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**USE OF AN OFF-BORE WEAPON SIGHT IN
URBAN AND WOODED TACTICS**

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Abstract

This report describes an experiment to investigate the utility of off-bore viewing and target engagement in urban and wooded terrain, and assess the implications of an off-bore weapon system on small team lethality and survivability. In this experiment twelve regular force infantry soldiers performed force-on-force tactical section attacks in both defensive and offensive missions, using off-bore (U.S. Land Warrior) and on-bore (in-service C79 optical sight) weapon sighting systems. Human factors measures included subjective utility and usability measures of the on-bore and off-bore systems. Data collection included questionnaires and focus groups. The results indicated that an off-bore weapon sight might provide advantages over a conventional on-bore sight, primarily in urban terrain and inside buildings where target ranges are short and the complex nature of close quarter urban battle creates many danger areas. In open streets or wooded terrain, an optical sight is preferred. Improvements are suggested for an off-bore sighting system such as improved camera quality, a wider field of view and the incorporation of a laser range finder and zoom capability.



Résumé

Le présent rapport décrit une expérience visant à étudier l'utilité de la visualisation hors axe et de l'engagement d'objectifs en terrain urbain et en terrain boisé, ainsi qu'à évaluer l'incidence d'un système d'arme hors axe sur la mortalité et la surviabilité d'une petite équipe. Au cours de cette expérience, douze fantassins de la Force régulière ont mené des attaques de section tactique force contre force dans le cadre de missions défensives et offensives, au moyen de systèmes de visée d'arme hors axe (U.S. Land Warrior) et dans l'axe (viseur optique C79 en service). Les mesures de facteurs humains comprenaient des évaluations subjectives de l'utilité et de l'utilisabilité des systèmes dans l'axe et hors axe. La collecte des données s'est effectuée par des questionnaires et des groupes de discussion. Les résultats ont indiqué qu'un viseur d'arme hors axe pouvait procurer des avantages sur un viseur dans l'axe ordinaire, principalement en terrain urbain et à l'intérieur d'immeubles, où les objectifs sont peu éloignés et où la nature complexe des combats urbains rapprochés crée de nombreuses zones dangereuses. Un viseur optique est préférable dans les rues dégagées ou en terrain boisé. Des améliorations sont proposées pour un système de visée hors axe, notamment l'amélioration de la qualité de la caméra, l'élargissement du champ de vision et l'incorporation d'un télémètre laser ainsi que d'un zoom.



Executive Summary

A number of soldier modernization programs have incorporated an off-bore weapon sighting system into their future soldier system ensemble. An off-bore sighting system includes a video camera boresighted to the rifle barrel of the soldier's personal weapon, which can be used to remote the sight image to a Helmet Mounted Display (HMD). By using an off-bore system soldiers can limit the duration and extent of exposure to enemy fire by remaining behind cover while observing the field of fire through their video sight.

While the notion of using an off-bore system to increase soldier survivability seems attractive, little is known about the lethality effectiveness and tactical employment implications of these systems.

This report describes a preliminary experiment to investigate the issues associated with off-bore sighting systems in small Unit tactics in both an urban and wooded setting. In the experiment twelve regular force infantry soldiers performed force-on-force tactical section attacks in both defensive and offensive missions, using off-bore (U.S. Land Warrior) and on-bore (in-service C79 optical sight) weapon sighting systems. Human factors measures included subjective utility and usability measures of the on-bore and off-bore systems.

In its current state, the example off-bore weapon system (U.S. Land Warrior ver 0.6) used for this experiment was judged to be significantly less acceptable than the current in-service C79 optical sight for speed and accuracy of detecting and engaging static and moving targets, local situation and battle awareness, speed of advance and assault, and maintenance of mission tempo.

Perceptions were even more polarized in favour of the optical sight in wooded terrain where the off-bore system proved more difficult to use. The homogenous, organic nature of wooded terrain made it difficult for the soldier to establish and maintain a visual reference between the camera image and the actual terrain during observation and target search. The image quality of the system was insufficient for identifying camouflaged soldier targets in wooded terrain unless those targets physically moved while being observed.

Participants indicated that an off-bore system had its' greatest potential in urban terrain. An off-bore system was preferred over the optical sight for observing and fighting from cover at short ranges, particularly during close quarter battle in buildings. While building clearing tempo was slowed by the use of an off-bore system, participants believed that their survivability was improved in close quarters and danger crossing areas.

While the potential of off-bore systems was recognized for select applications, participants suggested that there was considerable room for technology improvement and further study to determine the best ways and means of deploying such a capability in combat.

Design recommendations for an off-bore system are suggested and areas for further investigation are indicated.



Sommaire

Un certain nombre de programmes de modernisation destinés au soldat incorporent un système de visée d'arme hors axe au futur équipement du soldat. Un système de visée hors axe comprend une caméra vidéo alignée sur le canon de l'arme personnelle du soldat et pouvant transférer l'image du viseur vers un afficheur monté sur casque (HMD). Grâce au système hors axe, les soldats peuvent limiter la durée et l'étendue d'exposition au tir ennemi en restant à couvert tout en observant le champ de tir au moyen de leur viseur vidéo.

Bien que l'utilisation d'un viseur hors axe pour améliorer la surviabilité du soldat semble attrayante, on ne dispose que de peu d'information au sujet de l'incidence qu'ont ces systèmes sur la mortalité et l'emploi tactique.

Le présent rapport décrit une expérience préliminaire visant à étudier les questions liées aux systèmes de visée hors axe dans les tactiques des petites unités en terrain urbain et en terrain boisé. Au cours de cette expérience, douze fantassins de la Force régulière ont mené des attaques de section tactique force contre force dans le cadre de missions défensives et offensives, au moyen de systèmes de visée d'arme hors axe (U.S. Land Warrior) et dans l'axe (viseur optique C79 en service). Les mesures de facteurs humains comprenaient des évaluations subjectives de l'utilité et de l'utilisabilité des systèmes dans l'axe et hors axe.

Dans la situation actuelle, le système d'arme hors axe utilisé pour cette expérience (U.S. Land Warrior, version 0.6) a été jugé nettement moins acceptable que le viseur optique C79 actuellement en service, pour ce qui est de la vitesse et de la précision de détection et d'engagement des objectifs fixes et mobiles, de la connaissance de la situation locale et du combat, de la vitesse de progression et d'assaut ainsi que du maintien du rythme des missions.

Les perceptions étaient même encore plus polarisées en faveur du viseur optique en terrain boisé, où le système hors axe s'est révélé plus difficile à utiliser. La nature homogène organique du terrain boisé compliquait la tâche du soldat qui devait établir et maintenir une référence visuelle entre l'image de la caméra et le terrain réel durant l'observation et la recherche d'objectif. La qualité d'image du système ne suffisait pas pour identifier les objectifs que constituaient des soldats camouflés en terrain boisé à moins que ces objectifs ne se déplacent durant l'observation.

Les participants ont indiqué qu'un système hors axe offrait le meilleur de son potentiel en terrain urbain. Le système hors axe s'est avéré préférable au viseur optique pour les observations et combats à couvert et à courte distance, particulièrement durant les combats rapprochés à l'intérieur d'immeubles. Bien que le système hors axe ait réduit la vitesse de dégagement des immeubles, les participants ont soutenu que leur surviabilité se trouvait améliorée durant les combats rapprochés et le franchissement de zones dangereuses.

Même s'ils ont reconnu le potentiel des systèmes hors axe pour certaines applications, les participants ont affirmé qu'il y avait nettement place à des perfectionnements technologiques et à une autre étude visant à déterminer la meilleure façon de déployer cette capacité en cours de combat.

Des recommandations de conception d'un système hors axe sont proposées et des domaines de recherches futures sont indiqués.



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1. Background

A number of soldier modernization programs have incorporated an off-bore weapon sighting system into their future soldier system ensemble. An off-bore sighting system (see Figure 1) includes a video camera boresighted to the rifle barrel of the soldier's personal weapon, which can be used to remote the sight image to a Helmet Mounted Display (HMD). By using an off-bore system soldiers can limit the duration and extent of exposure to enemy fire by remaining behind cover while observing the field of fire through their video sight.

While the notion of using an off-bore system to increase soldier survivability seems attractive, little is known about the lethality effectiveness and tactical employment implications of these systems.

This report describes a preliminary experiment to investigate the issues associated with off-bore sighting systems in small Unit tactics in both an urban and wooded setting.



Figure 1: Off-Bore System (Land Warrior)



2. Aims

The following aims were pursued in this experiment:

- Investigate the utility of off-bore viewing and target engagement in urban and wooded terrain.
- Assess the implications of an off-bore weapon system on small team lethality and survivability.



