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Impediments to effective use of the Small Arms Trainer:

84mm Short-Range Anti-Armour Weapon (Heavy) and C9A1 Light Machine Gun

Stuart C. Grant

Defence R&D Canada
Technical Report
DRDC Toronto TR 2007-003
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Canada

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Sponsored by Directorate of Army Training.

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, National Council on Ethics in Human Research, Ottawa, 1998 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

Difficulties encountered during validation trials of the Small Arms Trainer (SAT) C9A1 light machine gun and Short Range Anti-Armour Weapon (Medium) (SRAAW(M)) simulations are documented. Sources of difficulty included the way the SAT was handled by users, integrating SAT sensors with the SRAAW(M), design of SAT components, SAT facilities, and programming errors in the C9A1 serials. Improvised solutions are described and long-term solutions are recommended.

Résumé

Des difficultés éprouvées lors des essais de validation du simulateur de tir aux armes légères (STAL) pour la mitrailleuse légère C9A1 et l’arme antiblindé à courte portée (moyenne) (AABCP) (M) sont annotées. Les sources de difficulté comprenaient la façon dont le STAL était employé par les utilisateurs, l’intégration des capteurs du STAL à l’arme AABCP(M), la conception des éléments du STAL, les installations de STAL et des erreurs de programmations dans les séries de simulation de tir de la C9A1. Des solutions improvisées sont décrites et des solutions à long terme sont recommandées.

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Executive summary

Impediments to effective use of the Small Arms Trainer: 84mm Short Range Anti Armour Weapon (Heavy) and C9A1 Light Machine Gun

Stuart C. Grant; DRDC Toronto TR 2007-003; Defence R&D Canada – Toronto; January 2007.

Introduction or background: The army is currently fielding the Small Arms Trainer (SAT) to support army weapons training. The Directorate of Army Training (DAT) tasked Defence Research and Development Canada with evaluating the SAT. Deficiencies in the use of the SAT emerged during field trials intended to validate the SAT C9A1 light machine gun and Short Range Anti Armour Weapon (Medium) (SRAAW(M)) simulation and to establish the transfer of training attainable. The deficiencies in the use, design, and installation of the SAT are documented here.

Results:

- Inconsistencies in the manufacture and care of the SRAAW(M) interfered with mounting of the SAT sensors on the SRAAW(M).
- Handling procedures for the simulated SRAAW(M) ammunition and the construction of the simulated ammunition lead to damage of the simulated ammunition.
- Low contrast in the visual display made at least one target very difficult to see.
- Some C9A1 serials from the Shoot To Live training manual are incorrectly programmed in the SAT.
- The dummy belt of ammunition for the C9A1 is prone to damage, rendering the belt unusable.
- The slope and surface texture of firing ramps built for C7 firing can be incompatible with the C9A1 bipod.
- The SAT C9A1 simulation frequently loses zero on the serials with targets beyond 300 m.

Significance: These deficiencies lead to damage to the SAT and undermine training value. The recommended changes to training, support, and design of the SAT will alleviate these deficiencies.

Future plans: This research program is completed. The results of this report can be used for the specification and selection of future devices like the SAT.

Sommaire

Impediments to effective use of the Small Arms Trainer: 84mm Short Range Anti Armour Weapon (Heavy) and C9A1 Light Machine Gun

Stuart C. Grant; DRDC Toronto TR 2007-003; R & D pour la défense Canada – Toronto; Janvier 2007.

Introduction : L'Armée met actuellement en service le simulateur de tir aux armes légères (STAL) pour appuyer l'instruction au tir des armes de l'Armée. La direction de l'instruction à l'Armée de terre (DIAT) a chargé Recherche et développement pour la défense Canada d'évaluer le simulateur de tir aux armes légères (STAL). Des carences dans l'utilisation du simulateur ont été découvertes pendant des essais sur le terrain qui étaient destinés à valider la simulation de tirs de mitrailleuse légère C9A1 et de l'arme antiblindé à courte portée (moyenne) (AABCP)(M) du STAL et à établir le niveau de transfert d'instruction possible. Les carences dans l'utilisation, la conception et l'installation du simulateur STAL sont indiquées dans le présent document.

