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# IMPACT OF NIGHT VISION DEVICES ON INDIVIDUAL AND GROUP MOVEMENT AND SEPARATION ON THE BATTLEFIELD

by:
Paul G.S. Vilhena and Harold A. Angel

Human*systems*® Incorporated
111 Farquhar St., 2nd Floor
Guelph, ON N1H 3N4

Project Manager:
Harold A. Angel (519)-836-5911

Project Director:
David W. Tack (519)-836-5911

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

DRDC Toronto Scientific Authority
LCol Linda Bossi
(416) 635-2197

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# Abstract

A twelve-day field trial was undertaken at Fort Benning, Georgia over the period of 26 April to 18 May 2004. Data from eight regular force infantry NCOs and Officers from 3rd Battalion Princess Patricia's Canadian Light Infantry Regiment, Edmonton, Alberta, were used in this part of the SIREQ-TD FBES VII Experiment. A total of 48 soldiers participated in two night operations conducted in a wooded area using a standard Platoon organizational structure. Two different levels of 'enabled capabilities' (i.e., all members equipped with Night Vision Goggles (NVGs) versus two members with NVGs) were tested in a repeated measures design. Data collection methods included questionnaires and human factors observer assessments of individual separation.

The results of this trial indicated that tactical spacing between individuals increased significantly when participants used night vision goggles (NVGs). NVGs also improved intra-section visual communications.

If precise measurement of tactical spacing is required for modelling efforts, then further studies will be required using accurate measurement tools. Future studies could also examine the impact of different terrain types, vegetation densities and illumination conditions on individual separation.

# Résumé

Un essai en campagne de douze jours a eu lieu à Fort Benning, en Géorgie, du 26 avril au 18 mai 2004. Des données recueillies auprès de huit sous-officiers et officiers d'infanterie de la Force régulière, membres du 3e Bataillon du Régiment Princess Patricia's Canadian Light Infantry, Edmonton (Alberta), ont été utilisées pour cette partie de l'expérience SIREQ-TD FBES VII. En tout, 48 soldats (deux sections) ont participé à deux opérations de nuit menées dans en milieu boisé selon une structure organisationnelle de peloton standard. Deux niveaux différents d'équipement (équipement de tous les membres avec les lunettes de vision nocturne (LVN), et équipement de seulement deux membres avec les LVN) ont fait l'objet d'essais selon un protocole de mesures répétées. Les méthodes de collecte de données comprenaient des questionnaires et des évaluations ergonomiques, par des observateurs, r de l'espacement entre les individus.

Les résultats de cet essai ont indiqué que l'espacement tactique entre les individus augmentait sensiblement lorsque les participants utilisaient les lunettes de vision nocturne (LVN). En outre, les LVN amélioraient les communications visuelles à l'intérieur des sections.

Si la mesure précise de l'espacement tactique est nécessaire aux travaux de modélisation, il faudra effectuer des études plus poussées à l'aide d'outils de mesure exacte. D'autres études pourraient également être menées pour examiner l'impact de différents types de terrains, de la densité de la végétation et des conditions d'illumination sur l'espacement entre les individus.

# Executive Summary

As part of Soldier Information Requirements – Technology Demonstration (SIREQ – TD), Defence Research and Development Canada (Toronto) has been examining the benefits and operational impact of dismounted soldier sensors. As part of the sensor benefit characterization, SIREQ-TD has examined the effectiveness of various night vision goggles (NVGs), image intensified weapon sights, and thermal weapon sights during dismounted infantry tasks.

Although the use of NVGs has been shown to improve dismounted terrain traverse and operational performance, the impact on individual separation has not been directly quantified. The goal of this trial was to investigate the effect of providing the entire Section with the NVGs versus providing just two personnel with NVGs (in-service distribution). A twelve-day field trial was undertaken at Fort Benning, Georgia over the period of 26 April to 18 May 2004. Data from nine regular force infantry NCOs and Officers from 3rd Battalion Princess Patricia's Canadian Light Infantry Regiment, Edmonton, Alberta, were used in this part of the SIREQ-TD FBES VII Experiment. Soldiers completed human factors tests while using standard Platoon organizational structure in two night time wooded operations. Soldiers were required to prepare plans for fighting and reconnaissance (recce) patrols, and advance to contact based on information given. Two different levels of 'enabled capabilities' (i.e., all members with NVGs versus two members with NVGs) were used in a repeated measures design. Data collection methods included questionnaires and human factors observer assessments. Data collectors assessed individual separation distances using a pacing method.