3. Method

This section gives an overview of experimental method and describes the approach, equipment used and measures.

3.1 Overview

The following description provides a general overview of the trial method. Further details are provided in subsequent sections.

A two-day field trial was undertaken at the McKenna Ranges in Ft. Benning, Georgia over the period of 16-17 December 2001. The trial used the McKenna MOU site village (Figure 2) and a wooded training area to the east of the McKenna village. Twelve regular force infantry soldiers performed force-on-force tactical section attacks in both defensive and offensive missions, using off-bore and on-bore, optical weapon sighting systems. In each session, eight soldiers formed an attacking section and four soldiers held a defensive position. A total of 6 urban missions and 6 wooded missions were performed.

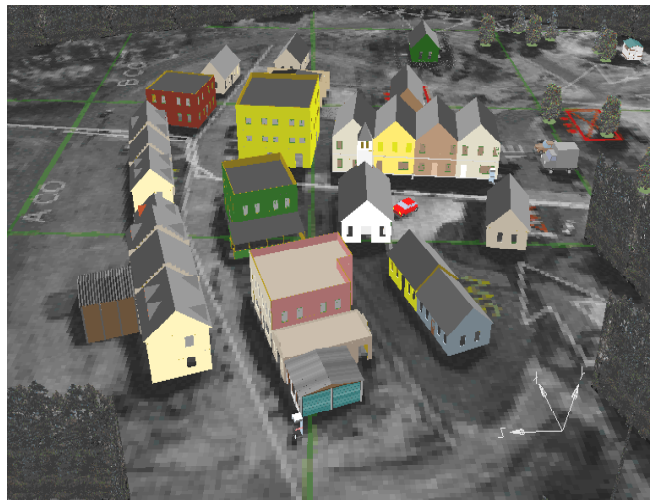


Figure 2: McKenna MOU Site

For each urban attack mission, participants were required to maneuver through the MOU streets, gain entry to an objective building, and clear the building by moving from room to room. In the defensive position, participants were required to defend an objective building from the assaulting force. For wooded missions, participants were required to maneuver through the woodline and attack a defensive position in the woods. In the defensive position, participants were required to defend their location from the assaulting force. In both the wooded and urban scenarios, a civilian hostage was placed in the defensive position. Attacking soldiers were instructed to engage the defending soldiers without harming the hostage, thereby requiring the shooter to confirm the target identity. Weapons operation included blank firing and use of the SIMLAS laser target engagement system to simulate live weapons effects.



Human factors measures included subjective utility and usability measures of the on-bore and off-bore systems. Data collection included questionnaires, focus groups and HF observer assessments.

3.2 Approach

The approach taken during the field trial is described in the following sections.

3.2.1 Briefing and Training

Prior to experimentation, all soldier participants were briefed on the goals and approach to the experiment. Participants were also trained on the use of the Land Warrior off-bore system and the tactics and practices of off-bore use in an urban warfare environment.

3.2.2 Missions:

Each mission comprised three phases.

Phase 1--Mission Briefing: Prior to the mission, the Section was provided with execution orders, rules of engagement and limited information about the enemy strength at the objective. Each mission emphasized small unit tactics, issues of control within the Section and within each assault group, stealth during the approach, and coordination during the assault. The missions were configured to standardize the experimental mission parameters between conditions, within the context of tactics for urban and wooded operations.

Phase 2-- Mission Execution: Based on the assigned orders, the Section executed the mission with four members using the conventional on-bore optical weapon sight and four members using the Land Warrior off-bore weapon sight. Four participants were designated as enemy force. Two of the enemy force soldiers used conventional on-bore optical weapon sights and two used the Land Warrior off-bore weapon sights. Friendly and enemy force personnel were outfitted with SIMLAS laser target engagement systems to record weapons engagements.

Phase 3--Post-Mission Measurements: Following each mission, participants completed a post-mission questionnaire (for attacking missions, task questionnaire data was only collected for the second mission). Specific issues were reviewed and displayed using the After Action Review (AAR) capabilities at the McKenna facility. A final focus group discussion was held at the completion of all missions.

The order of participants and systems used in each of the two terrain conditions (i.e. wooded and urban) is shown in Table 1.



Table 1: Order of Participants

Assault Group	Subject	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
1	1	Optical	Off-bore	Optical	Off-bore	Optical	Off-bore
	2	Optical	Off-bore	Optical	Off-bore	Optical	Off-bore
	3	Optical	Off-bore	Optical	Off-bore	Off-bore	Optical
	4	Optical	Off-bore	Optical	Off-bore	Off-bore	Optical
2	5	Off-bore	Optical	Optical	Off-bore	Off-bore	Optical
	6	Off-bore	Optical	Optical	Off-bore	Off-bore	Optical
	7	Off-bore	Optical	Off-bore	Optical	Off-bore	Optical
	8	Off-bore	Optical	Off-bore	Optical	Off-bore	Optical
3	9	Optical	Off-bore	Off-bore	Optical	Optical	Off-bore
	10	Optical	Off-bore	Off-bore	Optical	Optical	Off-bore
	11	Off-bore	Optical	Off-bore	Optical	Optical	Off-bore
	12	Off-bore	Optical	Off-bore	Optical	Optical	Off-bore

Defense
 Attack

Each participant used each system once in a defending mission and twice in attacking missions in both urban and wooded terrain, for a total of 12 missions per participant (i.e. six sessions in each of the urban and wooded terrains).

3.3 Equipment Used

The following sections describe the C79 optical and the Land Warrior Daylight Video Sight used during the field trial.

3.3.1 C79 optical sight

The on-bore sight used in this experiment was the in-service Elcan C79 optical sight (Figure 3). It was a waterproof, ruggedized sight, with shockproof optics and an adjustable reticle. The reticle in the C79 sight was a black vertical post. The sight picture provided 3.4X magnification, however, when using the C79 sight for aiming, the user had a restricted field-of-view. As the standard sight for the Canadian army, most soldiers are extensively trained with its use.



Figure 3: Elcan C79 Optical Sight

The C79 Optical Sight has the following specifications (see Table 2):

Table 2: C79 sight specifications

Criteria	Specification
Weight	0.7 kg (1.5 lb)
Magnification	3.4X standard
Field of View	8°

3.3.2 Land Warrior Daylight Video Sight (DVS) and Helmet Mounted Display

The off-bore system used in the experiment was the U.S. Land Warrior Daylight Video Sight (DVS) and Helmet Mounted Display (HMD). The Land Warrior system used the Kaiser Electronics' Daylight Video Sight (DVS). It was a Commercial-Off-The-Shelf (COTS) design, which had been ruggedized to meet the requirements of Land Warrior. The DVS (Figures 4 & 5) was a full colour, SVGA equivalent (525 Lines High Resolution TV imagery) miniaturized video camera that was used in conjunction with a Helmet Mounted Display (HMD) to provide the ability to fire from behind cover without requiring the soldier to expose their torso and head. The DVS has been demonstrated to perform consistently after the shock of weapon firing.



Figure 4: Weapon Mounted Daylight Video Sight (Front)



Figure 5: Weapon Mounted Daylight Video Sight (Side)

The monocular Helmet Mounted Display (HMD) included in the US Land Warrior system enabled the unaided eye to view the local surroundings (see Figure 6). It could be attached to the helmet to cover either the right or the left eye, and was connected to the DVS sight via a ruggedized cable. The HMD was an AMEL (Active Matrix Electro Luminescent) flat panel display providing VGA (600 X 400 pixel) resolution and a 40-degree field of view.



Figure 6: US Land Warrior Helmet Mounted Display (HMD)



The US Land Warrior helmet mounted display had the following specifications (see Table 3):

Table 3: US Land Warrior HMD Specifications

Criteria	Specification
Weight	0.09 kg (3.5 ounces)
Display Type	AMEL (Active Matrix Electro Luminescent)
Resolution	VGA, (640 X 480 pixels)
Field of View	40°
Connection	VGA, USB

3.4 User Acceptance Measures

At the conclusion of each mission, participants completed task questionnaires. Participants were required to rate the acceptability of the sight they used in the mission using the 7 point scale in Figure 7.

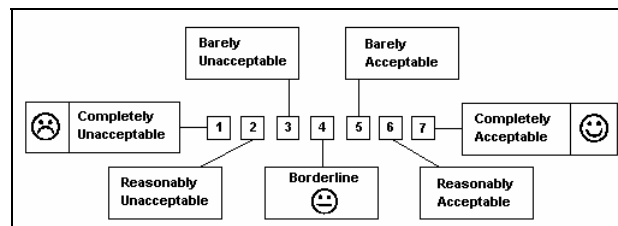


Figure 7: The Seven-Point Acceptability Scale

The task questionnaires asked participants to rate the acceptability of the sights in the following categories: surveillance, target engagement, survivability and overall.

