have awarded one point per hit.

Table 2: Range Practices and Personal Weapons Test – Level 3 Results by Platooon

		Range Practices						PWT 3		
GROUP	TRAINING CONDITION	3 group size, mm	4 group size, mm	5	6	7	8	Score	Pass (%)	Marksman (%)
7 Platoon	Live Fire	M = 144.6 SD = 43.7 n = 34	Missing	M = 177.5 SD = 60.5 n = 35	M = 27.8 SD = 11.9 n = 35	M = 6.0 SD = 0.0 n = 35	M = 37.8 SD = 8.4 n = 35	M = 63.3 SD = 6.8 n = 33	97	0
10 Platoon	Live Fire	M = 213.4 SD = 52.5 n = 40	M = 219.9 SD = 75.3 n = 40	M = 171.6 SD = 33.4 n = 40	M = 30.9 SD = 6.9 n = 40	M = 5.9 SD = 0.4 n = 40	missing	M = 50.1 SD = 10.7 n = 39	28	0
12 Platoon	Live Fire	M = 259.9 SD = 70.0 n = 37	M = 185.0 SD = 66.8 n = 37	M = 189.1 SD = 37.6 n = 38	M = 32.2 SD = 6.1 n = 38	M = 5.5 SD = 0.5 n = 38	M = 32.7 SD = 7.3 n = 38	M = 59.1 SD = 9.2 n = 38	58	3
8 Platoon	Mix Range Practices 3 – 5 SAT Range Practices 6 – 8 Live	M = 295.8 SD = 48.5 n = 26	Missing	M = 111.2 SD = 72.3 n = 35	M = 22.8 SD = 14.5 n = 35	M = 3.7 SD = 2.4 n = 35	M = 19.9 SD = 13.5 n = 35	M = 65.4 SD = 5.8 n = 22	.91	14
9 Platoon	Simulation	M = 295.6 SD = 67.7 n = 39	M = 341.9 SD = 86.1 n = 36	M = 152.6 SD = 27.3 n = 39	M = 19.8 SD = 5.5 n = 39	M = 4.8 SD = 1.0 n = 39	M = 14.7 SD = 4.9 n = 39	M = 58.7 SD = 9.6 n = 38	58	5
13 Platoon	Double Simulation Active Coaching	M = 283.1 SD = 57.7 n = 11	M = 299.5 SD = 81.5 n = 11	M = 177.9 SD = 18.6 n = 11	M = 27.5 SD = 6.1 n = 11	M = 5.2 SD = 0.6 n = 11	M = 13.6 SD = 3.3 n = 11	M = 59.9 SD = 6.6 n = 11	45	0
	Double Simulation Passive Coaching							M = 50.8 SD = 10.2 n = 12	33	0
	Double Simulation Combined							M = 55.2 SD = 9.7 n = 23	39	0

* M = mean; SD = standard deviation; n = number of observations

Validation of the SAT

To validate the SAT, statistical analysis was used to test for a relationship between soldiers' performances on the simulated range practices and on the live fire range. If the SAT is a valid simulation of live fire, one would expect a positive relationship between simulated and live performances. To test this idea, a series of regressions were performed. First, to provide a baseline for comparison, scores from the range practices for platoons trained on the range were used to predict their PWT3 scores. One would expect that predicting live fire PWT3 scores using live fire training data would be most accurate and provide an upper limit on how well PWT3 scores might be predicted from simulator training data. To this end, a linear regression was performed, using the data from the platoons trained on the range. The analysis found no relationship between live fire scores on the range practices and the live fire PWT3 scores. The adjusted R^2 statistic was not statistically significant. This is consistent with Australian findings (2) using Pearson correlation.

A partial least square regression was also performed. The partial least squares procedure is useful when there are a large number of predictor variables (scores on the practice serials) relative to the number of cases. The partial least squares procedure first identifies a small number of latent factors that describe the predictor variables and uses these factors to predict the latent factors in the dependent variables (5). This allows the predictive power of the data to be extracted without "overfitting" the data. The partial least square procedure did not return a significant relationship between performance on the live fire practice serials and the live fire PWT3 scores, Q^2 = not significant. This confirmed that PWT3 scores were not reliably predictable using live fire training data.

When these procedures were performed again—this time trying to predict PWT3 scores from simulator training data—similar results were obtained: The adjusted R^2 and Q^2 were not statistically significant. This inability to predict using simulator training data is not surprising, given the earlier inability to predict live fire PWT3 scores from live fire practice serials.