The results from this trial suggest that section-level individual separation increased with the use of more NVGs during night operations. Soldiers of sections fully equipped with NVGs were spaced further apart than when they were not all equipped with NVGs. Full deployment of NVGs increased unit survivability (fewer soldiers were within single fragmentation weapon kill zone) and the NVGs increased the unit's area of influence (the unit covered more ground).

Equipping all soldiers with NVGs improved intra-section visual communications. Even though soldiers were further apart, the leaders believed that their soldiers were much more capable of observing hand signals, passing on messages, etc. Speed of information passage improved when all soldiers were equipped with NVGs. The full use of NVGs also improved the section's awareness of the location of other assault groups within the section and with the location of other adjacent sections.

Recommendations for future research and investigations are discussed.

# Sommaire

Dans le cadre du Projet de démonstration de technologies portant sur les besoins des soldats en matière d'information (SIREQ - TD ), Recherche et développement pour la défense Canada – Toronto a étudié les avantages et l'incidence opérationnelle de l'utilisation de capteurs par des soldats à pieds. Au cours des travaux de SIREQ-TD visant à établir les caractéristiques des capteurs, on a examiné l'efficacité de lunettes de vision nocturne (LVN), viseurs d'arme à intensification d'image et de viseurs thermiques d'arme, lors de tâches de l'infanterie débarquée.

Bien que l'utilisation des LVN ait manifestement amélioré les performances lors des opérations et de la traversée de terrains à pieds, leur incidence sur l'espacement entre les soldats n'a pas été directement quantifiée. L'essai visait à comparer l'effet de l'équipement de tous les membres de la section avec les lunettes de vision nocturne (LVN), et l'effet de l'équipement de seulement deux membres avec les LVN (en usage). Un essai en campagne de douze jours a eu lieu à Fort Benning, en Géorgie, du 26 avril au 18 mai 2004. Des données recueillies auprès de neuf sous-officiers et officiers d'infanterie de la Force régulière, membres du 3e Bataillon du Régiment Princess Patricia's Canadian Light Infantry, Edmonton (Alberta), ont été utilisées pour cette partie de l'expérience SIREQ-TD FBES VII. Les soldats ont effectué des essais ergonomiques lors de deux opérations de nuit menées dans en milieu boisé selon une structure organisationnelle de peloton standard. Les soldats devaient préparer des plans de combat et de patrouilles de reconnaissance, et marcher à l'ennemi selon l'information communiquée. Deux niveaux différents d'équipement (équipement de tous les membres avec les lunettes de vision nocturne (LVN), et équipement de seulement deux membres avec les LVN) ont fait l'objet d'essais selon un protocole de mesures répétées. Les méthodes de collecte de données comprenaient des questionnaires et des évaluations ergonomiques par des observateur. Les responsables de la collecte des données ont évalué l'espacement entre les individus en utilisant une méthode mesure au pas.

Les résultats obtenus indiquent que l'espacement entre individus au niveau de la section augmentait avec l'utilisation d'un plus grand nombre de LVN lors des opérations de nuit. Les soldats des sections entièrement équipées de LVN étaient plus éloignés les uns des autres que ceux des sections partiellement équipées de LVN. Le déploiement intégral des LVN augmentait les possibilités de survie de l'unité (moins de soldats se trouvaient dans une unique zone de destruction par armes à fragmentation) et les LVN augmentaient la zone d'influence de l'unité (l'unité couvrait plus de terrain).