For defensive missions, each participant used each sight for one mission, and thus completed the task questionnaire immediately following that mission. For the attacking missions, each participant used each sight twice and completed the task questionnaire only after using the sight for the second time.



At the completion of all missions, participants completed two Exit Questionnaires, one for wooded missions and one for urban missions. On the exit questionnaires participants indicated their preference for either the optical or the off-bore sight for items in the following categories: surveillance, target engagement, survivability and overall. The following Preference Rating Scale was used (Figure 8).

Preference						
Optical Sight		No Difference			Off-bore Video Sight	
3	2	1	0	1	2	3

Figure 8: Exit Questionnaire Preference Rating Scale

A final focus group discussion was held at the completion of testing. Participants were encouraged to describe and discuss the lethality, survivability, and tactical implications of off-bore weapons systems and the usability of the Land Warrior off-bore interface.



4. Statistical Analyses

Table 4 shows the sample size for each condition.

Table 4: Statistical Sample Size

		Weapon System	
		Optical (On-Bore)	Off-Bore
Wooded	Attack	12	12
	Defend	12	12
Urban	Attack	12	12
	Defend	12	12

The order of mission/weapon system conditions was balanced within wooded and urban missions. Within group comparisons of mission/weapon system conditions were assessed using a non-parametric sign test for the questionnaire data. For exit questionnaire preference data, a t-test of means against a comparison constant of zero was used. Differences were identified at $p \leq 0.05$.



5. Results

Results are presented for the task questionnaires according to four mission types: Urban Attack, Urban Defence, Wooded Attack and Wooded Defence. Exit questionnaire and final focus group results are also presented.

5.1 Urban Attack

After each mission participants completed a task questionnaire according to the weapon sighting system used, whether they were members of the assaulting or defending force and whether the mission was in wooded or urban terrain. Since each participant used each system twice in an urban attacking role, participants completed the task questionnaire only after their second urban attack with each system. This section presents results from participants for the attacking section in urban missions. Participants rated the acceptability of the task questionnaire items using the seven-point acceptability scale in Figure 7. The percentage of participants who rated an item as unacceptable (i.e. < 4) are indicated. Percentages above 20% are shaded. Table 5 shows the results of a non-parametric sign test of task questionnaire results for urban attack missions. The results (median ratings) are shown graphically in Figure 9.

Table 5: Urban Attack Task Questionnaire Results

			Off-bore	Optical	Z and p values	Significant Differences
1	Observing from Cover (CQB)	median	6.0	6.0	Z=1.58 p =0.12	None
		% unacceptable	8.3%	8.3%		
2	Observing from Cover (0-50m)	median	6.0	6.0	Z=-0.00 p =1.00	None
		% unacceptable	8.3%	8.3%		
3	Observing from Cover (50-100m)	median	4.5	6.0	Z=2.04 p =0.04	Optical>Off-bore
		% unacceptable	25.0%	8.3%		
4	Confidence to move from Cover	median	5.0	6.0	Z=1.22 p =0.22	None
		% unacceptable	8.3%	0%		
5	Speed of Advance	median	5.0	6.0	Z=2.47 p =0.01	Optical>Off-bore
		% unacceptable	16.7%	0%		
6	Awareness of Tactical Conditions	median	5.0	6.0	Z=2.04 p =0.04	Optical>Off-bore
		% unacceptable	8.3%	0%		
7	Detecting Targets	median	5.0	6.0	Z=1.77 p =0.08	None
		% unacceptable	25.0%	0%		
8	Identifying Targets	median	4.5	6.0	Z=2.67 p =0.007	Optical>Off-bore
		% unacceptable	33.3%	0%		



Table 5: Urban Attack Task Questionnaire Results (Cont)

			Off-bore	Optical	Z and p values	Significant Differences
9	Targeting Speed (static target)	median	6.0	6.0	Z=1.79 p =0.07	None
		% unacceptable	16.7%	0%		
10	Targeting Speed (moving target)	median	4.0	6.0	Z=2.47 p =0.01	Optical>Off-bore
		% unacceptable	41.7%	0%		
11	Targeting Accuracy (0-50m)	median	5.5	6.5	Z=2.47 p =0.01	Optical>Off-bore
		% unacceptable	25.0%	0%		
12	Targeting Accuracy (50-100m)	median	4.0	6.0	Z=3.02 p =0.002	Optical>Off-bore
		% unacceptable	41.7%	0%		
13	Operating the system	median	6.0	6.5	Z=2.27 p =0.02	Optical>Off-bore
		% unacceptable	16.7%	0%		
14	Ability to Fight from Cover	median	6.0	5.5	Z=1.06 p =0.29	None
		% unacceptable	8.3%	0%		
15	Fire and Movement Mobility	median	5.0	6.0	Z=2.04 p =0.04	Optical>Off-bore
		% unacceptable	16.7%	0%		
16	Awareness of Enemy Positions	median	5.0	6.0	Z=1.33 p =0.02	Optical>Off-bore
		% unacceptable	25.0%	0%		
17	Awareness of Tactical Picture	median	5.5	6.0	Z=1.78 p =0.077100	None
		% unacceptable	16.7%	0%		
18	Ability to Engage Targets	median	5.0	6.0	Z=1.77 p =0.08	None
		% unacceptable	8.3%	0%		
19	Overall Survivability	median	5.5	6.0	Z=1.06 p =0.29	None
		% unacceptable	0%	0%		
20	Speed of Advance	median	5.0	6.5	Z=2.67 p =0.007	Optical>Off-bore
		% unacceptable	16.7%	0%		
21	Speed of Assault	median	5.0	6.5	Z=2.47 p =0.01	Optical>Off-bore
		% unacceptable	25.0%	0%		
22	Ease of Use	median	6.0	7.0	Z=2.04 p =0.04	Optical>Off-bore
		% unacceptable	16.7%	0%		



Table 5: Urban Attack Task Questionnaire Results (Cont)

		Off-bore	Optical	Z and p values	Significant Differences
23	Ease of Learning	median	6.0	Z=2.04 p=0.04	Optical>Off-bore
		% unacceptable	8.3%		
24	Tactical Feasibility	median	6.0	Z=1.58 p=0.11	None
		% unacceptable	16.7%		
25	General Situation Awareness During Use	median	5.0	Z=2.27 p=0.02	Optical>Off-bore
		% unacceptable	16.7%		
26	Confidence in System	median	6.0	Z=1.58 p=0.11	None
		% unacceptable	16.7%		
27	Overall Preference	median	5.0	Z=1.77 p=0.08	None
		% unacceptable	16.7%		

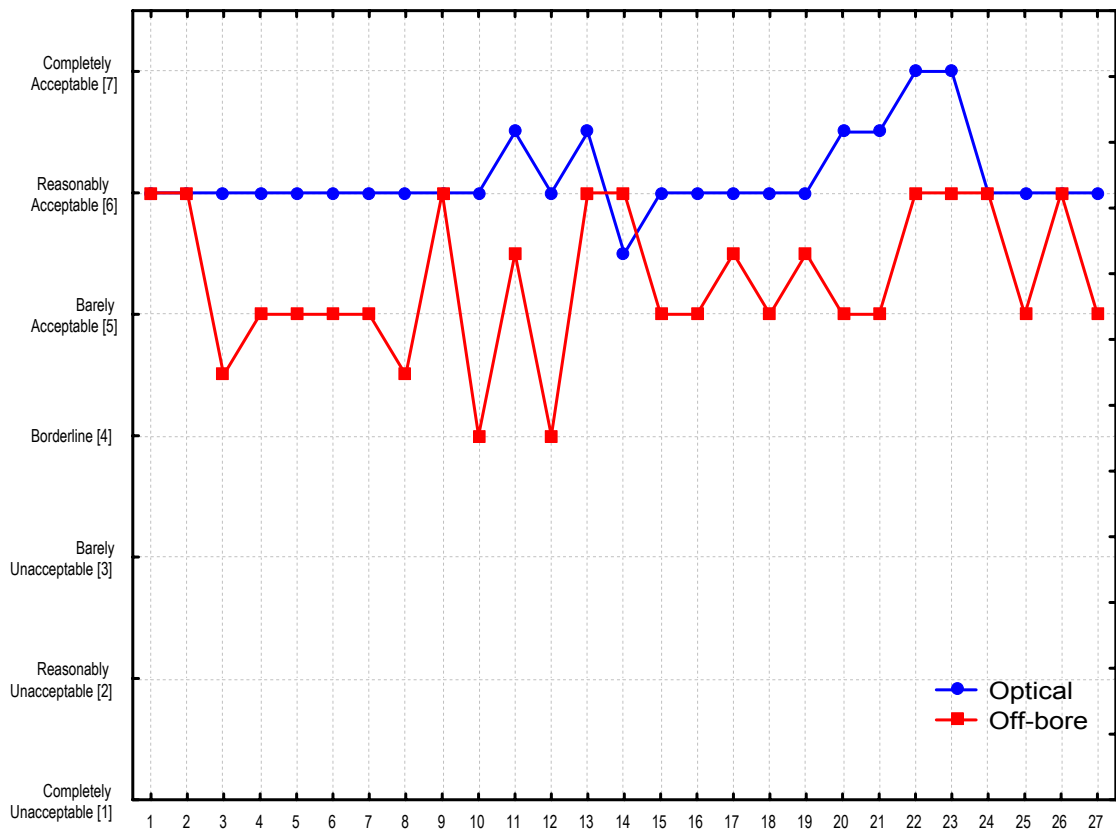


Figure 9: Task Questionnaire Results—Urban Attack



The optical sight was rated significantly more acceptable than the off-bore sight for the following questionnaire items:

