DRDC Toronto CR-2005-034

PRELIMINARY EVALUATION OF DISTRIBUTED SENSORS

by:
Harry A. Angel, and Paul G. S. Vilhena

Humansystems Incorporated
111 Farquhar St., 2nd Floor
Guelph, ON N1H 3N4

PWGSC Contract No. W7711-017747/001/TOR
Call-up No. 7747-16
HSI® SIREQ Item No. 94

On behalf of
DEPARTMENT OF NATIONAL DEFENCE

as represented by
Defence Research and Development Canada - Toronto
1133 Sheppard Avenue West
North York, Ontario, Canada
M3M 3B9

DRDC Toronto Scientific Authorities
LCol Linda Bossi
(416) 635-2197
Capt Jameel Adam
(416) 635-2138

May 2005

Abstract

The effects of adding enhanced vision and sighting sensors at the dismounted section and platoon level were evaluated in an 11-day field study at Fort Benning, Georgia over the period November 4 to 14 2002. A platoon of regular force infantry soldiers (3 Sections, platoon headquarters and C6 medium machine gun weapons detachment) conducted a series of section and platoon advance to contact and quick attack missions against a live enemy force. The effects of adding enhanced vision and different quantities and types of sighting systems at the team level were assessed using task performance (casualties), ammunition expenditure, engagement distance, and user acceptance metrics. Across all the attacks, the number of casualties inflicted by the enemy force varied from a high of 46.8% with the in-service equipment to a low of 19.2% with when all soldiers were issued with just monocular Night Vision Goggles (NVGs) and Laser Aiming Devices (LADs). Minor improvements in performance occur with the addition of dedicated thermal and Kite sights. The participants recommended that monocular NVGs with magnification and LADs should be issued to every member of the section and platoon. Furthermore, weapon mounted NVGs with magnification should replace the Kite Weapon sight at the section level. All of the participants agreed that there is a need for thermal sights at the platoon and section level. The participants also agreed that the minimum requirement was for one light-weight thermal weapon sight at the section level. Overall, the AN/PVS-14 NVG, Mini N/SEAS NVG, W1000 thermal weapon sight and AN/PAQ-4C LAD were rated as ready to "go to war". The AN/PAS-13B medium weight thermal weapon sight was rated as "not ready to go to war". Although the soldiers stated that thermal sights were required for scouts (or at least a scout) and the platoon commander, they believed that a high resolution thermal goggle or a fused thermal and Image Intensified (I^2) goggle may be the best way forward for dismounted platoons. Tactics techniques and procedures (TTPs) used in dismounted section and platoons will have to be modified to make optimum use of the novel sensor and universal vision systems.

Résumé

Les effets de l'addition de capteurs de vision améliorée et de visée au niveau de la section et du peloton à pied ont été évalués au cours d'une étude sur le terrain de 11 jours menée à Fort Benning, en Géorgie, durant la période du 4 au 14 novembre 2002. Un peloton de soldats d'infanterie de la Force régulière (3 sections, quartier général de peloton et détachement d'armes mitrailleuses moyennes C6) a effectué une série d'avancées de section et de peloton pour des missions de contact et d'attaque rapide contre une force ennemie réelle. Les effets de l'addition de capteurs de vision améliorée ainsi que de différentes quantités et de divers types de systèmes de visée au niveau des équipes ont été évalués à partir de mesures de la performance des tâches (nombre de victimes), de la consommation de munitions, de la distance d'engagement et de l'acceptation des utilisateurs. Sur l'ensemble des attaques, le nombre des victimes causées par la force ennemie variait du maximum de 46,8 % avec l'équipement en service au minimum de 19,2 % lorsque tous les soldats avaient été dotés seulement de lunettes de vision nocturne (LVN) monoculaires et de dispositifs de visée laser (DVL). On obtient de légères améliorations des performances en ajoutant des viseurs thermiques et Kite spécialisés. Les participants ont recommandé que chaque membre de la section et du peloton soit doté de LVN monoculaires à grossissement et de DVL. De plus, des LVN à grossissement montées sur arme devraient remplacer le viseur d'arme Kite au niveau de la section. Tous les participants ont souligné la nécessité de viseurs thermiques au niveau du peloton et de la section. Les participants ont également indiqué que chaque section avait besoin d'au moins un viseur d'arme thermique léger. Dans l'ensemble, on a jugé que les LVN AN/PVS-14, les LVN Mini N/SEAS, le viseur d'arme thermique W1000 et le DVL AN/PAQ-4C étaient « prêts à aller en guerre ». Le viseur d'arme thermique de poids moyen AN/PAS-13B n'a pas été considéré comme « prêt à aller en guerre ». En dépit de leur affirmation selon laquelle les éclaireurs (ou à tout le moins un éclaireur) et le commandant du peloton avaient besoin de viseurs thermiques, les soldats croyaient que des lunettes thermiques de haute résolution ou des lunettes combinées de type thermique à intensification d'image (I^2) constitueraient la meilleure solution pour les pelotons à pied. Les tactiques, techniques et procédures (TTP) utilisées dans les sections et pelotons à pied devront subir des modifications pour utiliser au mieux les nouveaux capteurs et systèmes de vision universelle.

Executive Summary

This experiment was done to support the Soldier Information REQuirements Technology Demonstration (SIREQ-TD) Project and the Land Forces Unit Surveillance, Target Acquisition and Night Observation (USTANO) program. The specific purpose of this preliminary study was to attempt to characterize collective performance with enhanced night vision sights and vision devices. The goal was to identify which mix of sensors at the section and platoon had the greatest impact.

An 11-day field study was undertaken at Fort Benning, Georgia over the period November 4 to 14 2002. A platoon of regular force infantry soldiers (3 Sections, platoon headquarters and C6 medium machine gun weapons detachment) and a four man enemy force were used in trial. The soldiers participated in simulated field missions at the section and platoon level during the night and once during the day. The effects of adding enhanced vision and sighting sensors at the team level were evaluated. Human factors (HF) measures assessed task performance (casualties), ammunition expenditure, engagement distance, user acceptance, etc. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

The main goal of this field trial was to assess the impact of equipping all of the dismounted platoon with monocular Night Vision Goggles (NVGs) and to assess the impact of adding Kite and thermal sights a at the section and platoon level. The sensor mixes assessed included the following:

Table i: Sensor Mix Options

	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Platoon Commander and Weapons Detachment	1x Maxi-Kite 2 x Biocular NVG 2 x LAD	1x Kite Weapon Sight 3 x Monocular NVGs 3 x LADs	2 x Thermal Weapon Sights 3 x Monocular NVGs 3 x LADs	2 x Thermal Weapon Sights 3 x Monocular NVGs 3 x LADs	2 x Thermal Weapon Sights 3 x Monocular NVGs 3 x LADs
Sections	2 x Biocular NVG 2 x LAD	8 x Monocular NVG 8 x LAD	2 x Kite Weapon Sight 8 x Monocular NVG 8 x LAD	2 Kite x Weapon sights 2 x Thermal Weapon Sights 8 x Monocular NVGs 8 x LAD	4 x Thermal Weapon Sights 8 x Monocular NVGs 8 x LADs

Significant improvements in performance were achieved when every soldier was issued a monocular NVG. Across all the attacks the number of casualties inflicted by the enemy force varied from a high of 46.8% with the in-service equipment in Mix 1 to a low of 19.2% with Mix 2. The losses associated with Mix 3 and 4 were approximately 20% while the losses associated with Mix 5 (night) was approximately 27%. During the day using thermal sights only, the overall number of casualties inflicted by the enemy force was approximately 20% against the Mix 5 equipped force. Caution is recommended in drawing conclusions that platoons and sections

equipped with the Mix 5 sensors performed poorer than when equipped with Mix 3 or 4 because Mix 5 had the lowest rate of ammunition expenditure and the estimated engagement distance was highest for Mix 5, suggesting better performance. The results do suggest that for advance to contact tasks a significant increase in performance occurs when all soldiers are issued with monocular NVGs and that minor improvements in performance if any, occur with the addition of dedicated thermal and Kite sights.

Nearly all of the soldiers recommended that the Land Forces should acquire a monocular NVG for every dismounted soldier. The monocular NVG should be designed such that it can be used with an afocal magnifier. The monocular NVG should be able to be used on a head, helmet or C7 weapon mount. During the exit focus group discussion the majority of the soldiers expressed the strong desire to have a Laser Aiming Device (LAD) with both a visible and an Infra Red (IR) laser. They stated the visible laser would be useful for close quarter battle and urban operations during the day and the IR laser would be useful for operations at night with NVGs. The soldiers also stated that there are a large number of occasions where a visible laser would act as a strong deterrent to hostile crowds and belligerents. All the soldiers involved in this trial did not believe USTANO should acquire any more Kite sights, nor were existing Kite sights needed at the section level if the section was equipped with NVGs and LADs.

All of the soldiers stated that thermal sights were required at the platoon level. The soldiers believed that scouts (or at least a scout) and the platoon commander should be issued with a thermal sight during advance to contact operations. The leaders strongly supported the notion of using thermal sights to identify enemy locations out of contacts, i.e. a switch from being reactive to proactive. The use of thermal sights allowed the section and platoon to manoeuvre out of contact to a position of tactical advantage. Although the soldiers stated that thermal sights were required for scouts (or at least a scout) and the platoon commander, they did not believe a dedicated thermal sight was the best way forward. The scouts preferred a thermal system that would allow them to scan continuously while on the move. Thus for the advance to contact phase of war, a high resolution thermal goggle or a fused thermal and I^2 goggle may be the best way forward for dismounted platoons.

In conclusion, the participants recommended that monocular NVGs with magnification and LADs should be issued to every member of the section and platoon. Furthermore, weapon mounted NVGs with magnification should replace the Kite Weapon sight at the section level. All of the participants agreed that there is a need for thermal sights at the platoon and section level. The participants also agreed that the minimum requirement was for one light-weight thermal weapon sight at the section level.

Overall, the AN/PVS-14 NVG, Mini N/SEAS NVG, W1000 thermal weapon sights and AN/PAQ-4C LAD were rated as ready to “go to war”. The AN/PAS-13B medium weight thermal weapon sight was rated as “not ready to go to war”.

Friendly forces also changed tactics and used scouts at both the section and platoon level. Tactics techniques and procedures (TTPs) will have to be modified to make optimum use of the novel sensor and universal vision systems.

Based on the results of this trial, further areas for research and investigation were recommended.

Sommaire

Cette expérience visait à soutenir les efforts de recherche déployés dans le cadre du projet SIREQ-TD (Projet de démonstration technologique des besoins des soldats en matière d'information) et du programme USTANO (Surveillance, acquisition d'objectif et observation nocturne (STANO) des unités). L'étude visait plus particulièrement la caractérisation des performances collectives obtenues au moyen de dispositifs de visée et de vision. Le but poursuivi était d'identifier quelle combinaison de capteurs avait la plus grande incidence au niveau de la section et du peloton.

Une étude sur le terrain de 11 jours a été menée à Fort Benning, en Géorgie, durant la période du 4 au 14 novembre 2002. Un peloton de soldats d'infanterie de la Force régulière (3 sections, quartier général de peloton et détachement d'armes mitrailleuses moyennes C6) et une force ennemie de quatre hommes ont joué un rôle dans l'étude. Les soldats ont pris part à des missions simulées sur le terrain au niveau de la section et du peloton, durant la nuit et une fois durant le jour. Les effets de l'addition de capteurs de vision améliorée et de visée ont été déterminés au niveau des équipes. Des mesures ergonomiques ont permis d'évaluer la performance des tâches (nombre de victimes), la consommation de munitions, la distance d'engagement, l'acceptation des utilisateurs, etc. La collecte des données s'est effectuée à l'aide de questionnaires, de groupes de consultation, de mesures de performances et d'évaluations ergonomiques par des observateurs.

L'essai sur le terrain visait principalement à évaluer l'impact de l'utilisation de lunettes de vision nocturne (LVN) monoculaires par tous les membres du peloton à pied et l'impact des viseurs Kite et thermiques dans la section et le peloton. Les ensembles évalués étaient les suivants :

	Ensemble 1	Ensemble 2	Ensemble 3	Ensemble 4	Ensemble 5
Commandant de peloton et détachement d'armes	1 Maxi-Kite 2 LVN bioculaires 2 DVL	1 viseur d'arme Kite 3 LVN monoculaires 3 DVL	2 viseurs d'arme thermiques 3 LVN monoculaires 3 DVL	2 viseurs d'arme thermiques 3 LVN monoculaires 3 DVL	2 viseurs d'arme thermiques 3 LVN monoculaires 3 DVL
Sections	2 LVN bioculaires 2 DVL	8 LVN monoculaires 8 DVL	2 viseurs d'arme Kite 8 LVN monoculaires 8 DVL	2 viseurs d'arme Kite 2 viseurs d'arme thermiques 8 LVN monoculaires 8 DVL	4 viseurs d'arme thermiques 8 LVN monoculaires 8 DVL

Les performances se sont améliorées de façon significative lorsque chaque soldat était doté de LVN monoculaires. Sur l'ensemble des attaques, le nombre des victimes causées par la force ennemie variait du maximum de 46,8 % avec l'équipement en service de l'ensemble 1 au minimum de 19,2 % avec l'ensemble 2. Les pertes ayant trait aux ensembles 3 et 4 atteignaient environ 20 %, et celles que produisait l'ensemble 5 (de nuit) s'élevaient à environ 27 %. Durant le jour, lorsque seuls les viseurs thermiques étaient utilisés, le nombre total de victimes causées par la force ennemie était d'environ

20 % par comparaison avec la force dotée de l'ensemble 5. Il est recommandé de faire preuve de prudence avant de conclure que les pelotons et les sections dotés des capteurs de l'ensemble 5 ont obtenu de moins bonnes performances qu'avec l'ensemble 3 ou 4, car les résultats semblent démontrer que, pour les tâches de marche à l'ennemi, les performances s'améliorent de façon significative lorsque tous les soldats sont dotés de LVN monoculaires et que des améliorations des performances mineures, voire nulles, résultent de l'addition de viseurs thermiques et Kite spécialisés.

Presque tous les soldats ont recommandé que les Forces terrestres fassent l'acquisition de LVN monoculaires pour chaque soldat à pied. Les LVN monoculaires devraient être conçues pour pouvoir s'utiliser avec un oculaire de grossissement afocal. Les LVN monoculaires devraient se monter sur la tête, sur un casque ou sur un adaptateur d'arme C7. Durant la discussion finale avec le groupe de consultation, la plupart des soldats ont exprimé le vif désir d'être dotés d'un dispositif de visée laser (DVL) à lasers visible et infrarouge (IR). Ils ont précisé que le laser visible serait utile pour les combats rapprochés et les opérations urbaines durant le jour et que le laser IR pourrait servir aux opérations de nuit avec LVN. Les soldats ont également précisé que, dans un grand nombre d'occasions, le laser visible représenterait un important moyen de dissuasion des foules hostiles et des belligérants. Aucun des soldats qui ont pris part à cette étude ne croyait qu'USTANO devrait acquérir d'autres viseurs Kite, ni que les viseurs Kite existants étaient nécessaires au niveau des sections, si celles-ci étaient dotées de LVN et de DVL.