Personal Weapons Test Level 3

Table 2 presents the results of each platoon's first attempt at the PWT3, with the exception of 13 Platoon. This platoon was divided into two sections that trained on two different SATs simultaneously so that they could complete two courses of SAT training in the time that other platoons completed the training once. During the conduct of the trial, it was observed that one of the section instructors was passive, advancing to the next serial after each firer received feedback from the SAT on performance in the previous serial. The other instructor was active, using the SAT feedback as a point of departure for coaching. On the basis of the feedback, this coach offered a diagnosis of the firer's error and offered a corrective measure. The passive instructor's section scored a mean of 50.8 on the PWT3 while the active instructor's section scored a mean of 60. This difference was statistically significant, $t_{19} = 2.55$, $p < .05$, and practically substantial: Only 33% of firers in the passive section passed the PWT3 on the first attempt as compared to 45% from the active section. For this reason, the data from the passively coached section in 13 Platoon will not be included in further analyses because the inferior instruction the section

received would cause the efficacy of that training condition to be underestimated. Although the different treatment of the two sections in 13 Platoon is unfortunate from an experimental and military perspective, it serves to illustrate the point that a training simulator leverages the instructor's skills; it does not replace them. How a simulator is used is at least as important as the simulator itself.

Analysis of variance comparing the performance of the live fire, simulated fire, mixed fire, and double simulated fire groups reveals a significant difference amongst the groups, $F_{3,177} = 4.36$, $p < .01$. Table 3 shows that a mix of live and simulated fire achieved the highest PWT3 scores. A priori, each of the training methods might reasonably be adopted, so all differences amongst them were tested for statistical significance using the Games-Howell test (6). The result indicated that the superiority of mixed training over pure live and simulated fire was statistically significant at the .05 level. Superiority over the double SAT training did not reach significance.

Table 3: Personal Weapons Test – Level 3 Results by Training Method

TRAINING CONDITION	MEAN SCORE	N	STANDARD DEVIATION
Live Fire	57.2	110	10.6
Simulation	58.7	38	9.6
Mix	65.4	22	5.8
Double Simulation	59.9	11	6.6

Limitations of the Trial Design

This trial is limited by the constraint that each platoon had a dedicated small arms instructor. Ideally, the same instructor would have coached every platoon, but this was not possible. As a result, not only did the training medium differ between platoons, so did the instructor. It could be argued that each platoon should contribute only a single data point to the analysis because it is the combined effects of instruction and training method that are being observed. This argument has some statistical merit. However, this limitation of the trial was known, and steps were taken to standardize coaching. In pre-trial meetings with the instructors, coaching techniques were reviewed and the need for commonality explained. Furthermore, personnel from the CTC Gagetown Small Arms Cell observed the conduct of training to assess comparability across platoons. On the basis of this precaution, one section in 13 Platoon was excluded because they received different coaching from the other troops. Finally, more than one platoon used the all live and all simulation instructional methods. It is therefore asserted that the findings of this trial are informative despite the confounding of instructor and instructional method. Nevertheless, there would be significant value in attempting to confirm these findings by repeating the trial with a new sample of soldiers.

4. Discussion

On the basis of the data collected, the following answers are offered to the questions posed by DAT:

What is the optimum balance of live and simulator training to reach the required marksmanship standard? Completing the first five range practices on the SAT and the final three range practices on the range lead to the best performance of the PWT3 relative to training with exclusively live or simulated fire. This mix is not necessarily optimal, however, because not all blends of live and simulated fire could be investigated, only a reasoned selection from the existing set of range practices. Other selections are possible and could prove more effective. Furthermore, entirely new range practices could be constructed to leverage the strengths of the SAT. These might include providing figures of merit for aspects of marksmanship that are measured by the simulator, such as trigger pull and cant angle.

What part or parts of training can be conducted in simulation, and what parts must be done in live firing? Soldiers can successfully prepare for the PWT3 by firing all serials in simulation (although mixing live and simulated fire will lead to better performance). This conclusion is based on the similar PWT3 results obtained by platoons trained using exclusively live or simulated fire. Nevertheless, other factors should be considered before a pure simulation training approach is adopted for the C7 rifle. The troops will likely have greater confidence in their abilities if they have more live fire experience. The confidence instilled in their leaders, other troops, allies, and enemies are also worth consideration. Furthermore, motivation may also be affected by the amount of simulation used. An infantry soldier who only rarely gets to use his primary weapon may find his military career less satisfying. Finally, by only going to the range to fire the PWT, soldiers will have fewer opportunities to learn and practice the procedures of a live fire range (e.g., drawing ammunition and working with the range safety officer).