- Observing from Cover (50-100m) (item #3),
- Speed of Advance (item #5),
- Awareness of Tactical Conditions (item #6) ,
- Identifying Targets (item #8),
- Targeting Speed (moving target) (item #10),
- Targeting Accuracy (0-50m) (item #11),
- Targeting Accuracy (50-100m) (item #12),
- Operating the System (item #13),
- Fire and Movement Mobility (item #15),
- Awareness of Enemy Positions (item #16),
- Speed of Advance (item #20),
- Speed of Assault (item #21),
- Ease of Use (item #22),
- Ease of Learning (item #23) and,
- General Situation Awareness During Use (item #25).

There were no questionnaire items where the off-bore sight was rated more acceptable than the in-service optical sight for urban attacks except for, “Ability to Fight from Cover” (item #14), and that difference was not statistically significant.

The off bore sight was rated unacceptable (less than 4 on the seven point scale) by more than 20% of participants for eight items:

- Observing from Cover (0-50m) (item #3),
- Detecting Targets (item #7),
- Identifying Targets (item #8),
- Targeting speed (moving target) (item #10),
- Targeting Accuracy (0-50m) (item #11),
- Targeting Accuracy (50-100m) (item #12),
- Awareness of Enemy Positions (item #16) and,
- Speed of Assault (item #21).

The optical sight had no questionnaire items rated unacceptable by more than 20% of participants for the urban attacks.



Trends in the graph in Figure 9 show that the off-bore sight tended to be rated less acceptable than the optical sight. However there were five items where they had the same median:

- Observing from Cover (CQB) (item #1),
- Observing from Cover (0-50m) (item #2),
- Targeting Speed (static target) (item#9),
- Tactical Feasibility (item #24) and,
- Confidence in System (item #26).

5.2 Urban Defence

This section presents results for the defending assault groups in urban missions. Participants used each system once in the urban defence and completed a task questionnaire after each urban defence mission. Participants rated the acceptability of the task questionnaire items using the seven-point acceptability scale in Figure 7.

Table 6 shows the results of a non-parametric sign test of task questionnaire results for urban defence missions. The median results are shown graphically in Figure 10.

Table 6: Urban Defence Task Questionnaire Results

			Off-bore	Optical	Z and p values	Significant Differences
1	Observing from Cover (CQB)	median	6.0	5.0	Z=2.00 p=0.04	Off-bore > Optical
		% unacceptable	8.3%	8.3%		
2	Observing from Cover (0-50m)	median	6.0	5.0	Z=1.06 p=0.29	None
		% unacceptable	8.3%	8.3%		
3	Observing from Cover (50-100m)	median	4.0	6.0	Z=1.21 p=0.23	None
		% unacceptable	8.3%	8.3%		
4	Confidence to move from Cover	median	5.0	6.0	Z=-0.32 p=0.75	None
		% unacceptable	8.3%	0%		
5	Awareness of Tactical Conditions	median	5.0	6.0	Z=2.00 p=0.04	Optical>Off-bore
		% unacceptable	8.3%	0%		
6	Detecting Targets	median	5.0	6.0	Z=0.95 p=0.34	None
		% unacceptable	8.3%	0%		
7	Identifying Targets	median	4.5	6.0	Z=1.33 p=0.18	None
		% unacceptable	25.0%	0%		
8	Targeting Speed (static target)	median	5.0	6.0	Z=2.02 p=0.04	Optical>Off-bore
		% unacceptable	16.7%	0%		



Table 6: Urban Defence Task Questionnaire Results (Cont)

			Off-bore	Optical	Z and P values	Significant Differences
9	Targeting Speed (moving target)	median	4.0	6.0	Z=2.02 p =0.04	Optical>Off-bore
		% unacceptable	16.7%	0%		
10	Targeting Accuracy (0-50m)	median	5.0	6.0	Z=1.58 p =0.11	None
		% unacceptable	16.7%	0%		
11	Targeting Accuracy (50-100m)	median	4.0	6.0	Z=2.02 p =0.04	Optical>Off-bore
		% unacceptable	41.7%	0%		
12	Operating the system	median	6.0	6.0	Z=894427 p =0.37	None
		% unacceptable	8.3%	0%		
13	Ability to Fight from Cover	median	6.0	5.0	Z=1.33 p =0.18	None
		% unacceptable	8.3%	8.3%		
14	Fire and Movement Mobility	median	5.0	6.0	Z=1.77 p =0.08	None
		% unacceptable	16.7%	0%		
15	Awareness of Enemy Positions	median	5.0	5.0	Z=0.35 p =0.72	None
		% unacceptable	8.3%	0%		
16	Ability to Keep Track of Enemy	median	4.5	6.0	Z=0.33 p =0.75	None
		% unacceptable	16.7%	0%		
17	Awareness of Tactical Picture	median	5.0	6.0	Z=1.06 p =0.29	None
		% unacceptable	16.7%	0%		
18	Ability to Engage Targets	median	5.0	6.0	Z=1.06 p =0.29	None
		% unacceptable	8.3%	0%		
19	Overall Survivability	median	5.5	5.5	Z=-0.35 p =0.72	None
		% unacceptable	0%	0%		
20	Capability in Defence (Urban)	median	6.0	5.5	Z=0.95 p =0.34	None
		% unacceptable	8.3%	0%		
21	Ease of Use	median	6.0	6.5	Z=1.50 p =0.13	None
		% unacceptable	0%	0%		
22	Ease of Learning	median	6.0	6.5	Z=2.04 p =0.04	Optical>Off-bore
		% unacceptable	0%	0%		
23	Tactical Feasibility	median	5.5	6.0	Z=1.06 p =0.29	None
		% unacceptable	8.3%	0%		



Table 6: Urban Defence Task Questionnaire Results (Cont)

		Off-bore	Optical	Z and P values	Significant Differences	
24	General Situation Awareness During Use	median	5.5	6.0	Z=1.22 p=0.22	None
		% unacceptable	16.7%	0%		
25	Confidence in System	median	5.0	6.0	Z=2.47 p=0.01	Optical>Off-bore
		% unacceptable	16.7%	0%		
26	Overall Preference	mean ± s.d.	6.0	6.0	Z=0.76 p=0.45	None
		median	16.7%	0%		