Tous les soldats ont mentionné que des viseurs thermiques étaient nécessaires au niveau du peloton. Les soldats croyaient que les éclaireurs (ou à tout le moins un éclaireur) et le commandant du peloton devraient être dotés d'un viseur thermique pour les opérations de marche à l'ennemi. Les chefs ont insisté sur les avantages que présentent les viseurs thermiques pour la détermination des positions ennemies hors de contact, ce qui constitue un passage d'une attitude réactive à une attitude proactive. L'utilisation de viseurs thermiques permettait à la section et au peloton de manœuvrer hors de contact jusqu'à une position d'avantage tactique. En dépit de leur affirmation selon laquelle les éclaireurs (ou à tout le moins un éclaireur) et le commandant du peloton avaient besoin de viseurs thermiques, les soldats ne croyaient pas qu'un viseur thermique spécialisé constituerait la meilleure solution. Les éclaireurs préféraient un système thermique qui leur permettrait d'effectuer un balayage continu en cours de déplacement. Ainsi, pour la marche à l'ennemi, des lunettes thermiques de haute résolution ou des lunettes combinées de type thermique à intensification d'image (I^2) pourraient constituer la meilleure solution pour les pelotons à pied.

En conclusion, les participants ont recommandé que chaque membre de la section et du peloton soit doté de LVN monoculaires à grossissement et de DVL. De plus, des LVN à grossissement montées sur arme devraient remplacer le viseur d'arme Kite au niveau de la section. Tous les participants ont souligné la nécessité de viseurs thermiques au niveau du peloton et de la section. Les participants ont également indiqué que chaque section avait besoin d'au moins un viseur d'arme thermique léger.

Dans l'ensemble, on a jugé que les LVN AN/PVS-14, les LVN Mini N/SEAS, le viseur d'arme thermique W1000 et le DVL AN/PAQ-4C étaient « prêts à aller en guerre ». Le viseur d'arme thermique de poids moyen AN/PAS-13B n'a pas été considéré comme « prêt à aller en guerre ».

Les forces amies ont également changé de tactiques et utilisé des éclaireurs au niveau de la section et du peloton. Les tactiques, techniques et procédures (TTP) devront subir des modifications pour utiliser au mieux les nouveaux capteurs et systèmes de vision universelle.

D'après les résultats de cet essai, d'autres secteurs de recherche et d'étude ont été recommandés.

Table of Contents

List of Tables

List of Figures

1. Background

The SIREQ cognitive task analyses identified the ability to detect and engage enemy soldiers as critical requirements for mission success. In the day, soldiers currently use optical sights, binoculars or just their eyes for detecting and or engaging targets. At night soldiers currently use both Night Vision Goggles (NVGs) and their unaided eyes for detecting targets. The Canadian Land Force does not currently possess significant numbers of Laser Aiming Devices (LADs) for use with the NVGs nor does the Land Force have access to thermal weapon sights at the dismounted platoon level.

The current means of detecting and identifying partially hidden enemy soldiers during the day and at night is deficient. To overcome these current deficiencies in target detection and acquisition, most soldier modernization programs have adopted the use of thermal weapon sights and individually assigned night vision goggles as part of their hardware ensemble. The cost of thermal sensor systems is prohibitive for general issue to the Land Force, more over, thermal systems do not work well is some select temperature ranges and in the presence of precipitation. For the Unit Surveillance Target Acquisition and Night Observation (USTANO) Project the issue is one of balance in relation to needs, i.e. how any systems of what type should the dismounted section hold, hence this study.

What systems? Accepting the deficiencies in our current methods of target detection and recognition, the choice of sensors still raises a number of issues and opportunities for investigation. Image Intensified (I^2) sights and goggles have been in use with the Land Force for a number of years. These systems function by amplifying available star and moonlight. SIREQ has investigated a number of NVGs including the following:

AN/PVS-7 biocular NVG

AN/PVS-14 monocular NVG

ANVIS-9 binocular NVG

AN/AVS-502 binocular NVG

AN/PVS-504/A biocular NVG

Panoramic 95° FOV NVG

Panoramic 70° FOV NVG

Although a number of advantages and disadvantages have been identified with the various NVGs, the AN/PVS-14 monocular NVG and the ANVIS-9 binocular NVG in particular have generally performed better than the other NVGs. While the provision of ANVIS-9s or AN/PVS-14s would seem the best systems for addressing many of the individual night vision challenges within the Section, SIREQ needs to determine the overall nature of section requirements. In addition to night vision devices SIREQ has investigated a limited number of image intensified weapon sights. These sights are mounted on a weapon system and are frequently magnified. The utility of using dedicated weapon sights versus goggles and laser aimers has not been fully investigated to date.

The Land Force is currently investigating the benefits of assigning thermal sights to dismounted infantry sections and platoons. Thermal sights are currently found on Land Force main battle tanks, infantry carriers, anti-armour weapons and tripod mounted long range surveillance devices. These systems function by detecting the thermal radiation emitted by any object. SIREQ has investigated a limited number of thermal devices including the following:

Nytech Light-weight thermal weapon sight

Raytheon W1000 Uncooled thermal weapon sight

There are a number of commercially available thermal weapon sights on the market today and development efforts have focused on developing lightweight uncooled systems capable of being mounted on individual rifle rifles. The performance of in-service and state-of-the-art thermal systems has not been fully characterized. While thermal systems will out perform image intensified systems in most instances, there are known limitations of thermal sights. Thermal sights do not work well in precipitation or on hot days where the background temperature matches the target temperature. Although there are a large number of thermal sights on the market today there are few if any dedicated thermal vision goggles available. While some manufacturers have matched thermal sensors to head mounted displays most thermal sensing is done in a hand held camera system. While the provision of thermal sights would seem the best systems for addressing many of the individual day and night detection challenges within the section, SIREQ needs to determine the overall nature of Section requirements.

SIREQ needs to determine how the use of enhanced day and night vision affects detection, recognition, identification and engagement and how these effects relate to measures of mission outcome. For example, does the provision of thermal systems enhance individual and/or collective situation awareness, distract attention from other demands, increase mental workload, support key decisions, improve team coordination and execution, etc? If some or all of these process related effects are realized by the addition of enhanced vision systems, are these enhancements sufficiently large enough to increase the likelihood and degree of mission success (e.g. fewer errors in execution, faster mission execution, fewer friendly casualties, more enemy casualties, fewer resources expended, etc.)? It is likely that providing enhanced vision will improve some elements of individual and/or collective performance and detract from others and that some of these enhancements will improve some aspects of mission outcome. The questions are “which systems and why” and “which aspects of mission outcome and why”. With the answers to these questions to hand, a balanced judgement among various enhanced vision options can be made.

What section configurations? Another feature of enhanced that has not been investigated concerns the choice of the most effective distributed sensor configuration (i.e. who in the Section should get what?). A number of sub-unit configurations are possible. For example, all rifle members can have NVGs while the C9 gunners have thermal sights, or only the Section Commander (Sect. Comd) and Second in Command (2IC) have thermal sights or, all members have NVGs and thermal sights and so on. Across this continuum of distributed sensor configurations within the Section lie a number of issues. Does Section performance improve as more members are provided with enhanced vision? Although every mission is different, there should be an optimal sensor configuration for Section operations. Although SIREQ is not limited by fiscal constraints there are still operational and physical constraints. SIREQ needs to

investigate the effects of patterns and factors affecting section operations to determine this configuration.

What platoon configurations? Investigating enhanced vision among Platoon members, engaged in a mission scenario, can also provide useful insights into the different section roles (support detachment, rifle sections, etc.) By analyzing the Measures of Performance (MOPS) of individual members, sections and platoon elements in offensive operation it should be possible to distinguish the benefits of sensor mixes. This analysis would provide a better understanding of baseline sensor requirements within a platoon, for a given mission, and would further highlight the deficiencies with the current in-service intra-platoon capability. Mapping detection ranges, engagement ranges, number of enemy kills, number of own forces injured, rounds fired, etc would enable ready trade-off analysis of the benefits and drawbacks of different technological options.

Future investigations? This investigation provides a first step down the pathway of investigating these and other intra-platoon sensor mix issues by examining the performance of a platoon engaged in simulated missions using laser engagement devices in a field environment. This study will serve as an exploratory effort to gain better insight into intra-platoon sensor mix issues and measures. By starting with a pilot study in a controlled field environment to investigate and platoon performance, we will also be better able to identify areas for further experimentation and to develop and refine experimentation plans for further field testing.

2. Aim

The aim of this experiment was to examine the impact of various sensor mixes on the performance of dismounted infantry sections. The goals included:

Investigate the effects of NVGs and novel sights on the performance of dismounted infantry sections and platoons in the advance to contact phase of war.

Identify who should have what sight or NVG in the dismounted platoon for offensive operations.

3. Method

The following description provides a general overview of the experimental method. Further details are provided in subsequent sections. It should be noted that this experiment was conducted after the live fire range study detailed at Reference M.

3.1 Trial Participants

Twenty eight males and 1 female regular force soldiers volunteered for this experiment from the 1st Battalion, Royal Canadian Regiment (1RCR) in Petawawa, Ontario. The mean age of the participants was 26.4 years (SD= 5.9, max= 39, min= 19). The mean service in the regular forces was 4.8 years (SD= 5.3, max= 19, min= 1). The mean time since last Personal weapons Test (PWT) for the participants was 5.9 months (SD= 4.1, max= 13, min= 1). One-third of the participants wore glasses but none of the participants was colour blind. Twenty percent of the participants used their left eye to aim but only one participant was left-handed. All the participants had some experience with NVGs and NVDs as well as training experience in urban operations. Three-quarters of the participants had moderate operational experience with night vision goggles and night vision devices.

3.2 Materials

All participants were required to complete the target detection and engagement tasks using a variety of enhanced vision systems and weapon sights.

3.2.1 Sensor Mix Options

A number of sensor mix options were identified with staff officers from the USTANO Project and Operational Research offices. The platoon and section mixes are detailed below in Table 1:

Table 1: Sensor Mix Options

	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Platoon Commander and Weapons Detachment	1x Maxi-Kite 2 x Biocular NVG 2 x LAD	1x Kite Weapon Sight 3 x Monocular NVGs 3 x LADs	2 x Thermal Weapon Sights 3 x Monocular NVGs 3 x LADs	2 x Thermal Weapon Sights 3 x Monocular NVGs 3 x LADs	2 x Thermal Weapon Sights 3 x Monocular NVGs 3 x LADs
Sections	2 x Biocular NVG 2 x LAD	8 x Monocular NVG 8 x LAD	2 x Kite Weapon Sight 8 x Monocular NVG 8 x LAD	2 Kite x Weapon sights 2 x Thermal Weapon Sights 8 x Monocular NVGs 8 x LAD	4 x Thermal Weapon Sights 8 x Monocular NVGs 8 x LADs

3.2.2 Vision and Sight Systems

Two monocular NVGs and two LADs were used in this trial. The two monocular NVGs were used interchangeably while the two LAD systems were not. The AN/PAQ-4C was used with C7 and C9 weapons while the AN/PEQ-2A was only used with the C6 medium machine gun. The following seven systems were evaluated in the trial.

3.2.2.1 Monocular AN/PVS-14

The AN/PVS-14 is a lightweight, high performance passive third generation monocular image intensifier system - see Figure 1a and Figure 1b. The AN/PVS-14 is either worn on the head as a goggle system or attached to the soldier's rifle. The goggle assembly is a head-mounted self-contained night vision system containing one monocular unit consisting of an objective lens assembly, an image intensifier tube, a housing assembly, and a monocular eyepiece assembly. The housing is mounted to a facemask assembly that is held by head straps to the user's head. The assembly incorporates an infrared (IR) light source, which provides illumination, to permit close in viewing. Other features include automatic brightness control, bright source protection, low battery indicator and high-resolution unity F1.2 lens.

Figure 1a: AN/PVS-14

Figure 1b: Weapon mounted AN/PVS-14

The AN/PVS-14 has the following specifications:

Magnification Power	1 X
Intensifier Tube	Gen. III
System Gain	3000 l/ft
Field of View	40 degrees
Depth of field	20cm- to infinity
Interocular Adjustment	-6D to +2D
Power Source	2 AA
Weight	680grams

3.2.2.2 *Mini N/SEAS Mini Night Single Eye Acquisition Sight*

The Mini N/SEAS is a lightweight, high performance passive third generation monocular image intensifier system - see Figure 2a and Figure 2b. The Mini N/SEAS is either worn on the head as a goggle system or attached to the soldier's rifle. The housing is mounted to a facemask assembly that is held by head straps to the user's head. Features include automatic shutdown, IR Illuminator and low battery indicator.

Figure 2a and 2b: Mini N/SEAS

The Mini N/SEAS has the following specifications:

Magnification Power	1 X
Intensifier Tube	Gen. III
Field of View	40 degrees
Focus Range	25cm to infinity
Interocular Adjustment	-6D to +2D
Power Source	1 AA
Battery life	30 hours (Alkaline)
	60 hours (Lithium)
Weight	350 grams (with batteries)

It should be noted that only a few Mini N/SEAS were available for assessment purposes in this trial.

3.2.2.3 *AN/PAS-13B Thermal Weapon Sight*

The AN/PAS-13B Thermal Weapon Sight (TWS) is a medium weight thermal weapon sight system - see Figure 3. The sight assembly is a weapon mounted self-contained IR night vision system containing one monocular unit. The AN/PAS-13 has a standby mode until eye contact has been made with the eyecup.

The unit is waterproof to 20 meters. Under ideal conditions, the range of the Heavy TWS AN/PAS-13 exceeds 6900 meters; Medium TWS AN/PAS-13 exceeds 4200 meters.

Figure 3: HTWS AN/PAS-13 and MTWS AN/PAS-13

The Heavy and Medium TWS AN/PAS-13 sights have the following specifications:

Magnification NFOV	3.3X (Medium) and 10.0X (Heavy)
Magnification WFOV	1.66X (Medium) and 5.0X (Heavy)
Field of View WFOV	18 x 10.8 degrees (Medium) 9 x 5.4 degrees (Heavy)
Field of View NFOV	6 x 3.6 degrees (Medium) and 3 x 1.8 degrees (Heavy)
Maximum range man	1.5 km (Medium) and 2.8 km (Heavy)
Maximum range Vehicle	4.2 km (Medium) and 6.9 km (Heavy)
Power Source	DL-5347, BB-2847 or vehicle power
Battery life	7 hours (disposable lithium) 3.5 hours (Rechargeable)
Weight	<2.3 kg (Medium) and < 2.5 kg (Heavy) (include batteries)

It should be noted that only AN/PAS-13B or medium weight thermal sights were used in this investigation.

3.2.2.4 W1000 Uncooled Thermal Weapon Sight

The W1000 is a lightweight thermal weapon sight system - see Figure 4a and Figure 4b. The sight assembly is a weapon mounted self-contained IR night vision system containing one monocular unit. The W1000 has a standby mode until eye contact has been made with the eyecup.

Under ideal conditions, the range of the W1000 exceeds 2400 meters.

Figure 4a and 4b: Thermal Weapon Sight

The W1000 weapon sight has the following specifications:

Magnification	3.1X (W1000-9) 1.8X (W1000-15)
Field of View	9 x 6.75 degree (W1000-9) 15 x 11.25 degree (W1000-15)
Maximum range man	1 km (W1000-9) 0.6 km (W1000-15)
Maximum range Vehicle	2.4 km (W1000-9) 1.4 km (W1000-15)
Power Source	BB-2847 Lithium
Battery life	8 hours (Lithium ion)
Weight	<1.7 kg (W1000-9) and < 1.6 kg (W1000-15) (include batteries)

It should be noted that due to equipment shortages only the Platoon Commander used the W1000 sight in this investigation.

3.2.2.5 Kite (4X) and Maxi-Kite (6X)

The Kite and Maxi-Kite (4X and 6X) is a lightweight night vision weapon I^2 sight system- see Figure 6. The sight assembly is a weapon mounted self-contained image intensifier (I^2) night vision system.