L'équipement de tous les soldats avec des LVN améliorait les communications visuelles à l'intérieur de la section. Même si les soldats étaient plus éloignés, les responsables étaient d'avis qu'ils étaient bien mieux en mesure d'observer les signaux manuels, de transmettre des messages, etc. La vitesse de transmission de l'information était supérieure lorsque tous les soldats étaient équipés de LVN. En outre, le déploiement intégral des LVN permettait à la section de mieux localiser les autres groupes d'assaut de la section ainsi que les sections voisines.

Des recommandations de recherches futures sont étudiées.

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# 1 Background

The SIREQ cognitive task analyses identified the ability to detect and engage enemy soldiers as critical requirements for mission success. During the day, soldiers currently use optical sights or their unaided eyes for detecting and 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 aimers for use with NVGs nor does the Land Force have access to thermal weapon sights at the dismounted Platoon level.

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 have performed better than the other NVGs (Angel and Nunes, 2001). The results of SIREQ experimentation have suggested that issuing all individuals with night vision systems would enable a Platoon to function with greater physical separation of individuals and elements, while still maintaining independent movement and action (Angel and Vilhena 2004).

The lack of NVGs means that soldiers must reduce tactical spacing at night so that individuals do not become lost. Depending on the ambient light available, spacing may be less than one to two meters. The "bunching up" of soldiers has significant tactical implications. Units become much more vulnerable to enemy fire and area weapons, and the unit's area of influence is greatly diminished. Allowing individuals to extend tactical spacing to daylight distances will greatly improve unit and individual survivability and combat effectiveness. The use of NVGs has been shown to improve individual dismounted terrain traverse and collective operational performance. Although improved tactical separation has been observed with the use of NVGs, this benefit has not been quantified.

# 2 Aim

The aim of the present study was to evaluate the impact of night vision devices on individual and group movement and separation on the battlefield for fighting patrols in wooded environments. Goals of the trial included:

- Comparing the impact of providing all soldiers with NVGs (AN/PVS-14) versus the in-service method of providing just two NVGs (AN/PVS-7D/504A) on individual separation (i.e., number of paces between individual soldiers) within a section during wooded manoeuvring.
- Comparing the impact of providing all soldiers with NVGs (AN/PVS-14) versus the in-service method of providing just two NVGs (AN/PVS-7D/504A) on control of movement within a section during wooded manoeuvring.

# 3 Method

It should be noted at the outset that this study was one of several studies being completed during the Fort Benning Experimental Series (FBES) VII. The Platoon missions were the venue for a variety of studies evaluating a number of factors, including:

- Determining the differences between digitally-enabled Sections (i.e., those with the AN/PVS-14) and currently non-digital-enabled Sections (i.e., the AN/PVS-7D/504A);
- Testing alternative tactics, techniques, and procedures to best take advantage of the digital capabilities;
- Comparing the impact of digital enabling during day and night operations;
- Determining the benefits for defensive planning and monitoring in an urban environment;
- Examining the impact of night vision devices on soldier and sub-unit field craft; and
- Evaluating the utility of various digital planning and briefing tools.

This study focused on the impact of providing all personnel with NVGs at night. The following description provides a general overview of the trial method. Further details are provided in subsequent sections.

A twelve-day field trial was undertaken at Fort Benning, Georgia over the period of 26 April to 18 May 2004. Eight regular force infantry NCOs and Officers from 3rd Battalion Princess Patricia's Canadian Light Infantry Regiment, Edmonton, Alberta, participated in the evaluation of digital tools experiments in the SIREQ-TD FBES VII Experiment. Soldiers participated in the experiment as members of a standard Platoon organizational structure in two night-time wooded operations. Based on information provided, platoons were required to prepare plans for fighting and recce patrols, and advance to contact. Two night vision systems and two levels of night vision enabling capabilities (i.e., all members with an NVG versus two members with an NVG) were tested in a repeated measures design. One human factors (HF) observer from the experimenter team was assigned to work with each of the Sections for the purposes of data collection. Each data collector was responsible for one Section leadership element at any one time. Data collection methods included questionnaires and human factors observer assessments.