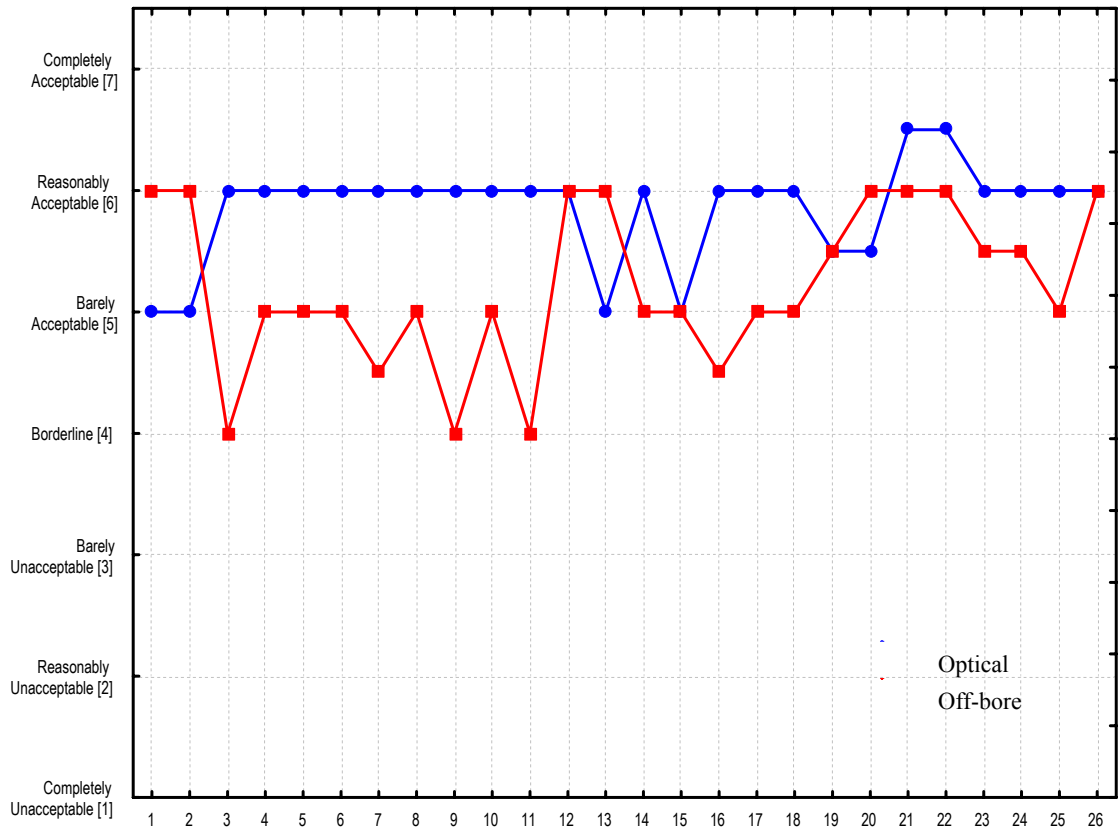


Figure 10: Task Questionnaire Results—Urban Defence



The optical sight was rated significantly more acceptable than the off-bore sight for

- Awareness of Tactical Conditions (item #5),
- Targeting Speed (static target) (item #8),
- Targeting Speed (moving target) (item #9),
- Targeting Accuracy (50-100m) (item #11),
- Ease of Learning (item #22) and,
- Confidence in System (item #25).

There was one item where the off-bore sight was rated significantly more acceptable than the optical sight for urban in-building defence.

- Observing from Cover (CQB) (item #1),

The optical sight had no questionnaire items rated unacceptable by more than 20% of participants for the urban attacks.

The off bore sight was rated unacceptable (less than 4 on the seven point scale) by more than 20% of participants for two items:

- Identifying Targets (item #7),
- Targeting Accuracy (50-100m) (item #11)

Trends in the graph in Figure 10 show the optical sight was generally rated slightly higher than the off-bore sight. However, most of those differences were not statistically significant.



5.3 Wooded Attack

This section presents results from participants in the attacking section in wooded missions. Since each participant used each system twice in a wooded attacking role, participants completed the task questionnaire only after their second wooded attack with each system. Participants rated the acceptability of the task questionnaire items using the seven-point acceptability scale in Figure 7.

Table 7 shows the results of a non-parametric sign test of task questionnaire results for wooded attack missions. The median results are shown graphically in Figure 11.

Table 7: Wooded Attack Task Questionnaire Results

			Off-bore	Optical	Z and p values	Significant Differences
1	Observing from Cover (CQB)	median	4.0	6.0	Z=2.00 p =0.04	Optical>Off-bore
		% unacceptable	33.3%	0%		
2	Observing from Cover (0-50m)	median	4.5	6.0	Z=2.85 p =0.004	Optical>Off-bore
		% unacceptable	41.6%	0%		
3	Observing from Cover (50-100m)	median	1.5	6.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	75.0%	0%		
4	Confidence to move from Cover	median	3.5	6.0	Z=2.85 p =0.004	Optical>Off-bore
		% unacceptable	50.0%	8.3%		
5	Speed of Advance	median	3.0	6.5	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	58.3%	0%		
6	Awareness of Tactical Conditions	median	4.0	7.0	Z=2.85 p =0.004	Optical>Off-bore
		% unacceptable	41.6%	8.3%		
7	Detecting Targets	median	2.0	6.5	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	75.0%	0%		
8	Identifying Targets	median	2.0	7.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	66.7%	0%		
9	Targeting Speed (static target)	median	2.5	6.5	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	83.3%	0%		
10	Targeting Speed (moving target)	median	2.0	6.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	100%	0%		
11	Targeting Accuracy (0-50m)	median	2.5	7.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	83.3%	0%		
12	Targeting Accuracy (50-100m)	median	2.0	7.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	91.7%	0%		



Table 7: Wooded Attack Task Questionnaire Results (Cont.)

		Off-bore	Optical	Z and p values	Significant Differences
13	Operating the system	median	4.0	Z=2.67 p =0.008	Optical>Off-bore
		% unacceptable	41.7%		
14	Ability to Fight from Cover	median	4.5	Z=1.44 p =0.15	None
		% unacceptable	8.3%		
15	Fire and Movement Mobility	median	3.5	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	50.0%		
16	Awareness of Enemy Positions	median	3.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	83.3%		
17	Awareness of Tactical Picture	median	4.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	41.7%		
18	Ability to Engage Targets	median	3.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	75.0%		
19	Overall Survivability	median	3.0	Z=2.67 p =0.008	Optical>Off-bore
		% unacceptable	75.0%		
20	Speed of Advance	median	3.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	75.0%		
21	Speed of Assault	median	3.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	75.0%		
22	Ease of Use	median	4.0	Z=2.84 p =0.004	Optical>Off-bore
		% unacceptable	41.7%		
23	Ease of Learning	median	5.0	Z=2.67 p =0.008	Optical>Off-bore
		% unacceptable	33.3%		
24	Tactical Feasibility	median	4.0	Z=2.84 p =0.004	Optical>Off-bore
		% unacceptable	50.0%		
25	General Situation Awareness During Use	median	2.5	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	58.3%		
26	Confidence in System	median	4.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	41.7%		
27	Overall Preference	median	3.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	58.3%		

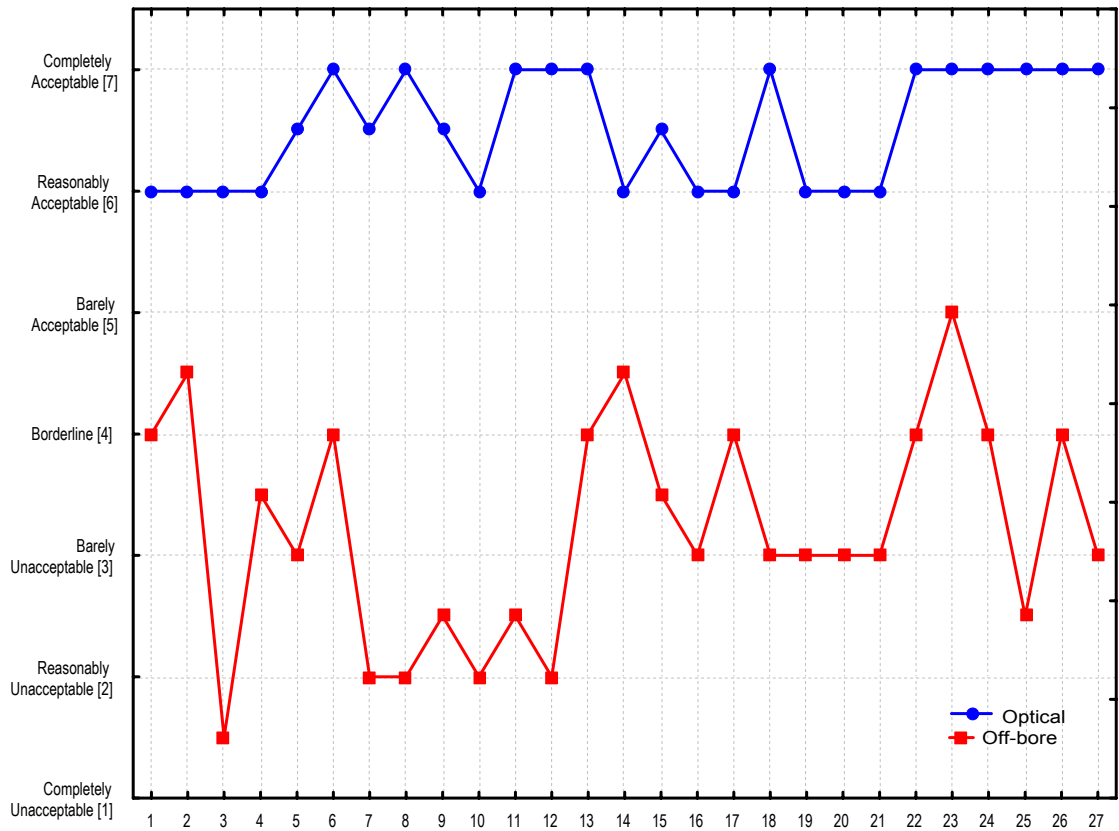


Figure 11: Task Questionnaire Results—Wooded Attack

The optical sight was rated significantly more acceptable than the off-bore sight for all questionnaire items except “Ability to Fight from Cover (item #14)” for the wooded attack.