Résultats :

- Des incohérences dans la fabrication et l'entretien de l'arme AABCP(M) ont entravé le montage des détecteurs du STAL sur l'arme AABCP(M).
- Les méthodes de manutention des munitions factices AABCP(M) et la construction des munitions factices se sont traduit par des dommages aux munitions factices.
- Au moins une cible était difficile à apercevoir en raisons des faibles contrastes sur l'écran d'affichage.
- Certaines séries de simulations de tir de C9A1 du manuel de formation intitulé « Tirer pour vivre » sont mal programmées dans le simulateur STAL.
- La bande de munitions factices de la mitrailleuse C9A1 est portée à s'endommager, ce qui la rend inutilisable.
- La pente et la texture de la surface des pas de tir érigés pour le tir du fusil C7 peuvent être incompatibles avec le bipied de la mitrailleuse C9A1.
- La simulation de tir à la mitrailleuse C9A1 du STAL perd fréquemment ses réglages lors de séries de tirs sur des cibles éloignées de plus de 300 m.

Portée : Ces carences se traduisent par des dommages au simulateur STAL et compromettent la validité de l'instruction. Les modifications recommandées pour l'instruction, le soutien et la conception du STAL permettront d'atténuer ces carences.

Projets futurs : Ce programme de recherche est terminé. Les résultats du présent compte rendu peuvent servir à la spécification et à la sélection de dispositifs futurs semblables au STAL.

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Acknowledgements

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I would also like to sincerely thank MCpl Dave Kozuska for operating the SAT and assisting in dealing with the difficulties documented in this report.

Captain Stephen Boyne, Army Liaison Officer, DRDC Toronto, provided invaluable assistance in the preparation of this trial and in tutoring me in the handling of the C9A1 and SRAAW(M).

Finally, I wish to thank Mr. Jim Clark for his photography of the SRAAW(M).

1 Introduction

The Director Army Training tasked Defence Research and Development Canada to investigate the army's newly acquired Small Arms Trainers (SAT). The tasking requested answers to the following questions:

- What is the optimum balance required, between live and simulator training, to achieve the required marksmanship standards for the 9mm pistol, C7A1 assault rifle, C8 assault carbine, C9A1 light machine gun, C7A1 with 40mm Grenade Launcher, C6, .50 cal heavy machine gun, M72A5 Short Range Anti-Armour Weapon (Light), 84mm Carl Gustav Short Range Anti-Armour Weapon (Medium) (SRAAW(M)) and the C3A1 sniper rifle?
- Is the SAT a valid simulation for each weapon it supports?
- Can a soldier be trained totally in simulation with a high degree of confidence that his / her weapon skills can immediately achieve the standards in live fire?
- Are there any deficiencies in the simulator that could be addressed through technological upgrades?
- Does the SAT enhance a soldier’s ability to train for operations?

In the course of answering these questions for the C9A1 light machine gun and the Short Range Anti-Armour Weapon (Medium) (SRAAW(M)), deficiencies and improper usage of the SAT were observed. This document is a technical report on shortcomings in the SAT hardware, software, and usage.

2 Observations and recommendations

2.1 Short Range Anti-Armour Weapon (Medium)

During data collection, Qualification Level 3 (QL3) Armour trainees used the SAT for training the SRAAW(M). They completed the Range Practices 1 and 3 of the SRAWW(M) weapons pamphlet (1). During the trial, a number of issues regarding the SAT system hardware and use of the system slowed the conduct of training and/or damaged the SAT.

2.1.1 Trigger Mount clearance

Problem The SAT simulation of the SRAAW(M) appends a Trigger/Latch Cable Assembly to an operational weapon. One of the steps in that procedure requires fitting a Trigger Mount collar around the cocking tube so that the state of the trigger (cocked versus uncocked) can be sensed. Figure 1 shows the Trigger Mount in place on the cocking tube.

Figure 1: SAT sensor Trigger Mount correctly installed

Installing the Trigger Mount requires passing the collar through the space between the cocking tube and the barrel of the SRAAW(M). This usually could not be done due to insufficient clearance between the barrel and the tube (see Figure 2). Five conversion kits and eight SRAAW(M) were available during the conduct of the trial. The collars could only be fitted on two of the SRAAW(M). This is due to variability in the clearance provided by each weapon. Any of the five collars would fit on the two weapons. None of the five collars would fit on the other six weapons.