## 3.1 Trial Participants

A total of 48 soldiers from the 3rd Battalion Princess Patricia's Canadian Light Infantry Regiment, Edmonton, Alberta participated in this study, however, only eight leadership elements (Non Commissioned Officers (NCOs) and Officers) of each platoon completed questionnaires. The mean age of the respondents (n =8) was 31.3 years (SD=4.7, min=23, max=35) their mean length of service in the regular forces, 10.7 years (SD=4.4, min=5, max=17). Two participants wore glasses, no participant was colour blind. Their mean operational tour experience was 2.4 years (SD=1.7, min=0, max=5).

## 3.2 Materials

All participants were required to complete a patrol task in a wooded environment at night using two levels of NVG distribution. The study was performed within an operational advance to a contact setting.

### 3.2.1 Vision Enhancement Systems

Monocular Near InfraRed (NIR) NVG and biocular NIR NVGs were used in this trial. The in-service biocular AN/PVS-7D/504A and the monocular AN/PVS-14 are described in detail below. These NVGs share many features, however, their primary differences lie in their ocular attribute and weight.

#### *3.2.1.1 Biocular AN/PVS-7D/504A*

The in-service AN/PVS-7D, and its functional equivalent AN/PVS-504A, is a lightweight, high performance, passive, third-generation biocular image intensifier system – see Figure 1. The AN/PVS-7D is either worn on the head as a goggle system or attached to the soldier's helmet. The goggle assembly is a head-mounted self-contained night vision system containing one biocular unit consisting of an objective lens assembly, an image intensifier tube, a housing assembly, and a binocular eyepiece assembly. The housing is mounted to a face mask assembly which is held by straps to the user's head.

**Figure 1: AN/PVS-7D/504A**

The assembly incorporates an infrared (IR) light source, which provides illumination to permit close-in viewing. Features include automatic brightness control, bright source protection, a low battery indicator, and a high-resolution unity F1.2 lens.

The AN/PVS-7D/504A has the following specifications:

| | |
|---|---|
| Magnification power | 1 X |
| Intensifier tube | Gen. III |

| | |
|---|---|
| System gain | 3000 fL/fL |
| Field of view | 40 degrees |
| Depth of field | 20cm to infinity |
| Inter-ocular adjustment | -6D to +2D |
| Power source | 2 AA |
| Weight | 680grams |

#### *3.2.1.2 Monocular AN/PVS–14*

The AN/PVS-14 is a lightweight, high performance, passive, third-generation monocular image intensifier system - see Figure 2. The AN/PVS-14 is either worn on the head as a goggle system or attached to the soldier's helmet. 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 face mask assembly which is held by 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, a low battery indicator, and a high-resolution unity F1.2 lens.

**Figure 2: AN/PVS-14**

The AN/PVS-14 has the following specifications:

| | |
|---|---|
| Magnification power | 1 X |
| Intensifier tube | Gen. III |
| System gain | 3000 fL/fL |
| Field of view | 40 degrees |
| Depth of field | 20cm- to infinity |
| Inter-ocular adjustment | -6D to +2D |
| Power source | 2 AA |
| Weight | 392 grams |

### 3.2.2 Mission Conditions

Missions were organized into two scenarios to emphasize different capabilities and conditions. Each scenario was performed in wooded terrain and emphasized navigation, link-ups, contact points, communication, coordination, hasty defence, assault, ambush, and securing an area or site. A sample of the mission information is shown below in Figure 3.


**Figure 3: Sample of wooded element insertion points**

## 3.3 Experimental Design

A repeated measures analysis of variance of the different levels of NVG distribution was performed for all criteria from the Control of Movement questionnaire (see Annex A). Differences were identified at $p < 0.05$. Spacing between individuals in a Section was measured by physical pacing by a member of the research team. The statistical plan is depicted in the table one below.