Most mean ratings for the off-bore sight were “unacceptable”. The “Ability to Fight from Cover (item #14)” was also the only questionnaire item that was not rated unacceptable (i.e. less than 4 on the seven-point scale) by more than 20% of participants for the off-bore sight.

There were no questionnaire items where the optical sight was rated unacceptable by more than 20% of participants.

Trends in the graph in Figure 11 show that the off-bore sight was consistently rated lower than the optical sight and was especially unacceptable for “Observing from Cover (50-100m) (item #3)”.



5.4 Wooded Defence

This section presents results for the defending assault groups in wooded missions. Participants used each system once in the wooded defence and completed a task questionnaire after each wooded defence mission. Participants rated the acceptability of the task questionnaire items using the seven-point acceptability scale in Figure 7.

Table 8 shows the results of a non-parametric sign test of task questionnaire results for wooded defence missions. The results are shown graphically in Figure 12.

Table 8: Wooded Defence Task Questionnaire Results

			Off-bore	Optical	Z and p values	Significant Differences
1	Observing from Cover (CQB)	median	5.0	5.0	Z=0.00 p =1.00	None
		% unacceptable	25.0%	16.7%		
2	Observing from Cover (0-50m)	median	5.0	6.0	Z=2.00 p =0.04	Optical>Off-bore
		% unacceptable	33.3%	16.7%		
3	Observing from Cover (50-100m)	median	3.0	6.0	Z=2.85 p =0.004	Optical>Off-bore
		% unacceptable	66.7%	16.7%		
4	Confidence to move from Cover	median	3.5	6.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	50.0%	8.3%		
5	Awareness of Tactical Conditions	median	3.0	6.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	58.3%	0%		
6	Detecting Targets	median	3.0	6.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	58.3%	0%		
7	Identifying Targets	median	3.0	6.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	66.7%	0%		
8	Targeting Speed (static target)	median	3.0	6.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	58.3%	0%		
9	Targeting Speed (moving target)	median	2.5	6.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	58.3%	0%		
10	Targeting Accuracy (0-50m)	median	3.0	7.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	66.7%	0%		
11	Targeting Accuracy (50-100m)	median	2.5	7.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	58.3%	0%		



Table 8: Wooded Defence Task Questionnaire Results (Cont)

			Off-bore	Optical	Z and p values	Significant Differences
12	Operating the system	median	4.0	7.0	Z=2.85 p =0.04	Optical>Off-bore
		% unacceptable	33.3%	0%		
13	Ability to Fight from Cover	median	4.0	6.0	Z=1.06 p =0.29	None
		% unacceptable	41.7%	8.3%		
14	Fire and Movement Mobility	median	4.0	6.0	Z=2.85 p =0.04	Optical>Off-bore
		% unacceptable	33.3%	0%		
15	Awareness of Enemy Positions	median	2.5	6.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	58.3%	0%		
16	Ability to Keep Track of Enemy Movement	median	2.5	6.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	58.3%	0%		
17	Awareness of Tactical Picture	median	2.5	6.0	Z=3.18 p =0.001	Optical>Off-bore
		% unacceptable	58.3%	8.3%		
18	Ability to Engage Targets	median	3.5	6.0	Z=2.85 p =0.04	Optical>Off-bore
		% unacceptable	50.0%	0%		
19	Overall Survivability	median	3.0	6.0	Z=2.21 p =0.03	Optical>Off-bore
		% unacceptable	58.3%	0%		
20	Capability in Defence (wooded)	median	3.5	6.0	Z=2.85 p =0.04	Optical>Off-bore
		% unacceptable	50.0%	0%		
21	Ease of Use	median	4.5	6.5	Z=2.27 p =0.02	Optical>Off-bore
		% unacceptable	25.0%	0%		
22	Ease of Learning	median	5.5	7.0	Z=2.27 p =0.02	Optical>Off-bore
		% unacceptable	16.7%	0%		
23	Tactical Feasibility	median	3.5	6.0	Z=2.85 p =0.04	Optical>Off-bore
		% unacceptable	50.0%	0%		
24	General Situation Awareness During Use	median	3.0	6.0	Z=2.85 p =0.04	Optical>Off-bore
		% unacceptable	58.3%	0%		
25	Confidence in System	median	3.5	6.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	50.0%	0%		
26	Overall Preference	median	3.0	6.0	Z=3.02 p =0.003	Optical>Off-bore
		% unacceptable	58.3%	0%		

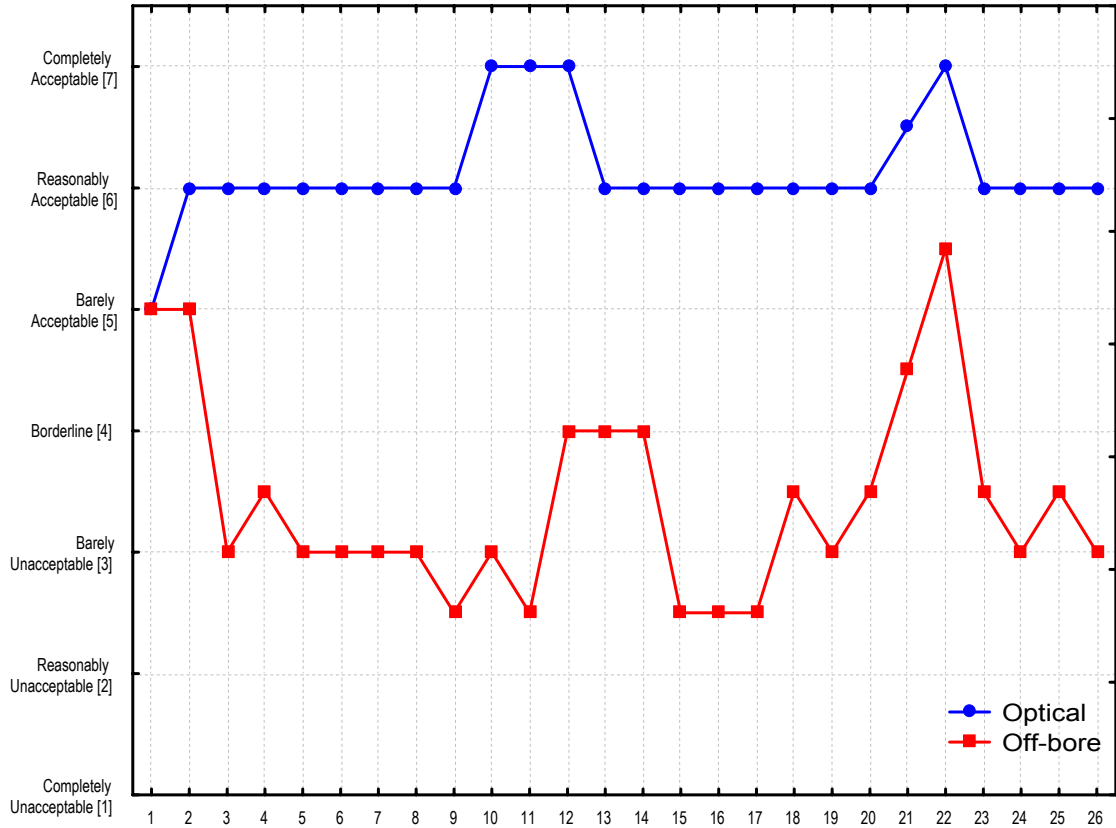


Figure 12: Task Questionnaire Results—Wooded Defence

The optical sight was rated significantly more acceptable than the off-bore sight for the wooded defence for all questionnaire items **except**:

- Observing from Cover (CQB) (item #1) and,
- Ability to Fight from Cover (item #13).

There were no questionnaire items where the off-bore sight **was not** rated unacceptable (i.e. less than 4 on the seven-point scale) by more than 20% of participants. Conversely, for the optical sight, there were no questionnaire items where the optical sight was rated unacceptable by more than 20%.