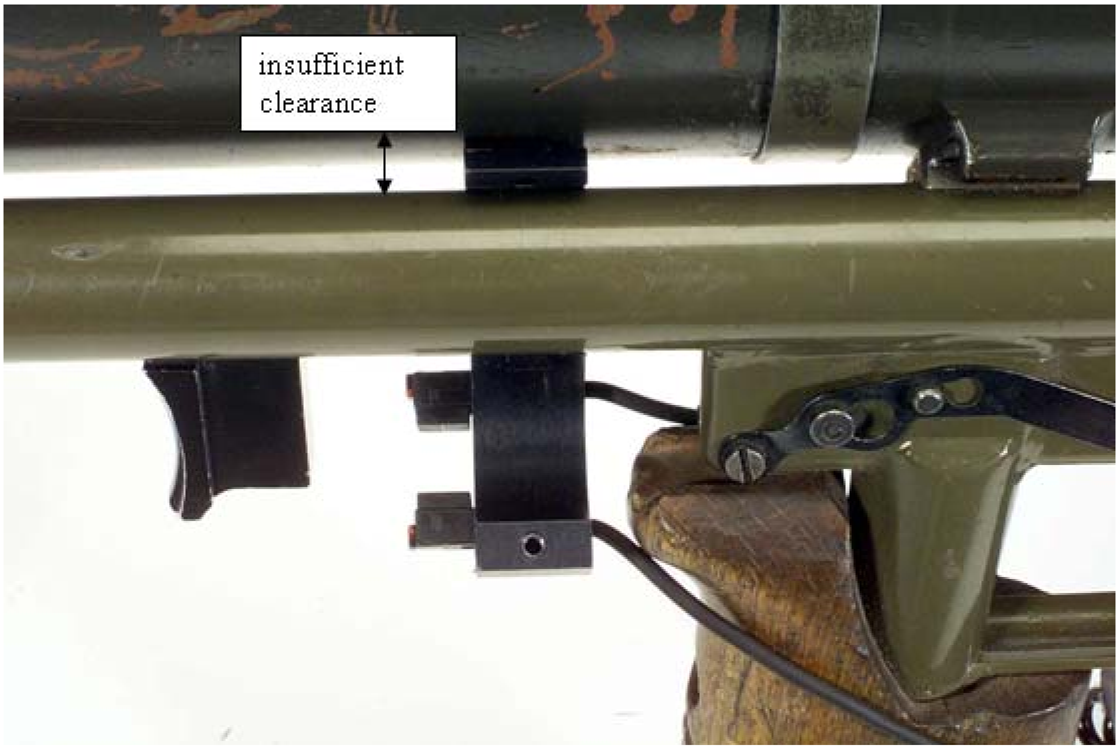

Figure 2: Clearance between cocking tube and barrel insufficient for Trigger Mount

Work-around An immediate work around was possible by driving the hinge pin out of the Trigger Mount collar and securing the Trigger Mount around the tube using gun tape. This was not generally satisfactory because the collar would begin to pivot after only a few rounds. The result was that either the weapon could not be cocked or that the sensor would not properly detect the state of the cocking mechanism.

Recommendation Individual SRAAW(M) capable of accepting the Trigger Mount should be identified and be specifically requested for use in the SAT. Weapons technicians should be informed of the required clearance between the cocking tube and the barrel and required to maintain a sufficient number of SRAAW(M) with sufficient clearance.

2.1.2 Sensor Latch Mount Screw

Problem Appending the conversion kit to the SRAAW(M) also requires attaching a Trigger/Latch Cable Assembly. This procedure requires removing the venturi latch/ejector screw, seen in Figure 4, attaching the latch end of the Trigger/Latch Cable Assembly, and securing it in place with the Sensor Latch Mount Screw, as seen in Figure 4. When correctly installed, a sensor in the Trigger/Latch Cable Assembly informs the simulation computer of the breech status. The Sensor Latch Mount Screw is critical for attaching the venturi sensor. It has an enlarged head that secures the Trigger/Latch Cable Assembly plate. Without this sensor operating properly, the SRAAW(M) will not operate in the simulator.

Figure 3: SRAAW(M) venturi latch / ejector screw.