**Table 1: Statistical plan**

| Measure | Method | Analysis |
|---|---|---|
| Participant responses on Control of Movement questionnaire | Subjective assessment by participant | ANOVA between 2 distributions for each question and overall (questionnaire). |
| Spacing between individual Section members | Visual inspection by member of research team | None – presentation of means and standard deviations |

### 3.3.1 Independent Variable

The independent variable being tested was the quantities of night vision devices distributed within a section. Two different quantities of enhancing night vision were used during the control of movement study

- Everyone equipped with an NVG (fully equipped distribution)
- Only two personnel equipped with an NVG (in-service distribution)

The capabilities of the two NVGs have been assessed previously (Angel and Nunes, 2001) and although one system is a monocular and the other is a biocular NVG, the difference in vision performance was not significant.

### 3.3.2 Dependent Variables

Dependent variables consisted of both subjective and objective measures. Data collection focused on the following HF criteria, described in more detail below:

- Average spacing and
- Control of Movement Questionnaire

#### *3.3.2.1 Average Spacing*

During the advance to platoon Rendez Vous (RV) point the section was ordered to stop and the distance between individuals within the section was paced and recorded by the observer. The sections were required to stop twice, on average, during each phase of the operation in this study.

Pacing is a standard distance measurement technique used in the military. Although a pace is traditionally estimated to be 2.5 to 3 linear feet in length, soldiers are trained to know the exact number of their paces for 100m (i.e. 123).

The pace of the observers varied somewhat due to physical size differences (statures of the observers varied from 1.67m to 1.79m). In an effort to see if data collectors were significantly different in their pace counts an inter-observer investigation was conducted. Analysis was conducted on pacing distances between observers and no significant differences were observed between observers for either when they assessed fully NVG-mediated pacing distances ($p=.78$) or when they assessed partially equipped pacing distances ($p=.72$).


#### 3.3.2.2 *Control of Movement Questionnaire*

Following the completion of each mission, leaders completed a 15-item Control of Movement questionnaire designed by the current researchers (see Annex A). The leaders were required to rate their perception of control of movement acceptability for each distribution level of NVGs used in this series of research. Subjects rated the levels of NVG distribution in the following four areas:

- Information transfer (five items);
- Awareness of location (six items);
- Coordination of movement (three items); and
- Overall acceptance (one item).

**Questionnaire Rating Scale**

Participants rated the acceptability of NVGs using the following seven-point scale (see Figure 4).

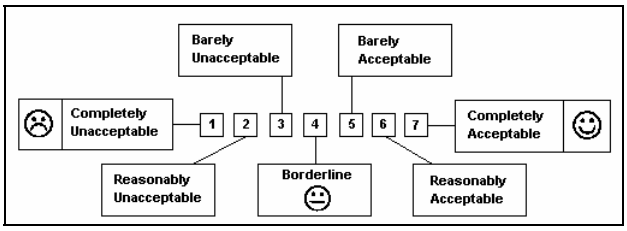



**Figure 4: Standard rating scale**

## 3.4 Procedures

The effects of the difference in distribution of NVGs on in-service organizational structures were evaluated at the platoon, section, and individual level. Assessment included two simulated platoon attacks against a live enemy force in the woods at night.

The experimental approach is outlined below for each phase of the mission: briefing, execution, and debriefing.

### 3.4.1 Briefing Phase

All participants were briefed on the goals and approach of the experiment. Platoons were composed partially of cohesive sub-units that had trained extensively together, and partially of sub-units that had not trained together. Participant preparation involved platoon-level training on the different NVGs.

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



- A statement of Command Intent comprising the mission goal and the desired end state;
- The mission objective and the proposed insertion points for each sub-unit;
- Actions on contact, snipers, obstacles, etc.;
- Necessary timings; and
- Outline of known enemy locations and strength.

Each sub-unit leader provided instructions to his sub-unit as required and plotted a route from insertion point to objective on a digital map with a GPS system or on a paper map with compass for the digitally and non-digitally enabled conditions.

### 3.4.2 Execution Phase

At the start of each mission, the live enemy force was positioned in the battle area. The sections of the platoon were then positioned at their respective start points.

Each sub-unit was required to move tactically along their assigned approach route. Each mission included a requirement for coordinated movement of the different elements, fire support placement, and assault on the objective.