Figure 5: Maxi-Kite and Kite

The Kite and Maxi-Kite 4X and 6X have the following specifications:

Magnification Power	4 X or 6X
Intensifier Tube	Gen. II(?)
Field of View	9.0 degrees (4X) 5.5 degrees (6X)
Focal Range	+15 m (4X) +25m (6X)
Interocular Adjustment	-6D to +2D
Power Source	2 AA
Weight	0.99 Kg (4X) (excluding batteries) 1.36 kg (6X)

3.2.2.6 AN/PAQ-4C IR Laser

The AN/PAQ-4C is an infrared LAD that attaches to the C7A1 rifle for night target engagement – see Figure 8. When the system is turned on it sends a steady infrared beam invisible to the naked eye along the C7A1's line of fire designating the point of impact on the target. The system utilizes a Class I laser (Helium-Neon) to generate the aiming point. The system marks targets out to a maximum range of 200-300 meters depending on the ambient light available.

The system weighs 9 ounces and is powered by either one lithium battery or two standard AA batteries. The characteristics of the laser are as follows:

Figure 6: AN/PAQ-4C

The AN/PAQ-4C has the following specifications:

Wavelength	830 nanometers
Power Output	0.7 Milliwatts (mW)
Range in Meters	1,000
Beam Width	0.3 milliradian (mR)
Beam Modulation	Steady

3.2.2.7 AN/PEQ-2 IR Laser

The AN/PEQ-2 is a dual laser LAD developed to allow a combination of both pinpoint aiming and broad beam target illumination – see Figure 10a and figure 10b. It was mounted to a weapon for operation. The AN/PEQ-2 is available in three models allowing for the selection of laser, infrared, or infrared/visible light illumination sources. Once mounted on a weapon, the lasers on the AN/PEQ-2 were easily and individually bore sighted using the independent azimuth and elevation adjustments. The unit is waterproof to 20 meters. Under ideal conditions, the range of the laser pointer exceeds 16 Kilometres.

Figure 7a and 7b: AN/PEQ-2

The AN/PEQ-2 has the following specifications:

Aiming IR Light	
Wavelength	830 nanometers
Power Output	25 Milliwatts (mW)
Range in Meters	>16,000
Beam Width (Divergence)	0.3 milliradian (mR)
Beam Modulation	Steady
Pointer/Illuminator	
Wavelength	830 nanometers
Power Output	30 Milliwatts (mW)
Range in Meters	>16,000
Spot Beam Width (Divergence)	0.3 milliradian (mR)
Flood Beam Width (Divergence)	>10 degrees
Beam Modulation	Steady
Weight	210 grams
Weight	5 ounces (with batteries)

3.2.3 Enemy Force

A live active enemy force participated in this study. During the section missions the enemy force consisted of at least one soldier with a C7 rifle and at most two soldiers. During the platoon mission the enemy force consisted of four soldiers equipped with3 x C7 rifles and one x C9 light machine gun.

3.2.4 Laser Engagement System

Force on force results were recorded using the SIMLAS laser assisted training system. The system consists of a "Laser-Unit", a "Master-Box" control unit recording combat information and serving as a chest sensor, a 360 degree helmet sensor plus arm sensors for each soldier. Shots fired on other soldiers are simulated as coded IR-laser beam by the laser unit and hits are recorded by the system. Laser beam signals are sent when blank rounds are fired from soldier weapons. If a soldier is hit and incapacitated, their weapon will not be able to fire laser signals. After each mission, the number of soldiers "killed" was recorded.

3.3 Experimental Design

An 11-day field study was undertaken at Fort Benning, Georgia over the period 4 to 14 November 2002. A Platoon of regular force infantry soldiers (three sections, platoon headquarters and a C6 medium machine gun weapons detachment) was required to participate in simulated field missions. Soldiers evaluated the assigned sensor mix as a member of an assault group, section

and in the platoon. The sensor mix assessed is detailed at Table 1. Baseline data on operational performance was collected as well as data on effects of adding enhanced vision sensors to dismounted infantry operations were collected. To evaluate the effects of providing enhanced vision- distributed sensors, a limited number of missions included the use of in-service equipment only while the majority was conducted with different mixes of sensors.

The effects of distributed sensors were evaluated at the fire team, section and platoon level in a progressive testing protocol. Platoons were dissolved so that participants assigned a particular sensor were first given the opportunity to gain experience on the sensor system at an individual level. Once an individual had mastered the new technology they were required to work in the context of their four-person assault group. Time was given for team training prior to progressing to section training. Once a section had gained some working experience with the assigned sensor mix they were assessed formally. Assessment included a number of simulated section attacks against a live enemy force (one or two-person trench). Upon completion of the section-level training and testing the platoon was reconstituted. Opportunity was given for platoon training and practice. The platoon was then assessed formally in a number of platoon level attacks against a four-man enemy force. Upon completion of the first mix assessment the soldiers were issued with new sensor mixes and the process was repeated

3.4 Independent Variables

During the 11 days of the study five different platoon sensor mixes were evaluated.

Analysis of variance, for sights/vision system was undertaken for all acceptability scale and performance results. Differences was identified at $p < 0.05$. The statistical plan for the target engagement experiment is as follows – see Table 2:

Table 2: Statistical Plan

Measure	Method	Analysis
Degree to which agree with Mission task Statements	Participative assessment by participant using the scale provided	Friedman ANOVA between: - Night vision systems

3.5 Dependent Variables

Data collection focused on the following HF requirements:

- Illumination/Luminance Assessment
- Visual Acuity and Contrast Sensitivity
- Casualties Sustained
- Ammunition usage
- Estimated engagement ranges
- Task Questionnaire
- Exit Questionnaire

3.5.1 Weather Conditions

The weapon sights and NVGs were evaluated during seasonal weather conditions at Fort Benning, Georgia. The weather conditions observed by the experimenters are described below in Table 3:

Table 3: Weather Conditions

Date night trial	Weather
November 05, 2002	Rain
November 06, 2002	Clear
November 07, 2002	Clear
November 10, 2002	Clear
November 12, 2002	Clear
November 13, 2002	Fog past 2330 hrs

3.5.2 Illuminance Assessment:

The testing was conducted during a period of starlight and for a short period of time, partial moonlight. Throughout each night of testing, ambient illuminance was measured with a set of photometers. Both unfiltered night sky radiation and radiation as defined in the Class A Night Vision Imaging system (NVIS) of MIL-L-85762A were measured with the Hoffman TSP-410 and a Hoffman ANV-410 illuminance meter. The Hoffman ANV-410 is filtered and calibrated to match the A response curve identified in MIL-L-85762A which is used in evaluating spectral radiance in the near infrared region utilized by Generation III night vision goggles. All measurements were taken at a point close to the center of the mission traces. The unfiltered (visible) illumination over the five evenings varied from a low of 0.3 milli-lux on the 5th of November at 2330 hrs to a high of 28.5 milli-lux on the 13th of November at 1930 hrs. The illumination as per the A NVIS varied from a low of 0.5 milli-lux on the 5th of November at 2330 hrs to a high of 41.5 milli-lux on the 13th of November at 1930 hrs. The average readings over the five nights are detailed below in Table 43.

Table 4: Illumination Assessments

Date			Illumination (mLux)
November 05, 2003	A NVIS	Mean	.297
		S.D.	NA
	Visible	Mean	.477
		S.D.	NA
November 06, 2003	A NVIS	Mean	1.4
		S.D.	0.1
	Visible	Mean	2.1
		S.D.	0.1
November 07, 2003	A NVIS	Mean	3.1
		S.D.	4.4
	Visible	Mean	3.7
		S.D.	4.0
November 10, 2003	A NVIS	Mean	6.5
		S.D.	8.9
	Visible	Mean	8.8
		S.D.	11.0
November 12 2002	A NVIS	Mean	13.1
		S.D.	8.7
	Visible	Mean	20.6
		S.D.	15.3
November 13 2002	A NVIS	Mean	30.3
		S.D.	9.1
	Visible	Mean	39.3
		S.D.	9.3

3.5.3 Visual Acuity and Contrast Sensitivity:

Prior to departing for the experiment, participants were screened for visual acuity and contrast sensitivity. A Snellen chart mounted on a well-lit office wall was used to test participants for visual acuity. Contrast sensitivity was assessed using the Contrast Sensitivity Test System. The DRDC-Toronto scientific authority conducted the initial screening.

During the night conditions with NVGs, the participant's visual acuity (smallest bar pattern) with each NVG system was measured using an ANV-20/20 night vision test device from Hoffman Engineering. Participants were screened to a minimum of 20/40 visual acuity with the NVG devices using a grid test pattern – see Figure 8a and 8b.

Figure 8a: ANV-20/20 NVD Infinity Focus System

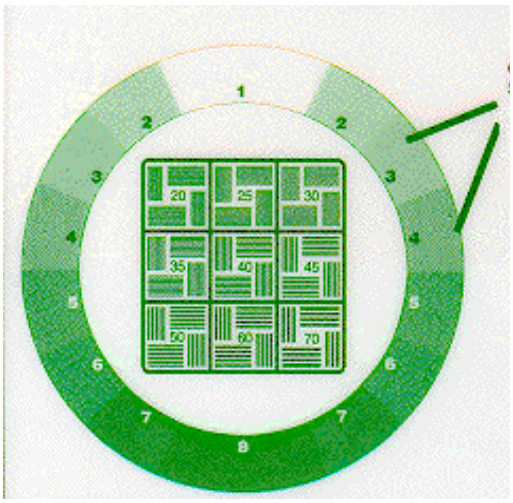

Figure 8b: ANV-20/20 Acuity Resolution Pattern

3.5.4 Casualties Sustained

Number of casualties inflicted on the assault force was recorded.

3.5.5 Ammunition Usage

Number of casualties inflicted on the assault force was recorded.

3.5.6 Estimated Engagement Distance

Number of casualties inflicted on the assault force was recorded.

3.5.7 Mission Mix Questionnaire

Participants were required to rate their overall agreement with a series of statements. The mission mix questionnaire is attached at Annex A.

3.5.8 Optimum Mix Exit Questionnaire

Participants were required to record optimum and minimum mix of NVGs, LADs, Illuminators and weapon sights for each of the different platoon and section positions. The optimum mix exit questionnaire is attached at Annex B.

3.5.9 Questionnaire Rating Scales

Participants rated acceptability in all questionnaires using the following seven-point scale (Figure 8).

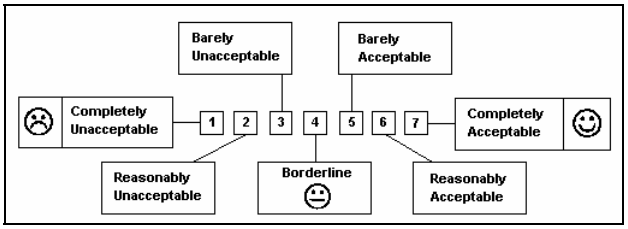

Figure 9: Standard Rating Scale

3.6 Procedures

The effects of distributed sensors were evaluated at the section and platoon level in a progressive testing protocol over the course of two nights per mix. On the first night soldiers were given the opportunity to practice at an individual, group, section and platoon level. On the second night assessment was conducted at the section and platoon level.

Participants assigned a particular sensor were first given the opportunity to gain experience on the sensor system at an individual level. Once an individual had mastered the new technology they were required to work in the context of their four-person assault group. Time was given for team training prior to progressing to section training. Once a section has gained some working experience with the assigned sensor mix they were assessed formally (on night two). Assessment included two assessed simulated section attacks against a live enemy force (one or two-person trench).

Upon completion of the section-level work-up training in night one, opportunity was then given for platoon training and practice. The platoon was then assessed formally in two platoon level attacks against a four- man enemy force on night two.

Upon completion of the first sensor mix assessment the soldiers were issued with new sensor mixes and the assessment process was repeated. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

3.6.1 Mission Descriptions

The missions used in the evaluation of team performance were goal-oriented, team-based in a contextually relevant small unit, infantry context, with functionally realistic environmental and terrain conditions. The experimental approach for each mission is outlined below, and aspects of the mission setup are described.

3.6.1.1 Sensor Mix Outline Approach

The experimental approach is described below for each of the briefing, execution, and debrief phases of the mission.

a) Briefing Phase: Prior to each mission the section or platoon received a hasty briefing by using a paper map of the mission terrain. Each briefing included:

- A command intent statement comprising the mission goal and the desired end state.
- The mission objective and the proposed approach routes

- Actions on contact, snipers, obstacles, etc.
- Timings necessary.
- Outline of known enemy locations and strength.

The sub-units were then given the opportunity to study the trace. Each platoon and or section commander then gave orders to his team as required.

b) Execution Phase: At the start of each mission, the live enemy force was positioned in the battle area. The sections and platoons were then positioned at their respective start points and the mission was started.

Each sub-unit was required to move and clear a suspected enemy position. Having manoeuvred to the objective, the sub-units were required to conduct a coordinated hasty attack on the objective. In most cases this required the participants to clear depth trenches by engaging and dispatching enemy soldiers as they are encountered, while being mindful of the likely location and status of the other sub-units.

An experimentation team member was assigned to work with each section or platoon element (weapons detachment).

c) Debrief Phase: Following the completion of the mission participants were required to complete several but brief questionnaires (i.e. teamwork questionnaire, sensor questionnaire) and participate in a short focus group. All mission outcome and laser engagement data were logged and archived for subsequent analyses.

3.6.1.2 Mission Trace

A number of traces were identified for this pilot. The ground was limited to open wooded and open country terrain. Traces were selected for the following features:

A network of approaches that could be used to reach a number of possible enemy positions for an assault. Each route was visually obstructed to ensure that the sister sections could not observe it other.

Sufficient complexity of terrain to ensure that soldier movement required monitoring, control, and coordination.

Adequate obstacles to enable the effective use of enemy forces during both the approach and the assault.

A number of possible start points on the ground to ensure that a mission could be repeated using a different approach and assault route for each test group.

Central administration and debriefing area with a number of potential traces radiating out, see Figure 10.

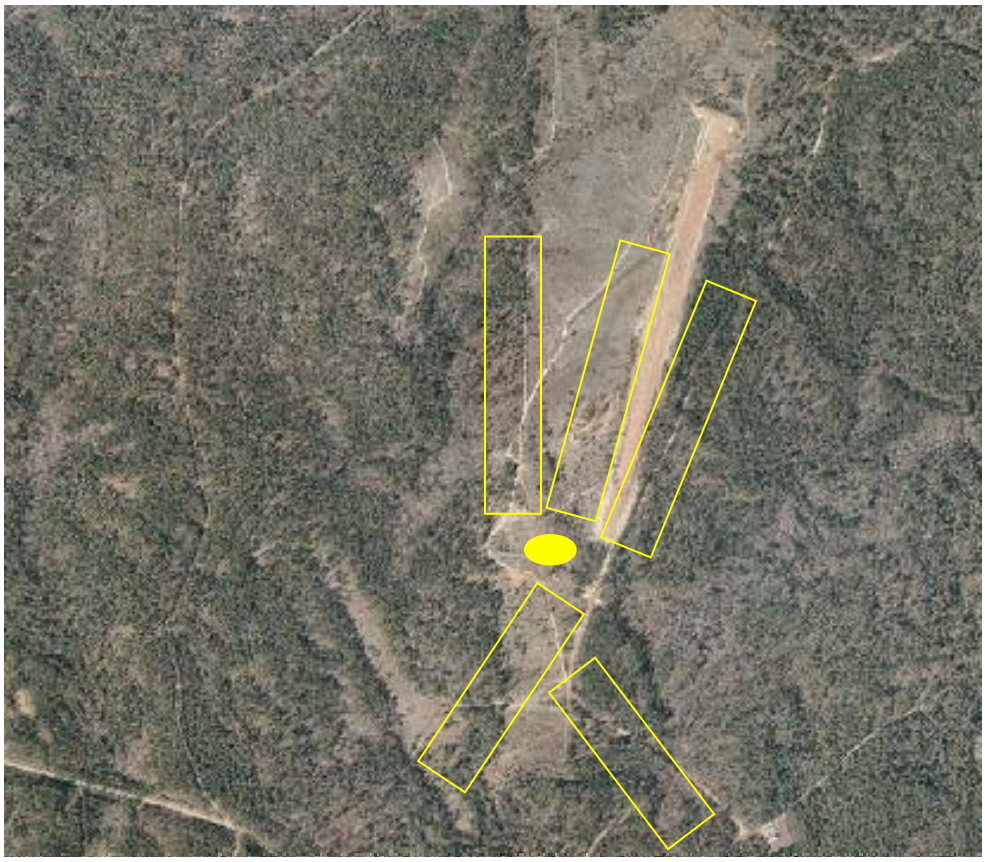

Figure 10: South West Fort Benning Manoeuvre Area

3.6.1.3 Enemy

A live enemy force was used to create a more challenging enemy that could anticipate and react to sub-unit actions, thereby requiring more concerted coordination of movement and fire.