At the start of the trial, the venturi latch/ejector screw was missing in three of the five conversion kits available. The absence of the screws appears to arise from the process in mounting and unmounting the conversion kit to the weapon. Interviews at Combat Training Centre Wainwright have identified a likely, although not documented, chain of events that lead to loss of the Sensor Latch Mount Screw.

At the end of SRAAW(M) training on the SAT, the conversion kit is removed. The user loosens or removes the Sensor Latch Mount Screw and removes the Trigger/Latch Cable Assembly. Instead of returning it to the conversion kit box, the Sensor Latch Mount Screw is replaced in the weapon. When the weapon is returned for storage and maintenance, maintainers discover the Sensor Latch Mount Screw. They correctly identify it as being non-standard, and replace it with a venturi latch/ejector screw that is the standard part for the weapon. The Sensor Latch Mount Screw is then lost to the SAT and is no longer available for future conversions.

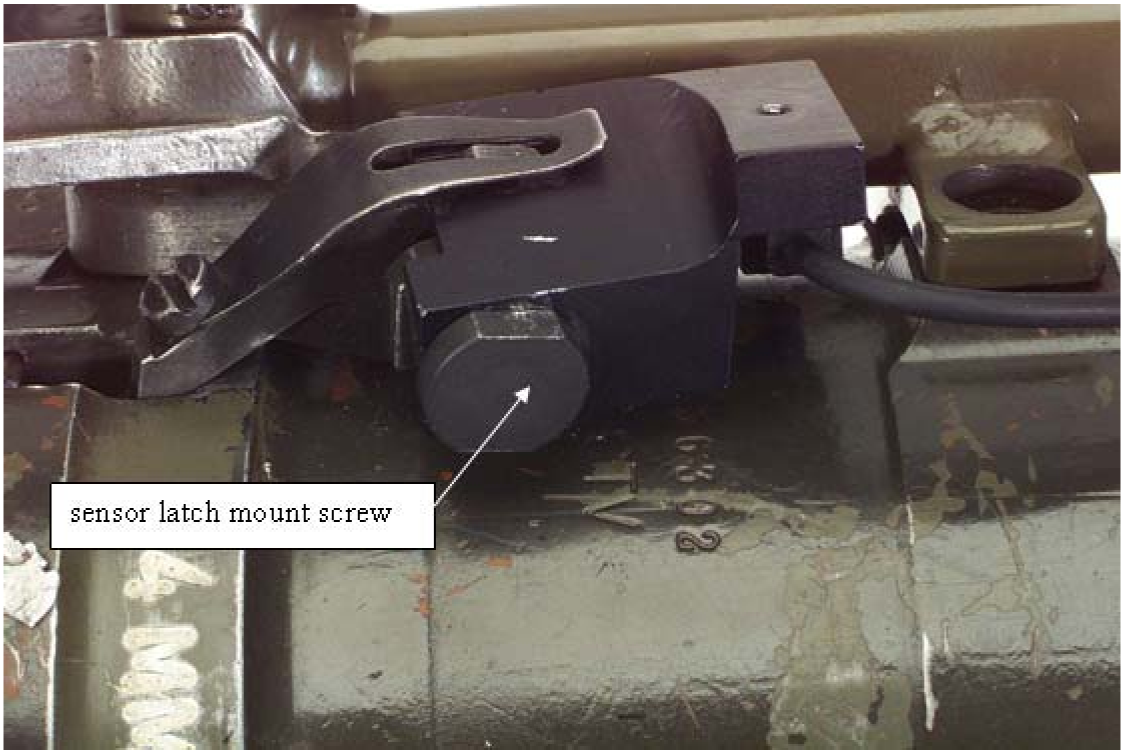

Figure 4. Sensor Latch Mount Screw holds the sensor in place.

Work-around Working around the problem is very difficult due to the unusual nature of the Sensor Latch Mount Screw. It is bare of threads on the lower end of the screw, and has a fine, possibly metric, thread on the upper end. The head is oversized and specially cut. During the course of the trial, determined searching in Edmonton and Vancouver failed to locate a replacement. The venturi latch/ejector screw, lacking the oversized head, cannot be used as a substitute. Ultimately, a welding rod was cut and filed to match the diameter and length of the Sensor Latch Mount Screw (see Figure 5). When inserted and gun-taped in place, it provided a reasonable, temporary solution.