Can soldiers be trained entirely in simulation with a high degree of confidence that they can immediately achieve the standard in live fire? No. Using the amount and types of training described here, the probability of a soldier achieving the PWT3 standard on the first attempt after training entirely in simulation is .58.

In addition, the trial found that performance on the PWT3 cannot be reliably predicted from performance on the range practices, regardless of whether they were done using live or simulated fire. One can hypothesize that the trainees had not yet developed consistency in their performance due to the limited practice they received, but the trial did not provide data to unambiguously support this idea. Any other source of variability could produce the same result, such as worn out weapons or inaccuracies in the scoring system.

Concluding Remarks

The superior results obtained using a mix of simulation and live fire cannot be explained conclusively within the scope of this trial. The mix of live and simulation was set by assigning to

live fire the training serials that were most difficult to simulate. The SAT is not conducive to running, so Serial 6 was conducted live. Serials 7 and 8 were also conducted live because they employ targets placed at 300 m, and the appearance of these targets in the SAT suffered from the limited resolution of the display. The mix, therefore, provided controlled training conditions and instructional features offered by the simulator for early training, and a good match to the live environment later in training. Other factors, however, might have contributed to the benefits of the mixed approach. Providing live fire experience of range control procedures, weapon recoil, and weapon report to troops otherwise trained entirely in simulation might provide increased confidence.

Future work is needed to replicate the results found in this trial. In addition to potentially confirming the present results, a future trial could test different live fire and simulation mixes set by competing hypotheses. The fidelity approach taken in this trial could be evaluated alongside a mix designed to maximally promote confidence and familiarization with the live fire context. Finally, future trials should also be aware of the challenge posed by the inconsistent marksmanship of troops learning to shoot. Their performance is liable to be unstable as they attend to the different aspects of marksmanship, and this will tend to make differences between groups difficult to detect unless large groups are tested.

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List of symbols/abbreviations/acronyms/initialisms

APWT1	Annual Personal Weapons Test (Phase 1)
CAF	Canadian Armed Forces
CFB	Canadian Forces Base
CTC	Combat Training Centre
DAT	Directorate of Army Training
DND	Department of National Defence
DRDC	Defence Research and Development Canada
m	Meter
MBdr	Master Bombadier
PWT3	Personal Weapons Test Level 3
R&D	Research and development
S&T	Science and technology
SAT	Small Arms Trainer
TR	Technical Report
UK	United Kingdom

Annex A Personal Weapons Test Level 3

From Department of National Defence. (1995). Shoot To Live Part 1 - Policy B-GL-318-006/PT-004.

SER	PRACTICE	TARGET	RANGE (m)	ROUNDS	POSITION AND SOLDIER'S INSTRUCTION	SCORING	RANGE INSTRUCTION
1	Sighting	1.3 m (4 feet) Fig 11 with white aiming mark	100	5	Firer's Choice	Nil	a. No time limit b. Each round and MPI indicated c. Provides check on zeroing.
2	Grouping	1.3 m (4 feet) Fig 11 with aiming mark	100	5	Prone supported or unsupported (firer's choice)	100 mm (4 inch) – 5 points 150 mm (6 inch) – 3 points HPS – 5	a. No time limit b. No indication c. 5 round group best 4 shots only to count
3	Application	Fig 11 in target frame	200	5	Prone unsupported	One point per hit HPS – 5	a. No time limit b. Target falls when hit then reappears
4	Snap Shooting	Fig 11 on stick	200	10	a. Prone unsupported – 4 rounds. Kneeling supported – 6 rounds. b. Sight adjusted. Selector lever on R. Rifle out of shoulder at start and after each exposure. c. Two rounds per exposure.	One point per hit HPS – 10	a. One trial exposure. b. Two exposures of five seconds and three of eight seconds. Interval between exposures not less than ten seconds. c. Position of target varies at each