Having manoeuvred to the objective, the sub-units then began a coordinated hasty assault on the objective. Each mission required the different sub-units in the platoon to clear the objective from different approaches (i.e., without line of sight between sub-units). 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. The general approach to the non-digital and digitally enabled conditions is outlined below.

#### *3.4.2.1 The Approach*

In all conditions, missions were conducted at night in a wooded area. The Platoon elements navigated independently to a contact point designated by the Platoon Commander in Orders from four separate insertion points. Elements then moved to their assault positions and awaited the order to assault. The Platoon Commander monitored the position of all friendly forces and launched the assault at the earliest practicable time. The full procedure, described below, varied slightly due to the differences in NVG distribution.

**In-Service Distribution**: When the platoons were equipped with two AN/PVS-7D/504As, the Platoon Commander learned the defensive posture of the enemy force, adjusted his plan, and communicated it face-to-face with the Platoon at the RV. H-hour (attack time) timings were established and briefed as part of the assault plan. Elements manoeuvred, by paper map, to their assault lines and initiated at H-hour. The two members of each section in the platoon were equipped with AN/PVS-7D/504A NVGs and a KITE night sight was available at the platoon headquarters. The Kite sight is a magnified image intensified night sight typically mounted on platoon support weapons.

**Enhanced Distribution**: When everyone in the platoon was equipped with an AN/PVS-14 NVG, the sections were inserted at different locations and navigated to a contact point using a digital map. The Platoon Commander performed the commander's recce using remote surveillance assets (e.g., scout with eyes-on), modified his plan, and communicated the modified plan through



remote orders (i.e., Platoon elements received their orders in their lay-up positions via radio). All members in the Platoon were equipped with NVGs and laser aiming devices.

#### *3.4.2.2 The Assault*

From their assault lines, platoon elements carried out the assault based on the H-hour timings and any pre-arranged signal (e.g., smoke, fire base). The assault was carried out according to orders and SOP drills. Coordination was performed using digital feedback, platoon-level radios, yelled voices, and/or hand signals.

### 3.4.3 Debriefing Phase

Following the completion of the mission, eight leaders completed a Control of Movement questionnaire.

## 3.5 Limitations

Due to time and equipment constraints, no precise measured assessments of section spacing were possible in the open woods. Only paced readings from observers during forced pauses to the section during navigation in the woods were possible. However, because the pace of an individual adapts to the difference of the terrain and obstructions, this method of recording distance between soldiers during the pauses for sections was inexact.

In addition, while the pace of the observers varied somewhat due to physical size differences (statures varied from 1.67m to 1.79m) they served as their own controls when assessing fully equipped sections and partially equipped sections.

# 4 Results

Differences in the two distributions of NVGs tested were measured via the spacing (number of paces, on average, between each soldier) assessments of each section and the Control of Movement Questionnaire. The responses of eight leadership elements were used in the control of movement evaluation. The results of this study are organized into two sections according to the two data collection methods and data types: Individual Spacing Results and Control of Movement Results.

## 4.1 Individual Tactical Spacing Results

The tactical distance between individuals was assessed by human factors data collectors. Spacing was operationally defined as the number of paces between individuals in a section. Measurements were taken twice per mission, on average.

The average spacing between individuals varied between 2.4 paces for in-service equipped sections to 4.7 paces for fully equipped sections –see Table 2. The results were collected in 105 separate data measurement events (52 for the in-service baseline assessment and 53 for the fully equipped section assessment). Individual spacing was assessed during the advance to contact, all round defence, the approach, and during the attack.

**Table 2: Means and standard deviations of spacing within a section**

| Spacing | | |
|---|---|---|
| | **Mean** | **SD** |
| **Fully equipped (8x NVG per Section)** | 4.7 | 1.2 |
| **In-Service distribution (2x NVG per Section)** | 2.4 | .4 |

Even with the limitation of different data collectors with their different pace counts, the results suggest that there are significant differences in tactical spacing between fully equipped and partially equipped sections. Sections fully equipped with NVGs are spaced further apart than when only two soldiers have NVGs.