3.6.1.4 Casualty Control

For this experiment live enemy and friendly soldiers were able to register hits on each other. The laser engagement system was configured such that any participant could be wounded or killed by any system. Upon completion of the mission "dead" participants were revived and their data was recorded.

3.7 Limitations

Due to equipment and time constraint issues, this trial had a number of limitations. Although the advance to contact / quick task was used to assess the effects of novel sensors on dismounted operations, only one phase of war was assessed. Therefore, the impact of these novel systems on peace support operations, MOUT operations, and in the defence could not be collected.

The participants' level of experience with the novel sensors was not optimal. Most had only received training on the sights and NVGs during the previous week's live fire range experiment (Reference M). The experimental protocol with a complete nights worth of training prior to assessment helped mitigate learning effects. The operational impact of the novel sensors also affected the tactics of the friendly and enemy forces. The enemy force learned to hide against both thermal and I^2 systems. Consequently, the difficulty of detecting the enemy increased though out the week. Friendly forces also changed tactics and used scouts at both the section and platoon level. Tactics Techniques and Procedures (TTPs) will have to be modified to make optimum use of the novel sensor and universal vision systems.

The lighting conditions for each night varied. Although the performance of the thermal systems was not affected by differences in illumination, the I^2 systems performed better when more ambient light was available. Only one sensor mix was tested in an evening, so sensor mixes tested with higher illumination should have had better performance than sensor mixes tested in lower illumination.

In order to train and test the individual sections and platoons, a variety of traces were developed. Although every effort was made to make the difficulty of the missions as equal as possible, the terrain and ground conditions varied with each trace. As a result the tactics employed by the leaders and the point of initial contact differed between sections. Consequently, the impact of mission difficulty could not be controlled completely.

The trial required a full eight- person section as enemy force for platoon attacks. Due to the limited number of troops available, only a four-man enemy force was used against the platoon attacks.

The trial used SIMLAS to collect data on casualties during each engagement. However, due to SIMLAS limitations:

- Only hits were registered (no wounds only kills are registered)
- Laser stopped by grass and smoke (limits cover fire)
- No beating zone for C9 and C6 (limits cover fire and effectiveness of machineguns)
- Equipment crashes (some participants could not be killed or could not kill during some engagements)
- Could not record cause of hit (who hit what?)
- Grenade affects are not recorded
- Ad hoc rail system for C9s was used
- SIMLAS did not function well with the C6

The limitations with the SIMLAS system thus created some uncertainty on the operational impact of utilizing novel night vision systems and sights. It was believed by leaders that section and platoon performance would be higher than that observed.

4. Results

Evaluation of different night vision systems was examined by analyzing the performance of platoon and section engagements, mission mix questionnaires and optimum mix exit questionnaires. The results of this study are organized as following:

- Casualties
- Ammunition Usage
- Estimated Engagement Ranges
- Mission Mix Questionnaire
- Optimum Mix Exit Questionnaire
- Focus Group

4.1 Casualty Results

The number of section level attacks (individual missions and platoon missions) varied from a low of six to a high of 12 per mix. Because each attack scenario was unique, the results for each mix condition were examined to identify any effects of leadership or task difficulty bias. It was noted that the results for Section Three in the Platoon attacks in Mix One were considerably different than the corresponding results of the other two sections in the same mixes. Thus the results for Three Section were removed from the mix one performance calculations. Across all the attacks the number of casualties inflicted by the enemy force varied from a high of 46.8% with the in-service equipment in Mix 1 to a low of 19.2% with Mix 2 – see Figure 12. The losses associated with Mix 3 and 4 were approximately 20% while the losses associated with Mix 5 (night) was approximately 27%. During the day the overall number of casualties inflicted by the enemy force was approximately 20% against the Mix 5 equipped force.

Approximately 46.8% of the soldiers (results included section one and two only) who participated in the Mix 1 or baseline missions became casualties in the section missions. The addition of monocular NVGs improved section performance and only 16.7 % of the section members became casualties. The addition of Kite sights at the section level did not improve section performance over the monocular condition (21.7%). The addition of a further two thermal sights at the section level (Mix 4) did not improve section performance (21.7% casualties) as compared to the Mix 2 condition. The addition of even more thermal sights at the section level (Mix 5) compromised performance and the casualty rate increased (30.4%). Section performance in the day was better than section performance at night (17.4% casualties as compared to 30.4%) – see Table 5. Approximately 49% of the soldiers who participated in the Mix 1 or baseline missions became casualties in the two platoon missions. When every soldier was equipped with a monocular NVG, the casualty rate dropped significantly to approximately 21.4% (Mix 2). The casualty rate increased to 21.3% in the Mix 3 condition where two Kite sights were added at the section level and two thermal sights were added at the platoon headquarters.

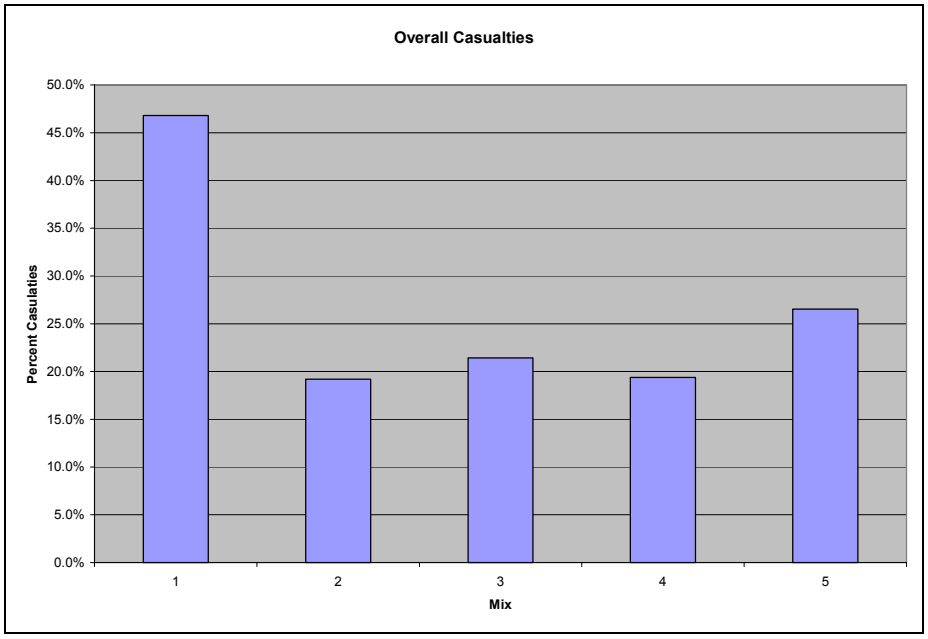

Figure 11: Casualties Results (Night)

The addition of two more thermal and Kite sights at the section level (Mix 4) slightly improved platoon performance (17.3% casualties) as compared to the all monocular NVG or Mix 2 condition. The addition of even more thermal sights at the section level (Mix 5) did not improve performance at the platoon level (casualty rate was 23.1%). Platoon performance in the day was similar to Platoon performance at night (21.1% casualties in the day as compared to 23.1% at night).

Table 5: Casualty Results

	Mix 1 (night)	Mix 2 (night)	Mix 3 (night)	Mix 4 (night)	Mix 5 (night)	Mix 5 (day)
Total # of Section Missions	4 (Section One and Two only)	6	6	6	3	3
Mean Section Casualties	40.6%	16.7%	21.7%	21.7%	29.1%	17.4%
Total # of Platoon Missions	2	2	2	2	1 (weather restricted testing)	2
Mean Platoon Casualties	48.6%	21.4%	21.2%	17.3%	23.1%	21.1%
Average # of Casualties	46.8%	19.2%	21.4%	19.4%	26.5%	20%

A significant improvement in performance was achieved when everyone in the platoon was issued an NVG. Even when soldiers were issued Kite sights many believed they could see better with the helmet mounted NVGs. The overwhelming acceptance of the monocular NVGs may be one of the reasons that section level performance did not improve with the addition of Kite or thermal sights. Once in contact soldiers preferred using their NVGs and lasers rather than relying on the heavier dedicated sights which hampered their mobility (soldiers could not move continuously while searching with dedicated sights). The very bulky and heavy (2.3kg) AN/PAS-13B medium weight thermal sights hampered riflemen performance. These sights were designed to work with support weapons and were not intended for use with a C7 rifle. Section performance in Mix 5 was compromised to some extent when half the section was equipped with these systems.

Once the enemy force had been exposed to the capabilities of the thermal sights they changed their tactics. During the training night for Mix 4 some enemy soldiers were observed and engaged at considerable distances (over 200m) by the advancing section thermal equipped riflemen. Once the enemy realized they were easily seen with the thermal sights they began to use folds in the ground, berms, logs etc. to hide behind. The enemy force remained hidden until they guessed the attacking force was in their kill zone. This change in tactics was particularly evident in the Mix 5 assessment and may have been a factor in the poorer section performance (as compared to Mix 4).

Overall, significantly more casualties were reported with Mix 1 (in-service) than with any other mix. Once everyone in the Platoon was issued an NVG the average number of overall casualties did not differ greatly (19.2 to 26.5%) between sensor mixes. Significantly, performance at night was comparable to performance in the day (average of 20% casualties).

In conclusion, low NVG capability or too much heavy thermal weapon sight (4 thermal sights) capability hampered both section and Platoon performance. The greatest increase in unit performance occurred after the soldiers were individually issued with NVGs.

4.2 Ammunition Expenditure

The number of rounds expended by the sections and platoons varied from a low of 30 rounds per C7 and 60 rounds per C9 and C6 in Mix 5 to a high of 50 rounds per C7 and 252 rounds per C6 and C9 during Mix 3 – see Table 6.

The number of rounds fired by an individual varied dramatically. During one mission in Mix 3 the C6 gunner fired over 400 rounds, while in another mission (Mix 5 –Day) the C6 gunner was a casualty at the beginning of the Platoon attack.

Table 6: Ammunition Expenditure Results

	Mix 1 (night)	Mix 2 (night)	Mix 3 (night)	Mix 4 (night)	Mix 5 (night)	Mix 5 (day)
Total # of Missions	4 Section (Section One and Two only) 2-Platoon	6 Section & 2 Platoon	6 Section & 2 Platoon	6 Section & 2 Platoon	3 Section & 1 Platoon	3 Section & 1 Platoon
Average # C7 rounds fired by a C7	40	43	50	39	30	46
Average # of linked rounds fired by a C9 or C6	126	132	252	108	60	150

A review of the ammunition expended results may suggest that soldiers were firing more aimed shots during the engagements in Mix 5 than other engagements and did not expend as much ammunition on suppressive fire.

4.3 Estimated Casualty Ranges

Upon completion of the attack, casualties were requested to pace the distance from where they were hit to the enemy's location. The estimated distance varied from a low of approximately 21m during the day for Mix 5 to a high of approximately 37m at night with Mix 5– see Table 7.

Table 7: Estimated Casualty Range Results

	Mix 1 (night)	Mix 2 (night)	Mix 3 (night)	Mix 4 (night)	Mix 5 (night)	Mix 5 (day)
Total # of Missions	4 Section (Section One and Two only) 2-Platoon	6 Section & 2 Platoon	6 Section & 2 Platoon	6 Section & 2 Platoon	3 Section & 1 Platoon	3 Section & 1 Platoon
Estimated Casualty Distance (mean)	25m	24m	24m	22m	37m	21m

Based upon the estimated distances, significantly longer range engagements occurred with Mix 5 at night compared to Mix 4 at night and Mix 5 during the day.

4.4 Mission Mix Questionnaire

Soldiers received a night of section and platoon training with their assigned sighting and NVG condition prior to a night of section and platoon testing. Each participant filled out a mission mix questionnaire at the end of each test run (every second night). The participants rated a number of task statements using a 7-point agree-disagree rating scale. The task statements varied from "My weapon sight/NVG helped me maintain proper formation and tactical spacing" to "The assigned weapon sight/NVG mix enhanced the overall performance of the Section. The Mix Task questionnaire is attached at Annex A.

4.4.1 Effect on Individual Performance

The mean ratings for 13 statements on the effect of C7 with no NVG, C7 with NVG, C7 with Kite sight, C7 with thermal weapon sight, C9 with no NVG and C9 with NVG on individual performance are detailed in Figure 12 and are tabulated in Annex C.

Overall, the participants slightly to completely agreed with all of the statements for the C7 with NVG, C7 with thermal weapon sight and with the C9 with NVG, i.e. the sighting/vision system improved individual performance. Conversely the participants slightly to completely disagreed with the statements for the C7 with no NVG and for the C9 with no NVG.