SER	PRACTICE	TARGET	RANGE (m)	ROUNDS	POSITION AND SOLDIER'S INSTRUCTION	SCORING	RANGE INSTRUCTION
							exposure.
5	Rapid Fire	Fig 11 in target frame.	200	15 One magazine of 10 one magazine of 5.	a. Fire trench (if available) or prone supported. b. Rifles loaded with 10 round magazine. Firer may be in aim when target appears. c. Change magazines	One point per hit HPS – 15	a. No trial exposure. b. Exposure: 40 seconds. c. Hits NOT indicated.
6	Application	Fig 11 in target.	300	5	Prone supported.	One point per hit HPS – 5	a. No time limit. b. Target falls when hit then reappears Hits not indicated
7	Snap Shooting	Two Fig 11s in target frame	300	10	a. Fire trench (prone supported if trench not available). b. Rifle loaded. Selector lever on R. Rifle out of shoulder at start and after each exposure. c. Two rounds at each exposure. One at each target	One point per hit HPS – 10	a. One trial exposure b. Five exposures of five seconds each. Interval between exposures not less than 10 seconds.
8	Fire and Movement		400	34 (one magazine of 14 rds and one mag of 20 rds)	a. Preparatory Stage 1) Firer, with two magazines adopts prone position at 400 m and loads 14 round magazine.	a. One point per hit b. HPS - 34	a. Preparatory Stage: 1) OIC Exercise explains practice after rifles are

SER	PRACTICE	TARGET	RANGE (m)	ROUNDS	POSITION AND SOLDIER'S INSTRUCTION	SCORING	RANGE INSTRUCTION
					2) Selector lever on S.		loaded and selector levers at S 2) OIC Exercise orders Butt Officer to commence the practice and control target exposure time.
		Two Fig 11's in forward target frame	300	6	b. Phase one. 1) When the target appears, the firer doubles forward, at the trail, to the 300 m firing point and fires three rounds from the prone supported or unsupported position (optional to firer) at each of the two Fig 11 targets. 2) Firing will STOP when targets		b. Phase one 1) Firer advances automatically when targets are exposed. 2) Targets (2 x Fig 11) are exposed for 45 seconds.

SER	PRACTICE	TARGET	RANGE (m)	ROUNDS	POSITION AND SOLDIER'S INSTRUCTION	SCORING	RANGE INSTRUCTION
					disappear. 3) Selector levers on S.		
		Same targets as Phase one	200	8	c. Phase 2: 1) When targets appear, the firer doubles forward, to 200 m firing point at the trail and fires 4 rounds from kneeling supported position at each Fig 11. 2) Firing will STOP when targets disappear. 3) Selector levers on S. Magazine changed when empty or when targets disappear.		c. Phase 2 After 10 sec pause two Fig 11 targets are exposed for 45 sec
		Two Fig 12 in rear target frame	100	8	d. Phase 3: 1) When targets appear, firer doubles forward at the trail to 100m firing point and fires 4 rounds from the prone		d. Phase 3. After 10 second pause two Fig 12 targets are exposed for 45 seconds.

SER	PRACTICE	TARGET	RANGE (m)	ROUNDS	POSITION AND SOLDIER'S INSTRUCTION	SCORING	RANGE INSTRUCTION
					unsupported at each Fig 12 target 2) Firing will STOP when targets disappear. Selector levers on S. STAND UP		
		Two Fig 11 in target frame. Choice of target to firer.	100		e. Phase 4: 1) Commence 10 seconds after end Phase 3. ALERT position. WATCH AND SHOOT. When target appears adopt kneeling unsupported position and fire two rounds at Fig 11. 2) Command ADVANCE, given 10 seconds after target disappears. Firer moves forward at walk, rifle at ALERTS, selector lever at S.		e. Phase 4: 1) A pause of 10 seconds is taken from end of last 45 sec exposure (Phase 3). 2) One Fig 11 target is exposed for eight seconds. 3) A pause of 35 sec is taken and a Fig 11 target is exposed for 5 seconds. 4) A pause of 25

SER	PRACTICE	TARGET	RANGE (m)	ROUNDS	POSITION AND SOLDIER'S INSTRUCTION	SCORING	RANGE INSTRUCTION
							seconds is taken and a Fig 12 target is exposed for 5 seconds. 5) A pause of 25 seconds is taken and a Fig 11 target is exposed for 5 seconds twice
		Same target.	75	2	3) Firer walks 25 m stops and fires two rounds from the standing positionat Fig 11 when it appears.		Notes: a. Timings for one Butt Officer: Phase 1 – Two Fig 11- 45 sec Between Phases 1 and 2 – 10 sec Phase 2 – Two Fig 11 – 45 sec Between Phase 2 and 3 – 10 sec Phase 3 – Two Fig
		Two Fig 12 in target frame. Choice of target to firer.	50	2	4) When target disappears firer continues to walkin ALERT position about 25 m STOPS and fires two rounds from the standing position at		