Recommendation Operators of the SAT should be informed of this mistake and cautioned. Maintainers should be told of the existence of the Sensor Latch Mount Screw and where the screw should be returned if it is found in a weapon. Extra Sensor Latch Mount Screws might be held as spares in the SAT facility. Finally, the Sensor Latch Mount Screw head might be painted a bright, distinctive colour, thereby indicating that it is not part of the operational weapon. Alternatively the Sensor Latch Mount Screw might be permanently attached to the Trigger/Latch Cable Assembly so that it is removed when the assembly is removed.

Figure 5. Improvised Sensor Latch Mount "Screw".

2.1.3 Round extension

Problem The dummy high explosive anti-tank (HEAT) 551 and anti-tank (AT) 751 SRAAW(M) ammunition used in the SAT collapses to provide the appearance of extracting a casing from the gun after firing. When the round is removed, it must be extended again before the next firing sequence. This works, but users must be instructed in how the round should be extended. During the trial, many users extended the round by grabbing it at the base and whipping or snapping the round, similar to snapping a towel or casting with a fishing rod. While this was effective, the internal construction of the round could not tolerate the resulting forces. Approximately half of the HEAT 551 and AT 751 rounds were broken in this manner. When the round breaks, the internal metal retainer is snapped. An example of a broken round with the snapped internal retainer is presented in Figure 6. Due to the speed of the separating pieces of the dummy round, the wiring connecting the two pieces may be yanked. If the wire breaks, the front piece of the round can fly uncontrolled in the SAT room, potentially injuring personnel or damaging other equipment.

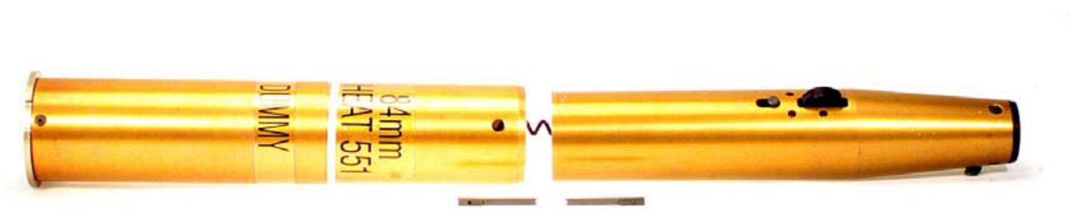

Figure 6. Broken SAT dummy 84 mm HEAT 551 round with snapped internal retainer piece.

Work-around Students switched ammunition, using whatever functional round was available. The high explosive dual purpose (HEDP) 502 round, being non-collapsing, was not susceptible to this problem.

Recommendation Users should be instructed on the proper way to extend the rounds. In addition, more robust construction of the internal retainer should be sought.

2.1.4 Collapsing round problem

Problem Collapsible rounds must fully collapse when loaded in the weapon. If this does not happen, the round acts as a ramrod, pushing the barrel insert out of the muzzle of the weapon (Figure 8). When this occurs, electrical contact between the round and the barrel insert is lost, making the system non-functional. Training must then be halted so the barrel insert can be reseated.

Figure 7. Barrel insert dislodged from loading a round that did not completely collapse.

Work-around Careful instruction and supervision on the loading of ammunition as well as inspection of the ammunition was required. Even this did not eliminate the problem, and the barrel insert had to be frequently reseated during the course of serials.

Recommendation The design of the collapsing rounds should be re-visited to see if the mechanisms can be made more reliable.

2.1.5 Visibility of targets

Problem Many users had trouble detecting targets at the 300 m range in Serial 3 of Range Practice 1 due to the low contrast between the target vehicle and the background. Even though targets may be difficult to see in an operational setting, this should probably be avoided in the SAT, because the goal of training is safe and effective operation of the weapon and not target detection.

Work-around The system operator pointed out the target to the firers by placing a finger on the screen.

Recommendation New images for the serial should be selected, providing greater contrast between the target and its background. Future upgrades of the SAT could specify greater resolution and brightness ranges in the display system.

2.2 C9A1 Light Machine Gun

During data collection, QL3 Armour trainees fired the C9A1 Practice Serials and the Personal Weapons Test Level 3 (PWT 3) (2) in the SAT before firing the PWT 3 on the range. During the trial, a problem with the SAT programming of the serials was discovered and some potential improvements for the installation of the SAT became apparent.