Trends in the graph in Figure 12 show that except in the case of fighting and observing from cover, the optical sight was consistently rated much higher than the off-bore sight.

5.5 Task Questionnaire Acceptability Summary

The results of the task questionnaire show that the off-bore weapon sight used in this experiment is unacceptable in many categories, while there were no questionnaire items where the optical sight was rated as unacceptable. Table 9 provides a summary of questionnaire items where the



mean questionnaire response was unacceptable (i.e. less than 4 on the seven-point scale) for the off-bore weapon sight.

Table 9: “Unacceptable” Questionnaire Ratings for Off-bore

	Wooded Attack	Wooded Defence	Urban Attack	Urban Defence
Observing from Cover (CQB)				
Observing from Cover (0-50m)	X			
Observing from Cover (50-100m)	X	X		
Confidence to move from Cover	X	X		
Speed of Advance	X	N/A		N/A
Awareness of Tactical Conditions	X	X		
Detecting Targets	X	X		
Identifying Targets	X	X		
Targeting Speed (static target)	X	X		
Targeting Speed (moving target)	X	X	X	
Targeting Accuracy (0-50m)	X	X		
Targeting Accuracy (50-100m)	X	X	X	X
Operating the system				
Ability to Fight from Cover				
Fire and Movement Mobility	X	X		
Awareness of Enemy Positions	X	X		
Ability to Keep track of Enemy Movement	X	X		
Awareness of Tactical Picture	X	X		
Ability to Engage Targets	X	X		
Overall Survivability	X	X		
Speed of Advance	X	N/A		N/A
Speed of Assault	X	N/A		N/A
Capability in Defence (urban)	X	X	N/A	
Capability in Defence (wooded)	N/A	N/A		
Ease of Use				
Ease of Learning				
Tactical Feasibility		X		
General Situation Awareness During Use	X	X		
Confidence in System	X	X		
Overall Preference	X	X		

X = off-bore condition received an “Unacceptable” mean rating (i.e. <4)



While in wooded missions, the off-bore sight was unacceptable for almost all items, while in urban attack missions it was unacceptable for only “Targeting Speed (moving target)” and “Targeting Accuracy (50-100m)”. For urban defence missions, it was unacceptable for “Targeting Accuracy (50m-100m) only. Comments from the focus group indicate that improvements to the camera resolution quality and field of view would make the off-bore system more acceptable for these areas.

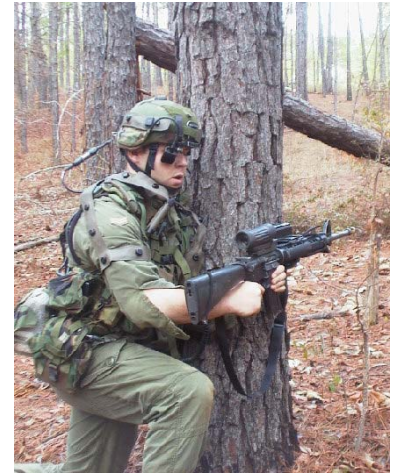
5.6 Focus Group

A focus group was held with all twelve soldiers. Overall, participants in the focus group felt that the C79 sight was an excellent device because it provided clear magnification for quick acquisition of targets and did not affect their field of view during target search. The soldiers trained constantly with the C79 sight, so they were very familiar with it. They also found it lightweight and easy to use as compared to the Land Warrior off-bore system. However, they acknowledged that the lack of ability to fire from cover without exposing their head and shoulders is a major disadvantage of the C79 sight, as compared to an off-bore system. The advantages and disadvantages of an off-bore system were discussed first for the wooded environment and then for the urban environment.



5.6.1 Wooded Terrain

When conducting an attack in the wooded environment, participants did not find the off-bore system to be effective. They felt they lost situation awareness while concentrating on the camera image, and found that their peripheral vision was greatly reduced. Using the off-bore system slowed down the speed of their advance and caused them to lose momentum. Their situation awareness was compromised by the attentional tunneling caused by the off-bore system and they were unable to keep track of the enemy or their own section members. They felt that they needed to get close to the enemy before using the off-bore system, and that the enemy could engage them before they got close enough. Participants also had difficulty with the wires becoming snagged and batteries becoming unplugged during the attack.



Once they had cover, participants felt that there was some use to the off-bore system. Some commented that it was better to have the off-bore system so that they could observe without exposing themselves to fire. However, even though they had cover, participants found it difficult to find targets using the off-bore system.

Participants in the defensive position in wooded terrain found it easier to use the off-bore system because their targets were moving. However, once the assaulting force stopped moving, participants found it almost impossible to find them using the off-bore camera. One participant commented that he noticed when a defending soldier had his off-bore camera pointing in one direction, the attacking force would watch the direction of the camera and charge to avoid the camera's eye. In the defence, participants felt they could engage target out to only about 20 to 50 metres in wooded terrain, even though they are trained to engage out to 300 metres.



Some problems with the off-bore system were related to the specific camera used, which participants commented had poor picture quality and resolution. They found they couldn't see anything further away than about 20 metres and it was almost impossible to detect targets in shaded areas or through smoke. Participants sometimes had to cover their eye with their hand to see the camera image in the sunlight. This required them to take their hand from their weapon, so they could not fire. As well, the size of the reticle in the off-bore camera display was about the size of a man at 70 metres. Therefore, any soldier targets near or beyond 70 metres were often obscured by the reticle marker itself.

The participants commented on problems with attentional tunnelling when using the off-bore camera system. However, others commented that this could be a problem when using the C79 scope as well. Participants felt that the off-bore sight also compromised hearing, because the user became consumed by the visual field, to a greater extent than with the C79 scope. Soldier had difficulty relating what they were seeing in their display to the sound field they were hearing



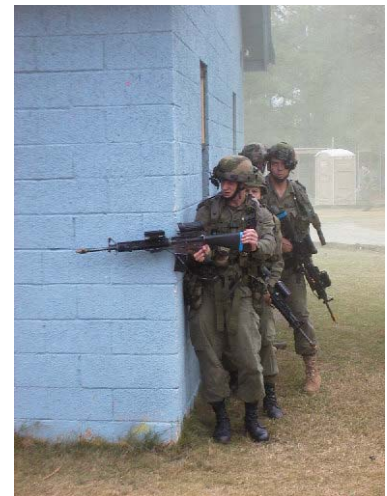
since the camera direction was usually very different to the orientation of the head. Additional training with the off-bore system may solve this problem.

Overall participants found the off-bore sight had some applications when under cover in the wooded terrain, however, it was not practical to use during the advance. If the camera quality was improved, participants indicated that the system would be more acceptable. Suggestions for improvement included: incorporating a laser range finder, adding the ability to zoom in and out, or using a fish-eye camera for a wider field of view.

5.6.2 Urban Terrain

When conducting attacks in an urban environment, participants commented that the off-bore system was excellent for use in and around buildings, but not effective when out in the urban streets. In the streets on the advance, participants felt that the off-bore system slowed down the advance and gave their position away to the enemy.

In buildings soldiers felt the off-bore system provided survivability and lethality in the close quarter battle. They felt that the ability to see down a hall or around a corner and target a threat without exposing their head was an excellent concept. The ability to engage longer-range targets was not seen as important for in-building missions because firing distances are typically less than 10 metres and each soldier's area of responsibility is smaller.



Participants felt they should use speed and aggression to get into a building, but once they have entered a building, they would be able to use stealth and caution with the off-bore sight to clear the building. This is when the participants felt an off-bore system would be the most useful. Without the off-bore camera, participants commented that they would spray bullets around a corner in order to kill any enemy there, but a booby trap may still exist. Using the off-bore camera could enable them to see a booby trap before entering the room.



Some participants didn't like the off-bore system because they felt it took too long to use and gave away their position to any hidden enemy. Since our infantry are trained to use speed and violence to clear a building, the change to a slower, more deliberate style was often disconcerting. Participants felt the head-mounted display on the Land Warrior system needed improvement because it moved around too much during the attack and the display was not readable in bright conditions. Participants found that the Land Warrior camera was too easily bumped off target during the mission. They expressed concerns that wires could become lost or break in situations where a replacement could not be quickly acquired.



The participants were asked how many members of the section should carry the off-bore system. Some participants felt only one or two per section were necessary. However, others felt that everyone in the section should have the capability, and only use it when necessary. Participants noted that if only two soldiers carried the system, you couldn't always be sure that they were in the best position to use it. Often the need for such a system would be dependant on the battle situation and the terrain. For example, the ability to have the lead soldier in a stack able to send a video image of a room to the rest of the stack prior to breaching or at a dangerous crossing could be beneficial but you can't always guarantee that the soldier with the off-bore system would be that lead.