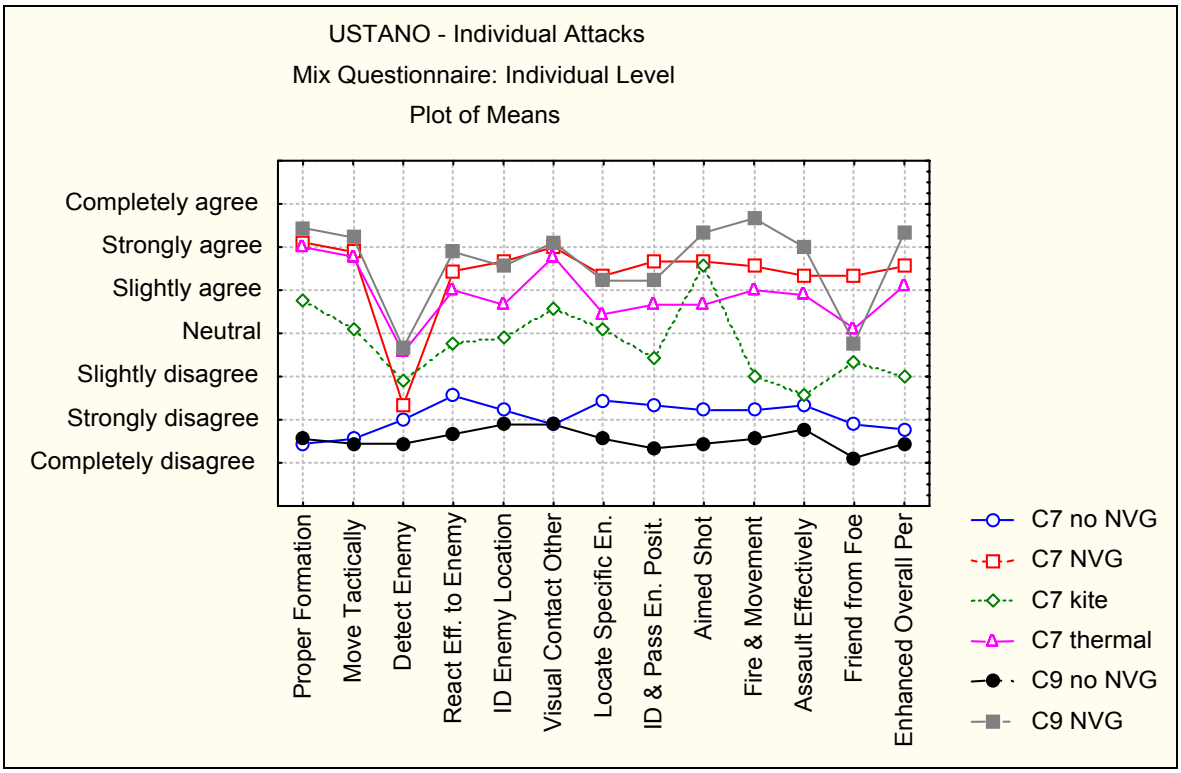

Figure 12: Mission Mix Questionnaire: Effects on Individual Performance

Across all the metrics, performance with individuals carrying the C7 with NVG, Kite or thermal sight was rated significantly better (higher acceptance) than with individuals carrying the C7 alone. The C9's with NVGs were rated significantly better than their unequipped counter parts.

The soldiers believed they could perform better with NVGs and thermal sights than without.

My weapon sight/NVG helped me maintain proper formation and tactical spacing

There was strong agreement by C7 & NVG users and C7 & thermal sight users that their sight combination helped them maintain proper formation and tactical spacing. There was strong to complete agreement with this statement by C9 & NVG users. There was complete to strong disagreement with this statement by C7 without NVG and C9 without NVG users. C7 with Kite sight users slightly agreed that the sight combination helped them maintain proper formation and tactical spacing.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 alone (Friedman $\chi^2(3, 32)=57.9$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=20.0$, $p<0.00$).

Significant improvements to individual spacing and proper formation keeping were attained with the use of NVGs or thermal sights. Although Kite sights improved individual performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement.

I could move tactically with my weapon sight/NVG.

There was strong agreement by C7 and thermal sight and C9 with NVG users that they could move tactically with their weapon sight combination. There was slight agreement with this statement by C7 with NVG and C7 with Kite users. There was strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 32)=46.9$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=20.0$, $p<0.00$).

Significant improvements to individual tactical movement were attained with the use of NVGs or sights. Although Kite sights and NVGs improved individual performance over the no NVG baseline, the use of thermal sights provided the highest degree of improvement.

My weapon sight/NVG allowed me to detect the enemy prior to their opening fire.

There was strong disagreement by the C7 without NVG and C9 without NVG users that the sight combination helped them to detect the enemy prior to their opening fire.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 32)=38.8$, $p<0.00$). The C7 with Thermals and Kites were also rated significantly better than the C7s with NVGs. The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=5.55$, $p<0.01$).

Negligible improvements to the detection of enemy force personnel were obtained with the use of NVGs or thermal sights. As stated earlier, significant learning effects were noted with the enemy force; they switched tactics to using cover from fire and did not rely upon cover from view prior to opening fire. That being said, NVGs or sights were better than the no NVG condition.

My weapon sight/NVG allowed me to react effectively to enemy fire.

There was slight to strong agreement by C7 and NVG, C& with Kite and C7 with thermal sight users that the sight combination helped them to react effectively to enemy fire. There was strong to complete agreement with this statement by C9 and NVG users. There was complete to slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 32) = 38.29$, $p < 0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20) = 15.2$, $p < 0.00$).

Significant improvements to an individual's ability to react to effective enemy fire were attained with the use of NVGs or sights (Friedman $\chi^2(3, 32)=38.29$, $p<0.00$. Although Kite sights improved individual performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement.

My weapon sight/NVG allowed me to identify the enemy's exact position

There was slight to strong agreement by C7 and NVG, C7 with Kite and C7 with thermal sight users that the sight combination helped them to identify the enemy's position. There was strong agreement with this statement by C9 and NVG users. There was strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 32) = 40.6$, $p < 0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 19) = 19.0$, $p < 0.00$).

Significant improvements to an individual's ability to identify the exact enemy's position were attained with the use of NVGs or sights. Although Kite sights improved individual performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement.

My weapon sight/NVG allowed me to keep in visual contact with other members of my assault group and sub-unit.

There was strong agreement by C7 and NVG, C7 with thermal sight and C9 with NVG users that the sight combination helped them to keep in visual contact with other members of their assault group and sub-unit. There was strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 32) = 53.5$, $p < 0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20) = 20.0$, $p < 0.00$).

Significant improvements to an individual's ability to remain in contact with his fire team and sub-group members were attained with the use of NVGs or sights. Although Kite sights improved individual performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement.

My weapon sight/NVG allowed me to locate specific enemy positions

There was slight agreement by C7 and NVG, C7 with Kite and C7 with thermal sight users that the sight combination helped them to locate specific enemy positions. There was strong agreement with this statement by C9 and NVG users. There was strong disagreement with this statement by

C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 32)=40.0$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=12.8$, $p<0.00$).

Significant improvements to an individual's ability to locate specific enemy positions were attained with the use of NVGs or sights. LADs greatly simplified the task of identifying enemy positions passed on by others. Although Kite sights improved individual performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement.

My weapon sight/NVG helped me to identify and to pass on specific enemy positions

There was slight agreement by C7 and NVG, C7 with Kite and C7 with thermal sight users that the sight combination helped them to identify and pass on specific enemy positions. There was slight to strong agreement with this statement by C9 and NVG users. There was strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 32)=41.5$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=14.22$, $p<0.00$).

Significant improvements to an individual's ability to identify and pass on specific enemy positions were attained with the use of NVGs or thermal sights. Although Kite sights improved individual performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement.

I could give aimed shots with my weapon sight/NVG

There was slight to strong agreement by C7 and NVG, C7 with Kite and C7 with thermal sight users that the sight combination allowed them to give aimed shots. There was strong agreement with this statement by C9 and NVG users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 29)=41.6$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=20.0$, $p<0.00$).

Significant improvements to an individual's ability to give aimed shots were attained with the use of NVGs or night sights.

I could conduct effective fire and movement with my weapon sight/NVG

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination helped them to conduct effective fire and movement. There was strong to complete agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kite users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs was rated significantly better (higher acceptance) than the C7 with the thermal sight. The C7 with NVGs and the C7 with thermal sight were rated significantly better (higher acceptance) than the C7 with the Kite sight.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 31)=30.9$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=20.0$, $p<0.00$).

Significant improvements to an individual's ability to conduct effective fire and movement were attained with the use of NVGs or thermal sights. Although Kite sights improved individual performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement.

I could assault effectively with my weapon sight/NVG.

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination allowed them to assault effectively. There was strong agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kite users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 31)=29.4$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=20.0$, $p<0.00$).

Significant improvements to an individual's ability to assault effectively were attained with the use of NVGs or thermal sights. Although Kite sights improved individual performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement.

My assigned weapon sight/NVG mix enhanced my ability to detect friend from foe (IFF).

There was slight agreement by C7 and NVG, C7 with Kite and C7 with thermal sight users that the sight combination enhanced their IFF ability. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 32)=36.6$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=8.9$, $p<0.00$).

Significant improvements to an individual's ability to identify friend from foe were attained with the use of NVGs or night sights.

My assigned weapon sight/NVG mix enhanced my overall performance

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination enhanced their overall performance. There was strong agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kite users. There was strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 31)=49.4$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 20)=16.2$, $p<0.00$).

Significant improvements to individual performance were attained with the use of NVGs or thermal sights. Although Kite sights improved individual performance over the no NVG baseline, the use of NVGs provided the highest degree of improvement.

4.4.2 Effect on Section Performance

The mean ratings for the 11 statements on the effect of C7 with no NVG, C7 with NVG, C7 with Kite sight, C7 with thermal weapon sight, C9 with no NVG and C9 with NVG on section performance are detailed in Figure 13.

Overall, the participants strongly agreed that the C7 with thermal sight and the C9 with NVG improved the section's performance. There was slight agreement that the C7 with NVGs or C7's with Kite sights improved section performance. Conversely the participants slightly disagreed that the C7 without an NVG improved section performance and strongly disagreed that an C9 without an NVG improved section performance.

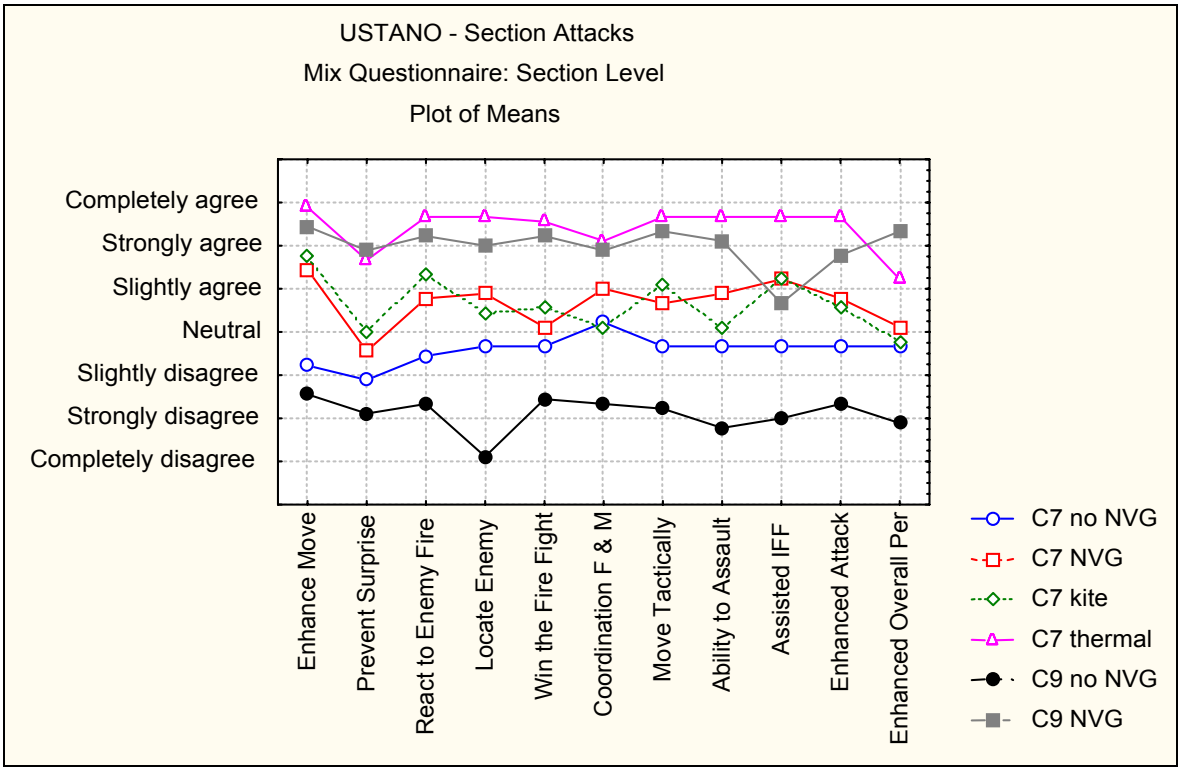

Figure 13: Mission Mix Questionnaire: Effects on Section Performance

Across all the metrics, section performance with individuals carrying the C7 with NVG, Kite or thermal sight was rated significantly better (higher acceptance) than with individuals carrying the C7 alone. The C9's with NVGs were rated significantly better than their unequipped counter parts.

The soldiers believed they could perform better with NVGs and thermal sights than without.

The assigned weapon sight/NVG mix enhanced the Section's ability to move tactically

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination enhanced the sections ability to move tactically. There was strong agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and

Kite users. There was strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 39)=64.0$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 24)=23.0$, $p<0.00$).

Significant improvements to the sections ability to move tactically were attained with the use of NVGs or thermal sights. Although Kite sights improved section performance over the no NVG baseline, the use of thermal sights provided the highest degree of improvement.

The assigned weapon sight/NVG mix prevented the Section from being surprised.

There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better (higher acceptance) than the C7 without an NVG (Friedman $\chi^2(3, 38)=27.5$, $p<0.00$). The C7 with Kite sights was rated significantly better (higher acceptance) than the C7 with NVG (Friedman $\chi^2(1, 47)=5.1$, $p<0.02$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 24)=14.7$, $p<0.00$).

Negligible improvements to the detection of enemy force personnel were obtained with the use of NVGs or thermal sights.

The assigned weapon sight/NVG mix allowed the Section to react effectively to enemy fire

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination helped the section to react effectively to enemy fire. There was strong agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kit users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better (higher acceptance) than the C7 without an NVG (Friedman $\chi^2(3, 36)=50.1$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 24)=20.2$, $p<0.00$).

Significant improvements to section performance reacting to effective enemy fire were attained with the use of NVGs or sights. Although Kite sights improved section performance over the no NVG baseline, the use of thermal sights provided the highest degree of improvement in section performance.

The assigned weapon sight/NVG mix enhanced the Section's ability to locate the enemy.

There was slight to strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination helped the sections ability to locate the enemy. There was strong agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kite users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better (higher acceptance) than the C7 without an NVG (Friedman $\chi^2(3, 21)=18.5$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 42)=36.1$, $p<0.00$).

Significant improvements to section performance locating the enemy were attained with the use of NVGs or sights. Although Kite sights improved section performance over the no NVG baseline, the use of thermal sights provided the highest degree of improvement in section performance.

The assigned weapon sight/NVG mix enhanced the Section's ability to win the fire fight

There was slight to strong agreement by C7 and NVG, C7 with Kite and C7 with thermal sight users that the sight enhanced the sections ability to win the fire fight. There was strong agreement with this statement by C9 and NVG users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better (higher acceptance) than the C7 without an NVG (Friedman $\chi^2(3, 36)=40.0$, $p<0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 24)=19.2$, $p<0.00$).

Significant improvements to section performance winning the fire fight were attained with the use of NVGs or sights. The use of NVGs provided the highest degree of improvement in section performance.

The assigned weapon sight/NVG mix enhanced the Section Commander's ability to coordinate Section fire and movement

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination enhanced the section commander's ability to coordinate section fire and movement. There was strong agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kite users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 31)=32.3$, $p<0.00$). The C7 with thermal sights were rated significantly better than the C7 with Kite sights (Friedman $\chi^2(1, 39)=5.1$, $p<0.02$). . The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 24)=23.0$, $p<0.00$).

Significant improvements to the section commander's ability to coordinate section fire and movement were attained with the use of NVGs or thermal sights. Although Kite sights improved section performance over the no NVG baseline, the use of thermal sights provided the highest degree of improvement in coordinated section performance.

The assigned weapon sight/NVG mix enhanced the Section's ability to move tactically in the approach.

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination enhanced the section's ability to move tactically during the approach. There was strong agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kite users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 38)=47.4$, $p<0.00$). The C7 with thermal sights were rated significantly better than the C7 with Kite sights (Friedman $\chi^2(1, 45)=4.0$, $p<0.05$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 24)=23.0$, $p<0.00$).