2.2.1 Incorrect serials

Problem Some of the Shoot To Live C9A1 range practices are incorrectly programmed in the SAT. The requirement to subdivide some Shoot To Live serials into sub-serials to accommodate the SATs performance review capabilities introduced some of the errors. The cause for other errors is not apparent. Annex A lists the programming errors in detail. These errors place an artificial ceiling on the score a firer can obtain. This not only undermines the predictive validity of the simulator, because stronger firers cannot outscore weaker firers, but it can also discourage firers if they do not know the reason for their low score.

Work-around The serials were fired as programmed. Instructors and students were informed that the programming error meant that scores in the SAT should not be compared to published CF standards and that their scores in the SAT would be lower than expected.

Recommendation The serials should be re-programmed to reflect the latest version of Shoot To Live.

2.2.2 Crushing of ammunition belt

Problem The SAT determines that the C9A1 is loaded through either the presence of a magazine in the weapon or by a specially modified round in the 5-round belt provided for the SAT C9A1. This modified round is the first round in the belt, and it is susceptible to crushing when the body cover is closed on the belt. When crushed, the modified round may not be detected properly, and the SAT behaves as if the C9A1 were not loaded. This damage leads to a disruption of the serial and frustration on the part of the firers.

Work-around During the course of the trial, when spare belts were no longer available, a magazine was used instead of the belt. This proved satisfactory.

Recommendation The modified round could be manufactured of a harder, solid metal, but this would likely result in cumulative damage to the body cover as it is closed on the improperly seated modified round. A new modified round might be manufactured that is shaped so that it was still detectable, yet was either not vulnerable, or tolerant, to crushing. Although it would require a redesign of the SAT C9A1, a new sensing mechanism not dependent on a modified round might be sought. Alternatively, the modified rounds might be treated as a consumable and replaced periodically.

2.2.3 Bipod movement

Problem The C9A1 bipod rests on a hard, smooth surface (e.g., plywood) in some SAT installations. This allows the weapon to skate and wander off-target when fired.

Work-around Placing the bipod on a soft or rough surface provides resistance that leads to more natural movement of the weapon. Rubber doormats proved to be satisfactory in the course of the trial.

Recommendation A non-skid surface for bipods should be provided in all SAT facilities.

2.2.4 Firing ramp elevation

Problem Some installations of the SAT include angled firing ramps for use in the prone position. These ramps are unsuitable for use with the C9A1 because the elevation of the ramp when added to the elevation of the C9A1 bipod results in the muzzle being too high. The firer must adopt an unnatural and uncomfortable firing position that cannot be sustained for long.

Work-around A step in front of the ramp was improvised from available materials. This provided a lower surface for resting the C9A1 bipod, and allowed the firer to assume a normal firing position.

Recommendation If the ramps cannot be removed for safety, space, time, or other reasons, it is suggested that a step covered with a non-skid surface be provided beyond the front edge of the firing ramp.

2.2.5 Absence of butt pistol grip

Problem The C9A1 as delivered with the SAT does not include a pistol grip on the butt of the weapon. Instructors and students on the course complained that they could not achieve the locking grip as taught during the C9A1 course.

Work-around The weapon was fired as provided. The impact of this difference on the transfer of training when the butt pistol grip was used in the field is unknown.

Recommendation Butt pistol grips should be provided on the SAT C9A1 so that continuity from early training through to live field firing can be maintained.

2.2.6 Loss of zero

Problem The C9A1 SAT installation appears to lose its zero when fired at target ranges greater than 300 m. This is a software issue, and not a result of changes in the weapon. Occurrence of this problem is difficult to detect, because fewer hits are normally expected at longer ranges. This fault is diagnosed when a firer who previously obtained grouping on the centre of the target at 300 m, has all rounds fall off the edge of the target frame at 400m.

Work-around Re-zeroing the weapon and hope that the SAT holds zero through the long-range engagements.

Recommendation The supplier should rectify the error.

3 Conclusions

An attempt to conduct training research with the SAT encountered difficulty due problems with the design and use of the SAT. Adopting the work-arounds and implementing the recommendations of the report should deliver real benefits to the CF. In the case of the SRAAW(H), three of the problems could be fixed by permanently mounting the SAT sensors to SRAAW(H) dedicated use in the SAT. The benefits of acting on the recommendations in this report reduced damage to the SAT, improved training value, and fewer modifications required of SAT facilities.