5.7 Exit Questionnaire

For the Exit Questionnaire, participants rated their preference for either the optical or off-bore sight according to the scale shown in Figure 8. A t-test against a reference constant of zero was conducted to determine if any significant preference existed. The results were coded according to the scale as follows:

- -3 indicated a very strong preference for the optical sight,
- -2 indicated a strong preference for the optical sight,
- -1 indicated a slight preference for the optical sight,
- 0 indicated no preference between the optical and off-bore sights,
- 1 indicated a slight preference for the off-bore sight,
- 2 indicated a strong preference for the off-bore sight, and,
- 3 indicated a very strong preference for the off-bore sight,

Thus a difference from the zero reference constant on the negative side indicated a preference for the optical sight, while a difference on the positive side indicated a preference for the off-bore sight.

Participants completed the exit questionnaire twice, once for urban missions and once for wooded missions. The results are summarized in Table 10. Where there was a significant preference, the sight that was preferred is highlighted in the table.

Table 10: Exit Questionnaire Preference Results

	Wooded		Urban	
	Preference	t value and p-value	Preference	t value and p-value
Observing from Cover (CQB)	None	t=0.94 p=0.37	Off-bore	t=3.74 p=0.003
Observing from Cover (0-50m)	None	t=-0.15 p=0.88	Off-bore	t=3.31 p=0.006
Observing from Cover (50-100m)	Optical	t=-6.19 p<0.001	Optical	t=-2.23 p=0.04
Confidence to move from Cover	None	t=-0.69 p=0.50	None	t=0.63 p=0.54
Awareness of Tactical Conditions	None	t=-1.74 p=0.11	None	t=0.17 p=0.86



Table 10: Exit Questionnaire Preference Results (Cont.)

	Wooded		Urban	
	Preference	t value and p-value	Preference	t value and p-value
Detecting Targets	None	t=-1.74 p=0.11	None	t=-0.14 p=0.89
Identifying Targets	Optical	t=-4.15 p=0.001	None	t=-1.60 p=0.14
Targeting Speed (static target)	Optical	t=-3.50 p<0.001	None	t=-1.82 p=0.09
Targeting Speed (moving target)	Optical	t=-7.24 p<0.001	Optical	t=-4.71 p<0.001
Targeting Accuracy (0-50m)	Optical	t=-2.97 p=0.013	None	t=-1.00 p=0.34
Targeting Accuracy (50-100m)	Optical	t=-12.85 p<0.001	Optical	t=-5.70 p<0.001
Ease of Operating the system	Optical	t=-2.28 p=0.04	None	t=-1.61 p=0.14
Ability to Fight from Cover	None	t=1.66 p=0.13	Off-bore	t=3.63 p=0.003
Fire and Movement Mobility	Optical	t=-4.18 p=0.001	None	t=-0.46 p=0.65
Awareness of Enemy Positions	None	t=-1.78 p=0.10	None	t=0.71 p=0.49
Ability to Keep track of Enemy Movement	None	t=-1.96 p=0.07	None	t=-1.26 p=0.23
Awareness of Tactical Picture	None	t=-2.09 p=0.06	None	t=-0.19 p=0.85
Ability to Engage Targets	Optical	t=-2.20 p=0.04	None	t=0.42 p=0.68



Table 10: Exit Questionnaire Preference Results (Cont.)

	Wooded		Urban	
	Preference	t value and p-value	Preference	t value and p-value
Overall Survivability	None	t=-0.76 p=0.46	Off-bore	t=2.25 p=0.04
Speed of Advance	Optical	t=-4.08 p=0.001	Optical	t=-2.20 p=0.05
Speed of Assault	Optical	t=-4.08 p=0.001	Optical	t=-2.34 p=0.03
Capability in Defence (urban)	N/A	N/A	Off-bore	t=2.91603 p=0.01
Capability in Defence (wooded)	None	t=-0.68 p=0.51	N/A	N/A
Ease of Use	None	t=-1.25 p=0.23	None	t=-0.52 p=0.61
Ease of Learning	None	t=-1.40 p=0.19	None	t=-0.92 p=0.37
Tactical Feasibility	None	t=-1.02 p=0.33	None	t=0.81 p=0.44
General Situation Awareness During Use	Optical	t=-2.49 p=0.03	None	t=-0.74 p=0.47
Confidence in System	Optical	t=-2.35 p=0.04	None	t=-0.63 p=0.54
Overall Preference	Optical	t=-2.46 p=0.03	None	t=0.69 p=0.49

In **Wooded** terrain:

The **Optical Sight** was preferred for:

- Observing from Cover (50-100m)
- Identifying Targets
- Targeting Speed (static target)
- Targeting Speed (moving target)



- Targeting Accuracy (0-50m)
- Targeting Accuracy (50-100m)
- Ease of Operating the System
- Fire and Movement Mobility
- Ability to Engage Targets
- Speed of Advance
- Speed of Assault
- General Situation Awareness During Use
- Confidence in System
- Overall Preference

There were no items where the off-bore sight was preferred for wooded terrain.

In Urban terrain:

The **Optical Sight** was preferred for:

- Observing from Cover (50-100m)
- Targeting Speed (moving target)
- Targeting Accuracy (50-100m)
- Speed of Advance
- Speed of Assault

The **Off-bore Sight** was preferred for:

- Observing from Cover (CQB)
- Observing from Cover (0-50m)
- Ability to Fire from Cover
- Overall Survivability
- Capability in Defence



6. Discussion

This section presents a summary discussion of the results of this study, as well as suggestions for improvements to the off-bore system used, and recommendations for further research.

6.1 Summary Discussion

In its' current state, the example off-bore weapon system (U.S. Land Warrior ver 0.6) used for this experiment was judged to be significantly less acceptable than the current in-service C79 optical sight for speed and accuracy of detecting and engaging static and moving targets, local situation and battle awareness, speed of advance and assault, and maintenance of mission tempo. Perceptions were even more polarized in favour of the optical sight in wooded terrain where the off-bore system proved more difficult to use. The homogenous, organic nature of wooded terrain made it difficult for the soldier to establish and maintain a visual reference between the camera image and the actual terrain during observation and target search. The image quality of the system was insufficient for identifying camouflaged soldier targets in wooded terrain unless those targets physically moved while being observed.

Participants indicated that an off-bore system had its' greatest potential in urban terrain. An off-bore system was preferred over the optical sight for observing and fighting from cover at short ranges, particularly during close quarter battle in buildings. While building clearing tempo was slowed by the use of an off-bore system, participants believed that their survivability was improved in close quarters and danger crossing areas.

While the potential of off-bore systems was recognized for select applications, participants suggested that there was considerable room for technology improvement and further study to determine the best ways and means of deploying such a capability in combat.

6.2 Improvements to Off-bore System

The following improvements are recommended for the off-bore sighting system used in this experiment:

- **Improved camera quality:** Many of the problems with the off-bore system stemmed from the quality of the camera. The camera needs to have better resolution and a wider field of view.
- **Zoom mechanism:** Many participants indicated that a zoom mechanism that would allow them to alternate quickly between viewing near and far targets would improve the camera.
- **Laser range finder:** If a laser range finder were incorporated into the off-bore camera, it would improve the soldier's ability to judge the distance to his enemy.
- **Improved wiring:** Many participants commented that they experienced problems with wires snagging during the missions. An improved wiring system, or possibly a wireless system is recommended.



- **Smaller Reticule:** The reticule pattern in the camera was found to be too large. A smaller reticule pattern would allow for more precise targeting and easier viewing.
- **Night Vision:** Because many missions are conducted at night, a night vision camera is recommended as an option for the off-bore weapon sight.
- **Ability to switch from right to left:** Participants commented that when using the camera to look around corners, it was difficult to look around a left-handed corner if they were right-handed and sometimes had to operate the trigger with their thumb. The off-bore system should be designed to operate identically regardless of handedness and the angle of a corner.

The incorporation of an off-bore weapon sight would also require further training of soldiers for use in all types of missions.

6.3 Further Research

The following areas of further research in off-bore weapon sights are recommended:

- An investigation into the appropriate field of view and resolution for an off-bore camera.
- An investigation of a zoom-mechanism on an off-bore camera.
- An investigation of the use of off-bore cameras with night vision (both image intensification and thermal devices) for night missions.
- An investigation of how off-bore camera information should be presented to the soldier's eye. This should include an analysis of head-mounted displays as well as non-head-mounted options (e.g. a tablet display mounted on the soldier's webbing).
- An investigation of how off-bore weapon sights should be deployed within a section. We need to determine if this is a tool for every soldier to carry or perhaps could be issued to only some soldiers.

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