Significant improvements to the section's ability to move tactically in the approach were attained

with the use of NVGs or sights. Although Kite sights improved section performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement in section performance.

The assigned weapon sight/NVG mix enhanced the Section's ability to assault

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination enhanced the section's ability to assault. There was strong agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kite users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 34) = 44.3$, $p < 0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 23) = 23.0$, $p < 0.00$).

Significant improvements to the section's ability to assault were attained with the use of NVGs or sights. Although Kite sights improved section performance over the no NVG baseline, the use of NVGs or thermal sights provided the highest degree of improvement in section assault performance.

The assigned weapon sight/NVG mix assisted in IFF during the Section's assault.

There was slight agreement by C7 and NVG, C7 and Kite and C7 with thermal sight users that the sight combination assisted in IFF during the section's assault. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 39) = 47.8$, $p < 0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 24) = 12.8$, $p < 0.00$).

Significant improvements to the section's ability to identify friend from foe were attained with the use of NVGs or sights.

The assigned weapon sight/NVG mix enhanced the speed and efficiency at which we completed the Section attack.

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination enhanced the speed and efficiency at which the section completed the attack. There was strong agreement with this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kite users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better (higher acceptance) than the C7 without an NVG (Friedman $\chi^2(3, 37) = 48.6$, $p < 0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 24) = 20.2$, $p < 0.00$).

Significant improvements to the section attack speed and efficiency were attained with the use of NVGs or sights.

The assigned weapon sight/NVG mix enhanced the overall performance of the Section.

There was strong agreement by C7 and NVG and C7 with thermal sight users that the sight combination enhanced the overall performance of the section. There was strong agreement with

this statement by C9 and NVG users. There was slight agreement with this statement by C7 and Kite users. There was slight to strong disagreement with this statement by C7 without NVG and C9 without NVG users.

The C7 with NVGs, thermal or Kite sights were rated significantly better than the C7 without an NVG (Friedman $\chi^2(3, 42) = 49.1$, $p < 0.00$). The C9 with NVGs was rated significantly better than the C9 without an NVG (Friedman $\chi^2(1, 24) = 20.2$, $p < 0.00$).

Significant improvements to overall section performance were attained with the use of NVGs or sights. Although any night vision aid improved section performance over the no NVG baseline, the use of thermal sights provided the highest perceived degree of improvement in section performance.

4.5 Optimum Mix Exit Questionnaire

After exposure to the different night vision and sighting systems possible the soldiers completed an optimum mix exit questionnaire. Each participant recorded their opinion on to what NVGs, LADs, illuminators and weapon sights that should/must be issued at the platoon and section level.

4.5.1 Minimum Platoon Commander NVG/Sight Issue

The platoon commander believed that as a minimum, future platoon commanders should be issued a monocular NVG with a LAD. As well the platoon commander believed that future platoon commanders should be issued with a light-weight thermal sight. The need for a light-weight thermal sight at the platoon headquarters was supported by a minority of soldiers (9 of 29). The need for the platoon commander to have a Kite sight was not supported by any soldiers. Comments supporting the requirement included the following:

- Needed to see objectives and for planning.
- PL commander should have a thermal so he can locate the enemy and plan an effective assault.
- Should have a thermal so he can exercise max control on the mission/platoon.
- To control all thermals.
- When lead sect comes under contact pl commander can tell where all enemy positions are to help him decide if we will do a left/right flanking.
- At least 1 thermal is necessary.
- The platoon commander needs thermal to properly plan the assault.

During discussions with the platoon commander it became evident that he used his thermal sight as an observation device, detecting friendly and enemy positions, etc. The platoon commander rarely used his thermal system as a weapon sight. The platoon commander may have benefited more from a thermal goggle or fused thermal and I^2 goggle system rather than a weapon sight.

4.5.2 Minimum Platoon Warrant Officer NVG/Sight Issue

The platoon Warrant Officer believed that as a minimum future platoon Warrant Officers should just be issued a monocular NVG with a LAD. As well the platoon Warrant Officer did not believe there was a requirement for Kite or thermal sight. The need for a light-weight thermal sight by the platoon Warrant Officer was supported by a minority of soldiers (5 of 29). The need for the platoon Warrant Officer to have a Kite sight was supported by just one soldier. Comments supporting the requirement included the following:

- The PL 2ic has the minimum of movement after IFF, a thermal will not hamper him and aids in ID targets.
- Needs a thermal to see objectives and for planning. Fire base duties for switching fire left/right.
- Pl WO does not require a thermal as he will be co-located with weapons detachment or will be in depth.
- The platoon commander needs thermal to properly plan the assault.

4.5.3 Minimum Platoon Signaler NVG/Sight Issue

The participants believed that as a minimum future platoon signalers should just be issued a monocular NVG with a LAD. The soldiers believed that any further weight would compromise his ability to carry the Platoon Radio and their ability to keep up with the platoon commander. The need for the Platoon signaler to have a Kite or thermal sight was supported by just one soldier.

4.5.4 Minimum Platoon Weapons Detachment Commander NVG/Sight Issue

The participants believed that as a minimum future platoon weapons detachment commanders should be issued a monocular NVG with a LAD. The need for a light-weight thermal sight by the platoon weapons detachment commander was supported by a minority of soldiers (11 of 29). The need for the weapons detachment commander to have a Kite sight was supported by a minority of soldiers (4 of 29). Comments supporting the requirement included the following:

- Weapons detachment commander should have a thermal and a kite.
- Can laze the enemy for C6 gunner.
- Has to be able to show the gunners the targets.

4.5.5 Minimum C6 Gunner NVG/Sight Issue

The C6 gunner believed that as a minimum future C6 gunner should be issued a monocular NVG with a LAD. The C6 gunner did not believe there was requirement for other sights during advance to contact and quick attack operations. The C6 gunner commented that the NVG and PEQ-2A LAD combination was particularly effective. Kite and thermal sights were too heavy to use in the advance to contact.

4.5.6 Minimum C6 Loader NVG/Sight Issue

The participants believed that as a minimum, future C6 loaders should be issued a monocular NVG with a LAD. The participants also believed that there was no need for the C6 loader to have a light-weight thermal or Kite sight.

4.5.7 Minimum Section Commander NVG/Sight Issue

The section commanders believed that as a minimum, future section commanders should be issued a monocular NVG with a LAD. There was disagreement between the section commanders on the additional need for a thermal sight. The need for a light-weight thermal sight by the section commander was supported by a minority of soldiers (3 of 29). The need for the section commanders to have a Kite sight was supported by a few soldiers (2 of 29). Comments supporting the requirement included the following:

- Thermal is nice but not an necessity. One per section is an asset.
- Section commander should have thermal and kite.
- One thermal per section so either sect commander or 2IC should have one.
- The sect commander would give the sight to a scout of his designation.
- Section commander and 2IC to control a thermal.
- A thermal at the commander level in the sections would be ideal.
- No kites needed in section.

4.5.8 Minimum Section 2IC NVG/Sight Issue

The section 2ICs believed that as a minimum future 2Ics should be issued a monocular NVG with a LAD. There was disagreement between the section 2ICs on the additional need for a thermal sight. The need for a light-weight thermal sight by the 2ICs was supported by a few soldiers (2 of 29). The need for the 2IC to have a Kite sight was also supported by a few soldiers (2 of 29). Comments supporting the requirement included the following:

- Section 2IC also should have whatever extra kit that is available.
- The 2IC's sight would be backup for scout.
- C9 illuminates target plenty with tracers, no pointer needed.

4.5.9 Minimum #1 Rifleman NVG/Sight Issue

The participants believed that as minimum, future #1 Rifleman should be issued a monocular NVG with a LAD. It should be noted that during the team missions the number one riflemen were frequently used as scouts. The need for a light-weight thermal sight by the #1 Rifleman was supported by a minority of soldiers (5 of 29). The need for the #1 Rifleman to have a Kite sight was supported by a minority of soldiers (4 of 29). Comments supporting the requirement included the following:

- Employed as Scout.
- One thermal between the two scouts is lots.
- Everyone in section should have NVGs, and lads.
- If in a scout role, he needs a thermal.

4.5.10 Minimum #2 Rifleman NVG/Sight Issue

The participants believed that as a minimum, future #2 Riflemen should be issued a monocular NVG with a LAD. It should be noted that during the team missions number two riflemen were frequently used as scouts. The need for a light-weight thermal sight by the #2 Rifleman was supported by a minority of soldiers (4 of 29). The need for the #2 Rifleman to have a Kite sight was supported by a minority of soldiers (4 of 29). Comments supporting the requirement included the following:

- Employed as Scout.
- For use in reconnaissance and scouting.

4.5.11 Minimum #3 Rifleman NVG/Sight Issue

The participants believed that as minimum, future #3 Riflemen should be issued a monocular NVG with a LAD. The need for a light-weight thermal sight by the #3 Riflemen was supported by only one soldier (1 of 29). The need for the #3 Rifleman to have a Kite sight was supported by a minority of soldiers (3 of 29). Comments supporting the requirement included the following:

- You need two riflemen that are not weighted down with kit so that they can be able to assault without hassle.
- Night vision scope should have a reticule pattern for the M203 as well as the C7.

4.5.12 Minimum #4 Rifleman NVG/Sight Issue

The participants believed that as minimum, future #4 Riflemen should be issued a monocular NVG with a LAD. The need for a light-weight thermal sight by the #4 Riflemen was not supported any soldiers. The need for the #4 Rifleman to have a Kite sight was supported by a minority of soldiers (2of 29). Comments supporting the requirement included the following:

- Scope should be about 4x power and have reticule patterns available for both M203 and C7.

4.5.13 Minimum #1 C9 NVG/Sight Issue

The #1 C9 gunners believed that as a minimum, future C9 gunners should be issued a monocular NVG with a LAD. The C9 gunners did not believe there was a need of any additional thermal or Kite sights when performing advance to contact or quick attacks. The need for a light-weight thermal sight by #1 C9 gunner was only supported by one soldier. The need for the #1 C9 gunner

to have a Kite sight was not supported by any soldiers. Comments supporting the requirement included the following:

- The gun with all the ammo is heavy enough without a big, bulky sight.
- C9s with maxi kite or w1000 would be ideal to allow it to fire out to max range.
- C9 illuminates target plenty with tracers, no pointer needed.

4.5.14 Minimum #2 C9 NVG/Sight Issue

The C9 gunners believed that as a minimum, future C9 gunners should be issued a monocular NVG with a LAD. The C9 gunners did not believe there was a need of any additional thermal or Kite sights when performing advance to contact or quick attacks. The need for the #2 C9 gunner to have a Kite sight was not supported by any soldiers.

4.6 Focus Group

The exit focus group occurred after this trial at the McKenna MOUT site, on November 15, 2002. Therefore, the discussion took place after most subjects had exposure to the different NVG & LAD, Kite and thermal systems. A summary of the comments made by the participants during the focus group discussion are presented below.

AN/PVS-14 Night Vision Goggle

Nearly all of the participants (28 of 29) believed the monocular AN/PVS-14 NVG was superior to the in-service AN/PVS-504A biocular NVG. Although the AN/PVs-14 was rated by the participants (28 of 29) as ready for immediate operations, a number of issues were raised. A number of soldiers (11 of 29) complained that the NVG came off the helmet mount. Of the 11 soldiers, six reported that the NVG fell off more than once in the trial. The majority of the soldiers (26 of 29) complained of excessive movement with the NVG, they found the NVG-mount system to have too much play. Similarly, 25 of 29 subjects reported problems with the NVG shutting off accidentally as they performed rapid field movements (dashing to cover, etc.) It is believed that the NVG auto shut-off mechanism was working too well when the NVG was jarred (AN/PVS-14 shuts-off when users flip the NVG up out of the way). Every soldier complained of fogging problems and the use of anti-fogging wipes or spray did not solve this problem. Unfortunately demisting shields were not available for issue in this trial. A significant number of soldiers (12 of 29) accidentally turned on their IR illuminator during their combat missions. This illumination would compromised the stealth and position of a platoon or section if a real enemy had even second generation NVGs. The soldiers all agreed that a better illumination lock out device was needed to prevent accidental discharge. A number of minor problems were reported with the durability of the plastic mounting bracket and the AN/PVS-14's battery cap. Concern was raised as to their suitability during winter operations. A number of soldiers questioned the utility of the lens cap/goggle retention cord. Many felt the lens cap should be attached or connected at the front of the goggle. Eight of the soldiers commented that they would cut off the retention cords if this NVG was issued to them. The majority (25 of 29) of the soldiers stated that

they could wear the AN/PVS-14 at the same time as they used the Kite sight. Conversely none of the soldiers could wear the AN/PVS-14 when they used the weight thermal sight. One soldier commented that after having identified the enemy position with his NVGs he lost orientation and could not pick up the enemy with his Kite sight. A number of other soldiers reported that they relied on their NVGs once in contact.

Mini N/SEAS Night Vision Goggle

Although the majority of soldiers used the AN/PVS-14 as their NVG, a small number of monocular Mini N/SEAS NVGs were available for assessment. The subjects who used the Mini N/SEAS and the AN/PVS-14 commented that they believed the Mini N/SEAS were superior to the AN/PVS 14 NVG. The participants considered the mounting system (Metal) and ease of adjustability (one control for all adjustment) as superior to the AN/PVS 14 NVG.

AN/PAQ-4C Laser Aiming Device

Although all of the participants (29 of 29) believed the AN/PAQ-4C Laser Aiming Device LAD was ready for immediate operations, concerns were raised over the frequent accidental activation of the laser during the advance to contact. Soldiers frequently fired their laser as they manoeuvred through the bush, adopted fire positions, etc. The Platoon leadership discussed the need for new SOPs to ensure that negligent laser discharges didn't occur (laser off until contact) or the use of a pressure switch trigger guard. A number of other issues were raised with the pressure switch and the bulk of the LAD system. Two soldiers reported that their pressure switch was intermittent and a number of other soldiers believed the AN/PAQ-4C was still too bulky. Two soldiers commented that the laser was too bright for the engagement distances witnessed in these trials. All of the soldiers reported that the AN/PAQ-4C remained secure on the new C7 triad mount.

AN/PEQ-2A Laser Aiming Device

The C7 gunner utilized the AN/PEQ-2A LAD with a reticule generation cover. The C6 gunner believed the AN/PEQ-2A was superior to the AN/PAQ-4C for use with the C6 MMG. Although the Platoon leadership believed in the use of reticule patterns for indicating enemy positions, arcs, etc. the engagement distances in this set of trials was too short to see obvious benefit.

Kite Image Intensified Night Sight

All the participants stated that the Kite sight was only suitable for defensive tasks. The sight was too heavy and bulky to use in advance to contact or in recce patrols. A significant number of participants that used the Kite sight (19) commented on problems with the Kite sight's eyepiece pressure activated on/off system. The eyecup was very stiff making it hard to activate the sight. This was a particular problem for soldiers wearing glasses. The soldiers also commented that the light amplification and resolution of the Kite sight was poor (this may be due to supposition that the Kite sights tested used older generation light amplification tubes). The soldiers also commented that the Kite sight should be equipped with objective lens and eye-piece diopter focus adjustments. Twelve of 16 soldiers who used both the Kite sight and the AN/PVS-14 NVG with the 3.power afocal magnifier in the associated range firing experiment stated that the NVG with magnifier performed better than the Kite sight. In addition to its superior light amplification performance, the AN/PVS-14 was significantly lighter, less bulky and more flexible for

dismounted operations. The soldiers did not express major concerns that the AN/PVS-14 required the use of an active sighting system (LAD) while the Kite had a passive aiming reticule.