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[1] Department of National Defence (1995) Short Range Anti-Armour Weapon (Medium), B-GL-317-006/PT-001, Department of National Defence.

[2] Department of National Defence (1995) Shoot To Live Part 1 - Policy. B-GL-318-006/PT4 Department of National Defence.

Annex A Discrepancies between SAT and C9A1 Range Practices

Table A1. *Discrepancies Between SAT and Shoot To Live Range Practices*

PRACTICE	SERIAL	DISCREPANCIES	REMARKS
1	1 –Familiarization	STL target is stop butt. SAT target is target board	
2	1 – Grouping Fire Trench	1. STL specifies one Figure 11 target in the front and the rear of the target frame. SAT provides only one Figure 11. 2. STL directs that four 5 round bursts should be fired from a 20 round belt, and that groupings be inspected after each burst. SAT breaks the serial into 4 parts, so that group size can be inspected after each part. Unfortunately, a 20 round belt is provided in each part, so firers must inspect four groupings of 20 rounds each	1. Firing 20 round bursts denies firer practice in limiting bursts to 5 rounds. 2. Denies information on firer's ability to control size of 5 round bursts.
2	3 – Grouping Fire Trench	Same as Practice 2, Serial 1.	Same as Practice 2, Serial 1.
3	1 – Limbering Up	STL target is stop butt. SAT target is Figure 11.	
3	2 – Grouping for Zeroing	STL directs that mean point of impact should be indicated after each of four 5 round bursts. SAT does not indicate mean point of impact after each burst.	Firers cannot adjust sights after each burst so cannot zero weapon.
5	6 – Deliberate Lying in the Open	1. STL allows a 10 round belt to be fired in two bursts. SAT provides one 10 round belt and one 5 round belt. 2. STL targets are at 400m. SAT targets are at 300m. 3. STL does not have time limit. SAT gives 30 second exposure. 4. STL highest possible score is 10. SAT highest possible score is 15.	1. SAT provides practice on different elements of shooting than STL. 2. Difference in scoring undermines comparison of scores between STL and SAT.
5	8 – Timed Lying in the Open	This serial is missing from SAT.	Firer receives less practice. Firer loses opportunity to score points, thus undermining score comparison between STL and SAT training.
7	3 – Timed Lying in the Open	STL provides two exposures of 15 seconds. SAT provides one exposure of 15 seconds.	Encourages higher rate of fire. Firer has less time to score points, undermining

			comparability of scores between SAT and STL.
7	5 – Timed Lying in the Open	Same as Practice 7 Serial 3.	Same as Practice 7 Serial 3.

STL = Shoot To Live.

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[1] Department of National Defence (1995). *Shoot-To-Live Part 1*. B-GL-318-006/PT-004. Department of National Defence, Canada.

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List of symbols/abbreviations/acronyms/initialisms

AT	Anti-Tank
CF	Canadian Forces
DAT	Director Army Training
HEAT	High Explosive Anti-Tank
HEDP	High Explosive Dual Purpose
PWT	Personal Weapons Test
QL3	Qualification Level 3
SAT	Small Arms Trainer
SRAAW(H)	Short Range Anti Armour Weapon (Heavy)

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Difficulties encountered during validation trials of the Small Arms Trainer (SAT) C9A1 light machine gun and Short Range Anti-Armour Weapon (Medium) (SRAAW(M)) simulations are documented. Sources of difficulty included the way the SAT was handled by users, integrating SAT sensors with the SRAAW(M), design of SAT components, SAT facilities, and programming errors in the C9A1 serials. Improvised solutions are described and long-term solutions are recommended.

Des difficultés éprouvées lors des essais de validation du simulateur de tir aux armes légères (STAL) pour la mitrailleuse légère C9A1 et l’arme antiblindé à courte portée (moyenne) (AABCP) (M) sont annotées. Les sources de difficulté comprenaient la façon dont le STAL était employé par les utilisateurs, l’intégration des capteurs du STAL à l’arme AABCP(M), la conception des éléments du STAL, les installations de STAL et des erreurs de programmations dans les séries de simulation de tir de la C9A1. Des solutions improvisées sont décrites et des solutions à long terme sont recommandées.

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Simulation; Small Arms Trainer;