SER	PRACTICE	TARGET	RANGE (m)	ROUNDS	POSITION AND SOLDIER'S INSTRUCTION	SCORING	RANGE INSTRUCTION
					Fig 12 when it appears.		12- 45 sec Between Phase 3 and 4- 10 sec Phase 4: i. two Fig 12 - 8 sec. Pause 35 sec ii. two Fig 12-5 sec. Pause 25 sec iii. two Fig 12-5 sec. Pause 25 sec iv. two Fig 12-5 sec. Pause 5 sec v. same two Fig 12-5 sec b. Dressing must be controlled during this phase
		One Fig 11 in target frame.	25	6	5) When target disappears command ADVANCE, STANDING BURST, WATCH AND SHOOT. Firer walks 25 m stops and fires one burst per exposure from the standing shoulder or hip position. 6) Firing will stop when targets go down (98 seconds after ADVANCE).		

Notes:

1) Scoring
   HPS – 84
   MKSM – 72
   PASS – 59
   FAIL – Below 59
2) The total amount of ammunition required for this test is 98 rounds.

Annex B Weather Conditions for Live Fire Shooting

Meteorological Report – CTC Gagetown

05 June 2000

A. Sunny
B. Light winds
C. High 18°C during the day; low 4°C during the evening

06 June 2000

A. Sunny
B. Winds east at 20 km/h during the day; northeast at 20 km/h during the evening
C. High 16°C during the day; low 6°C during the evening

07 June 2000

A. Rain and light showers throughout the day amounting to 10 mm; skies clearing at about 1800 hrs
B. Winds northeast at 30 km/h and shifting to northwest at 30 km/h in the afternoon; light winds in the evening
C. High 15°C during the day; low 6°C during the evening

08 June 2000

A. Sunny with cloudy periods developing in the afternoon
B. Winds southwest gusting to 20 km/h
C. High 22°C during the day; low 12°C during the evening

09 June 2000

A. Cloudy with occasional showers during the morning; partly cloudy during the afternoon
B. Winds west at 30 to 40 km/h; northwest at 20 km/h during the afternoon
C. High 17°C during the day; low 6°C during the evening

12 June 2000

A. Sunny with cloudy periods; overcast during the evening
B. Winds light
C. High 17°C during the day; low 5°C during the evening

13 June 2000

A. Sunny in the morning; mostly cloudy during the afternoon; skies clearing during the evening
B. Winds light
C. High 19°C during the day; low 8°C during the evening

14 June 2000

A. Sunny during the morning; cloudy periods in the afternoon; skies clearing in the evening
B. Winds light; southwest at 20 km/h in the afternoon.
C. High 23°C during the day; low 10°C during the evening

15 June 2000

A. Overcast
B. Winds south at 30 km/h; southwest at 20 km/h during the afternoon and evening
C. High 23°C during the day; low 15°C during the evening

19 June 2000

A. Sunny; a few clouds in the evening
B. Winds light
C. High 22°C during the day; low 10°C during the evening

20 June 2000

A. Sunny; overcast during the afternoon; skies clearing in the evening
B. Winds light; south at 20 km/h during the afternoon
C. High 24°C during the day; low 12°C during the evening

21 June 2000

A. Mainly sunny; becoming overcast around noon.
B. Winds south at 30 km/h
C. High 29°C during the day; low 14°C during the evening

22 June 2000

A. Overcast during the morning; sunny with cloudy periods in the afternoon; skies clearing in the evening
B. Winds southwest at 30 km/h
C. High 27°C during the day; low 16°C during the evening

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The Canadian Army uses the Small Arms Trainer (SAT) to support the use of infantry weapons. A trial was conducted at CFB Gagetown to validate the simulator and to determine how live and simulated fire should be used to prepare troops for the Personal Weapons Test Level 3 (PWT3). Six infantry platoons completed the range practices using either

- all live fire;
- all simulated fire;
- simulated fire, completing all range practices twice; or
- simulated fire for the first five range practices and live fire for the last three range practices.

Following training, all participants fired the PWT3 using live fire. Results indicated that a mix of live and simulated fire led to the highest scores on the PWT3 and the highest proportion of marksmen.

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simulation; small arms; transfer of training; training; simulator

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