AN/PAS-13B Medium Weight Thermal Sight

All the participants stated that the AN/PAS-13B medium weight thermal sight was only suitable for defensive or recce patrol tasks. The sight was too heavy (17 of 29) and bulky (21 of 29) to use in advance to contact. Soldiers could not use the AN/PAS-13B medium weight thermal sight with the monocular NVG in the down position. A significant number of participants that used the AN/PAS-13B medium weight thermal sight (14) commented that they had problems judging depth perception. They could not estimate whether targets were close or far. While the medium weight thermal sight could detect movement easily, a number of soldiers commented that the poor resolution of the sight made it more difficult to detect static targets. A large number of soldiers (21) had problems adjusting the focus and gain of the sight. It was difficult to get a crisp, high contrast image with the sight. The AN/PAS-13B medium weight thermal sight also suffered from a short battery life and the time to restart the sight after auto-shut off was deemed unacceptable by 16 of the soldiers. The auto-shut off feature of the sight was not supported by the soldiers. The sight shut off during the middle of as number of engagements. The expedient sight mount used with the AN/PAS-13B thermal sight was found to be wanting by a large number of soldiers. The size and weight of the sight suggests that two mounting and attachment points were needed rather than the single point used in this trial. Seventeen soldiers commented that the AN/PAS-13B medium weight thermal sight was too loose. Unlike the Kite sight, the soldiers (18 of 29) found the AN/PAS-13B easy to aim with. The soldiers (20 of 29) stated that the polarity switch (white hot to black hot) was a good feature and that it helped in detecting targets. The ability to have different reticule patterns for different weapon systems was also endorsed by all of the soldiers

W1000 Light-weight Thermal Sight

All the participants (17) that used both the W1000 and the AN/PAS-13B thermal sights stated that the W1000 was far superior to the AN/PAS-13B medium weight thermal sight and that the sight was “ready for war”. The W1000 was light, it had better resolution than the AN/PAS-13B medium weight thermal sight, and it was easier to zero. Soldiers commented that they could use the W1000 thermal sight with the monocular NVG in the down position, as well prescription glass wearers could operate the sight effectively. A significant number of participants that used the W1000 thermal sight (14) commented that they had less problems with depth perception than with the depth perception achieved with the AN/PAS-13B medium weight thermal sight. A large number of soldiers (19) had few problems adjusting the focus and gain of the sight.

The W1000 thermal sight also suffered from a short battery life but the time to restart the sight after auto-shut off was deemed to be quicker than the time required with the AN/PAS-13B medium weight thermal sight. A few soldiers (2) commented that they lost the reticule zero accidentally and that the sight needed some guard mechanism to prevent this in the future. A large number of soldiers also commented that the W1000 was difficult to zero and that the reticule adjustments were too sensitive. These soldiers also recommended that the aiming reticules should be a different colour because it was difficult at times to make out the green reticule on a green screen. The extreme brightness of the screen was also a concern for the soldiers.

Unlike the AN/PAS-13B, the soldiers believed that the W1000 could be used in advance to contact operations.

Sensor Mix

Nearly all of the soldiers (26 of 29) recommended that the Land Forces should acquire a monocular NVG for every dismounted soldier. The monocular NVG should be designed such that it can be used with an afocal magnifier. The monocular NVG should be able to be used on a head, helmet or C7 weapon mount.

During the exit focus group discussion the soldiers (25 of 29) expressed the strong desire to have an LAD with both a visible and an IR laser. They stated the visible laser would be useful for close quarters battle and MOUT operations during the day and the IR laser would be useful for operations at night with NVGs. The soldiers also stated that there are a large number of occasions where a visible laser would act as a strong deterrent to hostile crowds and belligerents. As well a visible laser can still be used with an NVG if the IR laser malfunctions and there may be a number of occasions when not every soldier will be issued an NVG.

All the soldiers involved in this trial did not believe USTANO should acquire any more Kite sights, nor were existing Kite sights needed at the section level if the section was equipped with NVGs and LADs.

All of the soldiers stated that thermal sights were required at the platoon and section levels. The soldiers believed that scouts (or at least a scout) should be issued with a thermal sight during advance to contact operations. Scouts however, must be given the proper time to scan for the enemy. During these trials the platoon and sections used scouts in their advance to contact missions. For much of the leadership this was a return to previously taught dismounted tactics. Discussions with the leadership suggested that the use of scouts had fallen out of favour in their unit because of the emphasis on mechanized operations.

The leaders strongly supported the notion of using thermal sights to identify enemy locations out of contacts, i.e. a switch from being reactive to proactive. The use of thermal sights allowed the section and platoon to manoeuvre out of contact to a position of tactical advantage. Thermal sights allowed the unit to use dead ground to approach the enemy unseen. As well, the thermal sights allowed the unit to quickly re-establish the location of the enemy positions and friendly covering forces.

Although the soldiers stated that thermal sights were required for scouts (or at least a scout), they did not believe a dedicated thermal sight was the best way forward. The soldiers preferred a thermal system which would allow them to scan continuously while on the move. Currently the scouts moved from bound to bound and scanned only when stationary. The soldiers believed that a high resolution thermal goggle or a fused thermal and I^2 goggle was the best way forward.

In conclusion, the participants identified monocular NVGs with magnification and LADs as the minimum equipment required for every member of the section and platoon. Furthermore, weapon mounted NVG with magnification should replace the Kite Weapon sight at the section level. The participants also believed there is a need for thermal units within the platoon and section level. All participants agreed that an minimum number of thermal weapon sights were one unit per section and one for the platoon commander.

Overall, the AN/PVS-14 NVG, Mini N/SEAS NVG, W1000 thermal weapon Sight and AN/PAQ-4C LAD were rated as ready to “go to war”. The AN/PAS-13B medium weight thermal weapon sight was rated as “not ready go to war”.

5. Discussion

Consistent with early SIREQ cognitive task analyses, this limited sensor mix study confirmed that the current means of detecting and identifying partially hidden enemy soldiers during the day and at night is deficient. Significant casualties at the section and platoon level were caused by a very small enemy force. Nearly 50% of the platoon became casualties when the baseline in-service platoon assaulted just a four-person enemy force. In addition to problems with providing aimed shots (at the muzzle flash) the platoon had difficulty traversing broken ground, maintaining tactical formations and coordinating movement. The provision of monocular NVGs to every soldier significantly improved the platoon's performance. Casualties dropped to approximately 19.2 % and improvements in all tactical activities were reported. Casualty rates dropped to those experienced in the day (20%). The universal issue of NVGs and LADs had a significant operational benefit.

The use of dedicated thermal and I^2 sights to overcome current deficiencies in target detection and acquisition was assessed by varying the type and quantity of dedicated sights to the section and platoon. The issue of two Kite sights at the section level did not improve section performance, indeed section casualty rates increased from 16.7% (NVG and LAD only) to 21.7% with Kite sights. The soldiers commented that the Kite sight had poorer resolution than the monocular NVGs and it was too heavy and bulky for advance to contact tasks. The soldiers universally preferred using a monocular NVG and a LAD to the Kite sight in the advance to contact phase of war. Although the issue of two thermal sights and two Kite sights at the section level did not seem to improve section performance, improvements in performance was observed at the platoon level. The use of additional thermal sights reduced casualty rates over the Kite-only condition (17.3 versus 21.2%). The issue of four thermal sights at the section and platoon level had mixed results, casualty rates increased (one to two additional casualties), but the amount of ammunition used decreased significantly and engagement distances increased significantly. The ammunition usage and engagement distances suggest a significant improvement in performance with the use of more thermal sights. The soldiers strongly supported the issue of thermal sights at the platoon and section level if possible. The weight and bulk of the sights appeared to have reduced the benefits in target detection and engagement performance. Soldiers commented that they preferred the use of NVGs and LADs once in contact.

The soldiers were asked to identify what systems, if any, individuals in the dismounted section and platoon should hold. There was near universal agreement that all positions require monocular NVGs and LAD as a minimum. Furthermore, the participants considered that most positions within the platoon and section in the advance to contact phase of war do not require a dedicated thermal or I^2 weapon sight. While there was no support for issuing Kite sights at the section or platoon level for this phase of war there was support for issuing thermal sights at the section and platoon level. The participants believed that scout(s) or section commanders should be issued with a thermal sight at the section level and that the platoon commander should have a thermal system. Interoperability suggests that the platoon commander should have the same light-weight thermal sight as that issued to the sections but it must be noted that the platoon commander may benefit more from a thermal or fused thermal and I^2 goggle system.

Although not assessed in this trial the soldiers expressed the strong desire for an LAD with a visible and an IR laser. A number of the participants had used the AN/PEQ-6 LAD that has both a visible and non-visible aiming laser. They believed the system provided the greatest flexibility for close quarter battle in the day and for general use at night. As well, the use of afocal magnifiers was not used in this trial but the participants had used 3-power magnifiers during the range work-ups for this trial. The soldiers believed the AN/PVS-14 with the 3-power magnifier performed better than the Kite sight. The soldiers believed that every soldier (if possible) should be issued an afocal magnifier to go with their monocular NVG.

The participants strongly supported the notion that a monocular NVG should be issued to dismounted soldiers. Both the AN/PVS-14 and the Mini N/SEAS were believed to be superior to the biocular in-service AN/PVS-504A. Due to the limited number of Mini N/SEAS available, the clear superiority of this device over the AN/PVS-14 was not demonstrated.

After only one night's worth of practice and training with the novel sensors the leaders modified their tactics and TTPs. Scouts were now utilized and soldier spacing resembled day-time distances. The leaders at all levels strongly supported the notion of using thermal sights and scouts to identify enemy locations out of contacts, i.e. a switch from being reactive to proactive. The use of thermal sights allowed the section and platoon to locate the enemy out of contact, allowed the leader to make his plan, allowed the section and platoon to manoeuvre out of contact and finally it allowed the section and platoon to attack in a coordinated manner, all at night. This suggests that the use of novel sights and the universal issue of NVGs may require a change in infantry battle drills.

Thermal sights were not a panacea however, after only a few engagements the enemy quickly realized that thermal sights turned night into day (if not better) and that foliage could not hide their position. The enemy thus changed tactics to hide behind ground features masking their thermal signature. This meant that the enemy had to remain hidden until they believed the friendly force was in their kill zone. Thermal sights did not allow the enemy the time or opportunity to carefully track their targets prior to engaging.

Although the soldiers stated that thermal sights were required for scouts (or at least a scout) and the platoon commander, they did not believe a dedicated thermal sight was the best way forward. The scouts preferred a thermal system that would allow them to scan continuously while on the move. The platoon commander also normally used his thermal sight as an observation device and not as a weapon sight. Thus for the advance to contact phase of war, a high resolution thermal goggle or a fused thermal and I^2 goggle may be the best way forward for dismounted platoons.

The participants in the trial indicated that the priority for re-equipping the Land Force for USTANO equipment should be as follows:

Monocular NVGs and LADs for all soldiers

LADS with IR and visible lasers for all soldiers

Magnifiers for the NVGs for all soldiers (if possible)

One light-weight thermal sights per section

One light-weight thermal sight for the platoon commander

The soldiers did not believe there was a requirement for more I^2 weapon sights within the section or platoon.

The distribution of thermal and I^2 sights depends on the operational context and while this experiment dealt with the advance to contact phase of war, the optimum sensor mix may be different when defence or MOUT operations are considered. The benefits of monocular NVGs were well demonstrated in this advance to contact experiment. Given the added surveillance tasks in the defence, it may be possible that monocular NVGs may not perform as well as biocular or binocular NVGs. The effectiveness of the night vision and sighting systems in the defence, observation post duties, and for recce patrolling was not addressed by this trial. Thus future studies should investigate the impact of issuing monocular NVGs to all soldiers and the use of limited thermal sights in wider range of operational scenarios. Additionally, the benefits of using thermal and or fused thermal and I^2 goggles should be examined for a variety of dismounted operational tasks.

6. References

A. CUQLOCK-KNOPP, V.G., TORGERSON, W., SIPES, D.E., BENDER, E., and MERRITT, J.O. (1995) A Comparison of Monocular, Biocular, and Binocular Night Vision Goggles for Traversing Off-road Terrain on Foot. (ARL-TR-747). Aberdeen Proving Ground, MD; U.S. Army Research Laboratory

B. BOFF, K.R., and LINCOLN, J.E (Eds.) (1988). Engineering Data Compendium: Human Perception and Performance, Volumes I and II. Wright-Patterson Air Force Base, OH

C. VELGER, M. (1998) Helmet-mounted displays and sights. Norwood MA: Artech House Inc.

D. MCLEAN, W.E., RASH, C.E., MCENTIRE, J.E., BRAITHWAITE, M.G., and MORA, J.C., (1997). A Performance History of AN/PVS-5 and ANVIS Image Intensification Systems in U.S. Army Aviation. Proceedings of SPIE – The International Society for Optical Engineering, 3058

E. CALDWELL, J.L., CORNUM, R.L.S., STEPHENS, R.L., and RASH, C.E. (1990) Visual processing: Implications for helmet mounted displays, Proceedings of SPIE – The International Society for Optical Engineering, 1290

F. LEGER, A., ROUMES, C., GARDELLES, C., CURSOLLE, J.P., and KRAUS, J.M. (1988) Binocular HMD For Fixed-Wing Aircraft: A Trade-Off Approach. Proceedings of SPIE – The International Society for Optical Engineering, 1988

G. ANGEL, H.A. (2004). Examination of the Effect of Night Vision Devices on Dismounted Terrain Traverse. Report CR2004-176. Toronto:ON, *Defence Research and Development Canada.*

H. ANGEL, H.A. (2004). A Comparison of Monocular, Biocular and Binocular Night Vision Goggles with and without Laser Aiming Devices for Engaging Targets in a Bush-lane. Report CR2004-172. Toronto:ON, *Defence Research and Development Canada.*

I. ANGEL, H.A. (2004). Examination of the Effect of Night Vision Devices on C7A1 Target Engagement Accuracy. Report CR2004-173. Toronto:ON, *Defence Research and Development Canada.*

J. ANGEL, H.A. (2005). Examination of the Effect of Night Vision Devices on Rifle Target Engagement Accuracy During Urban Operations. Report CR2005-066. Toronto:ON, *Defence Research and Development Canada.*

K. ANGEL, H.A., MASSEL, L.J. (2005). Examination of the Effect of Night Vision Devices on Rifle Target Engagement Accuracy During Bush Lane Engagements. Report CR2005-069. Toronto:ON, *Defence Research and Development Canada.*

L. ANGEL, H.A., VILHENA, P.G.S. (2005). Examination of the Effect of Goggle Field of View on Urban Target Detection. Report CR2005-023. Toronto:ON, *Defence Research and Development Canada*.

M. ANGEL, H.A., VILHENA, P.G.S. (2005). Comparative Evaluation of Dedicated Thermal, Image and Laser Aiming Device (LAD) Sights. Report CR2005-032. Toronto:ON, *Defence Research and Development Canada*.

Annex A :
Mission Mix Questionnaire

Soldier Level **SECTION A: Rate** the degree to which you agree with the following statements using the scale provided. Please consider your responses to these scales carefully:	**Agreement with Statement** **Strongly Disagree** / **Neutral** / **Strongly Agree** **1** **2** **3** **4** **5** **6** **7**
My weapon sight/NVG helped me maintain proper formation and tactical spacing.	○ ○ ○ ○ ○ ○ ○
I could move tactically with my weapon sight/NVG.	○ ○ ○ ○ ○ ○ ○
My weapon sight/NVG allowed **me** to detect the enemy prior to their opening fire.	○ ○ ○ ○ ○ ○ ○
My weapon sight/NVG allowed me to react effectively to enemy fire.	○ ○ ○ ○ ○ ○ ○
My weapon sight/NVG allowed me to identify the enemy's exact position	○ ○ ○ ○ ○ ○ ○
My weapon sight/NVG allowed me to keep in visual contact with other members of my assault group and sub-unit.	○ ○ ○ ○ ○ ○ ○
My weapon sight/NVG allowed me to locate specific enemy positions	○ ○ ○ ○ ○ ○ ○
My weapon sight/NVG helped me to identify and to pass on specific enemy positions	○ ○ ○ ○ ○ ○ ○
I could give aimed shots with my weapon sight/NVG.	○ ○ ○ ○ ○ ○ ○
I could conduct effective fire and movement with my weapon sight/NVG.	○ ○ ○ ○ ○ ○ ○
I could assault effectively with my weapon sight/NVG.	○ ○ ○ ○ ○ ○ ○
My assigned weapon sight/NVG mix enhanced my ability to detect friend from foe (IFF).	○ ○ ○ ○ ○ ○ ○
My assigned weapon sight/NVG mix enhanced **my** overall performance.	○ ○ ○ ○ ○ ○ ○

Section Level **SECTION B:** Rate the degree to which you agree with the following statements using the scale provided. Please consider your responses to these scales carefully:	**Agreement with Statement** **Strongly Disagree**			**Neutral**			**Strongly Agree**
	1	**2**	**3**	**4**	**5**	**6**	**7**
The assigned weapon sight/NVG mix enhanced the Section's ability to move tactically.	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix prevented the Section from being surprised.	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix allowed the Section to react effectively to enemy fire	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix enhanced the Section's ability to locate the enemy.	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix enhanced the Section's ability to win the fire fight.	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix enhanced the Section Commander's ability to coordinate Section fire and movement.	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix enhanced the Section's ability to move tactically in the approach.	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix enhanced the Section's ability to assault.	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix assisted in IFF during the Section's assault.	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix enhanced the speed and efficiency at which we completed the Section attack.	○	○	○	○	○	○	○
The assigned weapon sight/NVG mix enhanced the overall performance of the Section.	○	○	○	○	○	○	○

Annex B :
Sensor Best Mix Exit Questionnaire

Based upon your previous operational experience and your experiences over the past three weeks please record the optimum mix of NVGs, LADs, Illuminators and Sights that <u>should be</u> issued at the Platoon and Section level. As well please record the minimum mix of NVGs, LADs, Illuminators and Sights that <u>must be</u> issued at the Platoon and Section level. If there is no need for kit, please mark "NR" for not required. Please note there is room for additional comments at the end of the questionnaire.

Position	Optimum Issue	Minimum Issue	Comments
Platoon Commander	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Platoon Warrant Officer	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Platoon Signaler	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Platoon Weapons Detachment Commander	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	

Position	Optimum Issue	Minimum Issue	Comments
Platoon Weapons Detachment C6 Gunner	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Platoon Weapons Detachment C6 Loader	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Section Commander	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Section Riflemen #1	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Section Riflemen #2	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Section Rifleman #3 (Grenadier #1)	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	

Position	Optimum Issue	Minimum Issue	Comments
Section Rifleman #4 (Grenadier #2)	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Section C9 Gunner #1	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Section C9 Gunner #2	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Section 2IC	NVG: LAD/ILLUM: Weapon Sight:	NVG: LAD/ILLUM: Weapon Sight:	
Additional Comments			

Annex C :
Mission Mix Questionnaire Results

Table C1: Mission Mix Questionnaire results

1. My weapon sight/NVG helped me maintain proper formation and tactical spacing.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**32**	**187**	**48**	**62**	**20**	**89**
Average	**1.6**	**5.9**	**5.4**	**6.0**	**1.8**	**6.3**
STDEV	**1.1**	**0.9**	**1.8**	**0.8**	**1.0**	**1.0**
2. I could move tactically with my weapon sight/NVG.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**32**	**185**	**48**	**62**	**20**	**88**
Average	**2.4**	**5.4**	**5.3**	**5.9**	**1.8**	**6.2**
STDEV	**1.7**	**1.6**	**1.8**	**0.9**	**1.0**	**0.9**
3. My weapon sight/NVG allowed **me** to detect the enemy prior to their opening fire.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**32**	**188**	**48**	**60**	**20**	**89**
Average	**1.5**	**3.5**	**4.0**	**3.9**	**1.4**	**3.3**
STDEV	**1.1**	**2.1**	**2.1**	**2.2**	**0.9**	**2.2**
4. My weapon sight/NVG allowed me to react effectively to enemy fire.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**32**	**186**	**48**	**59**	**20**	**88**
Average	**2.6**	**5.6**	**5.2**	**5.5**	**1.9**	**6.2**
STDEV	**1.7**	**1.0**	**1.9**	**1.2**	**1.1**	**1.1**
5. My weapon sight/NVG allowed me to identify the enemy's exact position						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**32**	**187**	**48**	**60**	**19**	**87**
Average	**2.0**	**5.4**	**5.1**	**5.5**	**1.7**	**6.0**
STDEV	**1.4**	**1.4**	**2.1**	**1.4**	**1.0**	**1.2**

6. My weapon sight/NVG allowed me to keep in visual contact with other members of my assault group and sub-unit.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**32**	**187**	**48**	**62**	**20**	**89**
Average	**1.9**	**6.0**	**5.3**	**5.8**	**2.0**	**6.3**
STDEV	**1.4**	**0.8**	**2.0**	**0.9**	**1.2**	**0.9**
7. My weapon sight/NVG allowed me to locate specific enemy positions						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**32**	**187**	**48**	**60**	**20**	**86**
Average	**2.2**	**5.3**	**4.8**	**5.3**	**1.7**	**5.8**
STDEV	**1.5**	**1.3**	**2.0**	**1.5**	**0.8**	**1.3**
8. My weapon sight/NVG helped me to identify and to pass on specific enemy positions						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**32**	**182**	**48**	**60**	**20**	**85**
Average	**2.1**	**5.4**	**4.8**	**5.4**	**1.5**	**5.5**
STDEV	**1.4**	**1.2**	**2.2**	**1.3**	**0.8**	**1.6**
9. I could give aimed shots with my weapon sight/NVG.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**31**	**185**	**48**	**60**	**20**	**85**
Average	**2.6**	**5.8**	**5.6**	**5.5**	**1.6**	**5.9**
STDEV	**1.7**	**1.0**	**1.4**	**1.5**	**0.8**	**1.3**
10. I could conduct effective fire and movement with my weapon sight/NVG.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**31**	**187**	**47**	**60**	**20**	**56**
Average	**2.7**	**5.8**	**4.8**	**5.5**	**1.9**	**6.1**
STDEV	**1.7**	**0.9**	**2.1**	**1.2**	**1.0**	**0.9**

11. I could assault effectively with my weapon sight/NVG.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**31**	**178**	**47**	**60**	**20**	**85**
Average	**2.8**	**5.9**	**4.8**	**5.5**	**1.8**	**6.0**
STDEV	**1.7**	**0.7**	**2.2**	**1.2**	**1.0**	**1.2**
12. My assigned weapon sight/NVG mix enhanced my ability to detect friend from foe (IFF).						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**32**	**186**	**48**	**62**	**20**	**87**
Average	**1.8**	**5.0**	**4.8**	**4.9**	**1.3**	**3.8**
STDEV	**1.3**	**1.3**	**2.1**	**1.6**	**0.6**	**2.1**
13. **My** assigned weapon sight/NVG mix enhanced **my** overall performance.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**31**	**188**	**48**	**62**	**20**	**89**
Average	**1.6**	**5.8**	**4.8**	**5.5**	**1.7**	**6.2**
STDEV	**1.1**	**1.0**	**2.0**	**1.2**	**1.1**	**1.1**
14. The assigned weapon sight/NVG mix enhanced the Section's ability to move tactically.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**41**	**174**	**48**	**58**	**24**	**91**
Average	**2.2**	**5.7**	**5.4**	**6.0**	**2.2**	**6.1**
STDEV	**1.6**	**1.2**	**1.6**	**0.8**	**1.4**	**1.1**
15. The assigned weapon sight/NVG mix prevented the Section from being surprised.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**41**	**173**	**48**	**56**	**24**	**90**
Average	**2.0**	**4.2**	**4.5**	**4.3**	**1.8**	**4.2**
STDEV	**1.4**	**2.1**	**2.2**	**2.3**	**1.2**	**2.2**

16. The assigned weapon sight/NVG mix allowed the Section to react effectively to enemy fire						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**41**	**172**	**47**	**55**	**24**	**89**
Average	**2.7**	**5.6**	**5.3**	**5.8**	**2.2**	**6.0**
STDEV	**1.8**	**1.0**	**1.8**	**0.9**	**1.4**	**1.2**
17. The assigned weapon sight/NVG mix enhanced the Section's ability to locate the enemy.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**23**	**171**	**48**	**56**	**42**	**89**
Average	**2.8**	**5.5**	**5.2**	**5.6**	**1.9**	**5.9**
STDEV	**2.0**	**1.2**	**1.8**	**1.2**	**1.4**	**1.2**
18. The assigned weapon sight/NVG mix enhanced the Section's ability to win the fire fight.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**40**	**171**	**48**	**55**	**24**	**88**
Average	**2.7**	**5.5**	**5.3**	**5.4**	**2.3**	**5.8**
STDEV	**1.9**	**1.1**	**1.6**	**1.3**	**1.7**	**1.3**
19. The assigned weapon sight/NVG mix enhanced the Section Commander's ability to coordinate Section fire and movement.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**37**	**164**	**47**	**51**	**24**	**88**
Average	**2.5**	**5.5**	**4.6**	**5.6**	**2.3**	**5.8**
STDEV	**1.9**	**1.1**	**1.8**	**0.9**	**1.4**	**1.3**
20. The assigned weapon sight/NVG mix enhanced the Section's ability to move tactically in the approach.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**42**	**174**	**48**	**56**	**24**	**90**
Average	**2.5**	**5.8**	**5.2**	**5.9**	**2.1**	**6.1**
STDEV	**1.9**	**1.2**	**1.7**	**1.0**	**1.2**	**1.2**

21. The assigned weapon sight/NVG mix enhanced the Section's ability to assault.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**41**	**172**	**47**	**54**	**23**	**88**
Average	**2.5**	**5.6**	**5.0**	**5.7**	**1.8**	**5.9**
STDEV	**1.8**	**1.0**	**1.9**	**0.9**	**1.1**	**1.3**
22. The assigned weapon sight/NVG mix assisted in IFF during the Section's assault.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**41**	**173**	**48**	**57**	**24**	**89**
Average	**2.4**	**5.3**	**5.3**	**5.3**	**1.9**	**4.0**
STDEV	**1.8**	**1.1**	**1.7**	**1.4**	**1.4**	**2.0**
23. The assigned weapon sight/NVG mix enhanced the speed and efficiency at which we completed the Section attack.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**41**	**171**	**48**	**56**	**24**	**89**
Average	**2.4**	**5.5**	**5.3**	**5.5**	**2.2**	**5.8**
STDEV	**1.8**	**1.3**	**1.8**	**1.3**	**1.5**	**1.4**
24. The assigned weapon sight/NVG mix enhanced the overall performance of the Section.						
	C7 No NVG	**C7 with NVG**	**C7 with Kite**	**C7 with thermal**	**C9 no NVG**	**C9 with NVG**
Number(n)	**42**	**175**	**48**	**57**	**24**	**91**
Average	**2.2**	**5.7**	**5.3**	**5.6**	**2.0**	**6.1**
STDEV	**1.7**	**1.1**	**1.7**	**1.3**	**1.4**	**1.1**

DOCUMENT CONTROL DATA
(Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document, Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's document, or tasking agency, are entered in section 8.)

Publishing: DRDC Toronto

Performing: Humansystems® Incorporated, 111 Farquhar St., 2nd floor, Guelph, ON N1H 3N4

Monitoring:

Contracting: DRDC Toronto

2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.)

UNCLASSIFIED

3. TITLE (The complete document title as indicated on the title page. Its classification is indicated by the appropriate abbreviation (S, C, R, or U) in parenthesis at the end of the title)

Preliminary Evaluation of Distributed Sensors (U)
Évaluation préliminaire des capteurs distribués

4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.)

Harry A. Angel; Paul G. S. Vilhena

5. DATE OF PUBLICATION (Month and year of publication of document.)

May 2005

6a NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)

69

6b. NO. OF REFS (Total cited in document.)

13

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Contract Report

8. SPONSORING ACTIVITY (The names of the department project office or laboratory sponsoring the research and development − include address.)

Sponsoring: DLR 5, NDHQ OTTAWA,ON K1A 0K2

Tasking:

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant under which the document was written. Please specify whether project or grant.)

12QG01

9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)

W7711−017747/001/TOR

10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document)

DRDC Toronto CR 2005−034

10b. OTHER DOCUMENT NO(s). (Any other numbers under which may be assigned this document either by the originator or by the sponsor.)

SIREQ #94

11. DOCUMENT AVAILABILITY (Any limitations on the dissemination of the document, other than those imposed by security classification.)

Defence departments in approved countries − Document has initial limited distribution through Exploitation Manager − TTCP and NATO countries and agencies − Unlimited after initial limited distribution

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11), However, when further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

Other − Document to have initial Limited announcement

DOCUMENT CONTROL DATA
(Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

(U) The effects of adding enhanced vision and sighting sensors at the dismounted section and platoon level were evaluated in an 11−day field study at Fort Benning, Georgia over the period November 4 to 14 2002. A platoon of regular force infantry soldiers (3 Sections, platoon headquarters and C6 medium machine gun weapons detachment) conducted a series of section and platoon advance to contact and quick attack missions against a live enemy force. The effects of adding enhanced vision and different quantities and types of sighting systems at the team level were assessed using task performance (casualties), ammunition expenditure, engagement distance, and user acceptance metrics. Across all the attacks, the number of casualties inflicted by the enemy force varied from a high of 46.8% with the in−service equipment to a low of 19.2% with when all soldiers were issued with just monocular Night Vision Goggles (NVGs) and Laser Aiming Devices (LADs). Minor improvements in performance occur with the addition of dedicated thermal and Kite sights. The participants recommended that monocular NVGs with magnification and LADs should be issued to every member of the section and platoon. Furthermore, weapon mounted NVGs with magnification should replace the Kite Weapon sight at the section level. All of the participants agreed that there is a need for thermal sights at the platoon and section level. The participants also agreed that the minimum requirement was for one light−weight thermal weapon sight at the section level. Overall, the AN/PVS−14 NVG, Mini N/SEAS NVG, W1000 thermal weapon sight and AN/PAQ−4C LAD were rated as ready to “go to war”. The AN/PAS−13B medium weight thermal weapon sight was rated as “not ready to go to war”. Although the soldiers stated that thermal sights were required for scouts (or at least a scout) and the platoon commander, they believed that a high resolution thermal goggle or a fused thermal and Image Intensified (I2) goggle may be the best way forward for dismounted platoons. Tactics techniques and procedures (TTPs) used in dismounted section and platoons will have to be modified to make optimum use of the novel sensor and universal vision systems.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U) Soldier Information Requirements Technology Demonstration Project; SIREQ TD; enhanced vision; sensors; distributed sensors; monocular; Night Vision Goggles; NVG; NVD; Laser Aiming Devices; LAD; thermal sight; Kite sight; weapon mounted NVG; section attack; Tactics techniques and procedures; TTP