## 4.2 Control of Movement Results

The Control of Movement questionnaire was used to compare leaders' subjective assessments of the impact of differing NVG distribution within the section and platoon. The results are described below.

At the end of each mission, the leadership elements of the platoon rated the acceptability of each distribution approach for control of movement on 15 statements using a 7-point rating scale

(Figure 4 in an earlier section of this paper), from 1 (Completely Unacceptable) to 7 (Completely Acceptable).

### 4.2.1 Information Transfer Results

The impact on the level of NVG distribution was assessed for a variety of information transfer criteria. Overall the fully equipped section was judged to be "Barely to Reasonable Acceptable" for the five information transfer assessment criteria – see Figure 5. Conversely the In-service equipped section was judged to be "Borderline to Barely Acceptable".

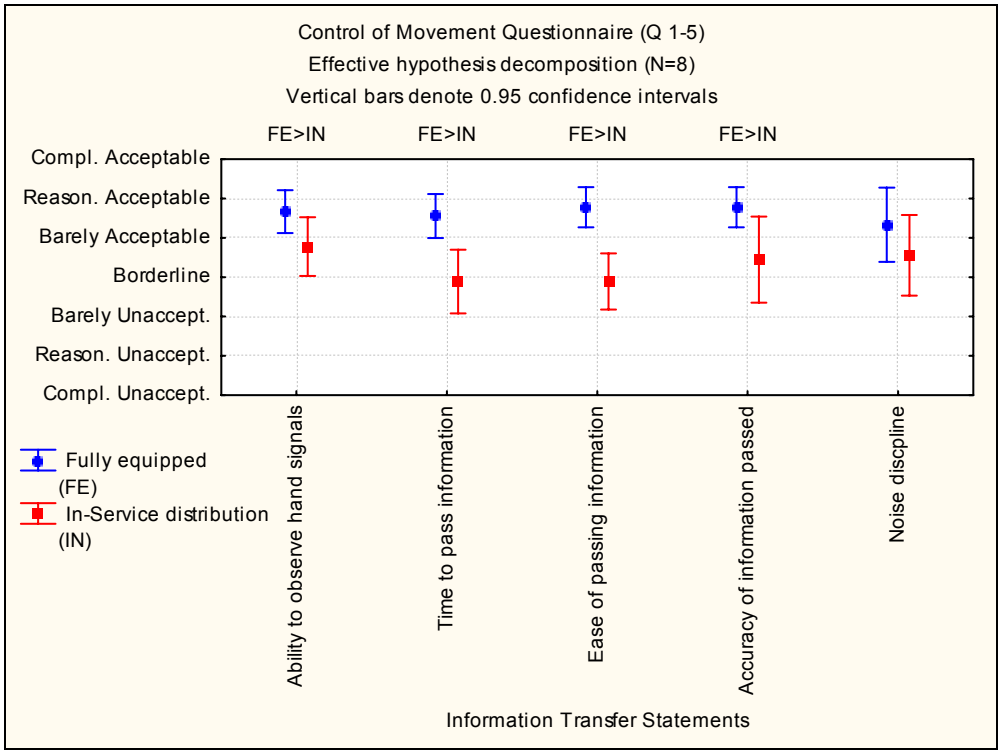



**Figure 5: Control of movement statement results (Q 1-5)**

A repeated measures analysis of variance for each criterion indicates that the fully equipped section was considered significantly more acceptable than the partially equipped section for all but the noise discipline information transfer area. ANOVA results are detailed in Annex B

Even though soldiers were further apart, the leaders believed that information could be passed quicker, more accurately and more easily when all section members were equipped with NVGs.

The results also indicate that the use of NVGs did not significantly impact noise discipline. Soldiers attempted to move stealthily, either with NVGs or without.

### 4.2.2 Situation Awareness Results

The impact on the level of NVG distribution was assessed for a variety of situational awareness criteria. Overall the fully equipped section was judged to be "Borderline to Barely Acceptable" for the six situational awareness assessment criteria – see Figure 6. Conversely the In-service equipped section was judged to be "Barely Unacceptable to Barely Acceptable".

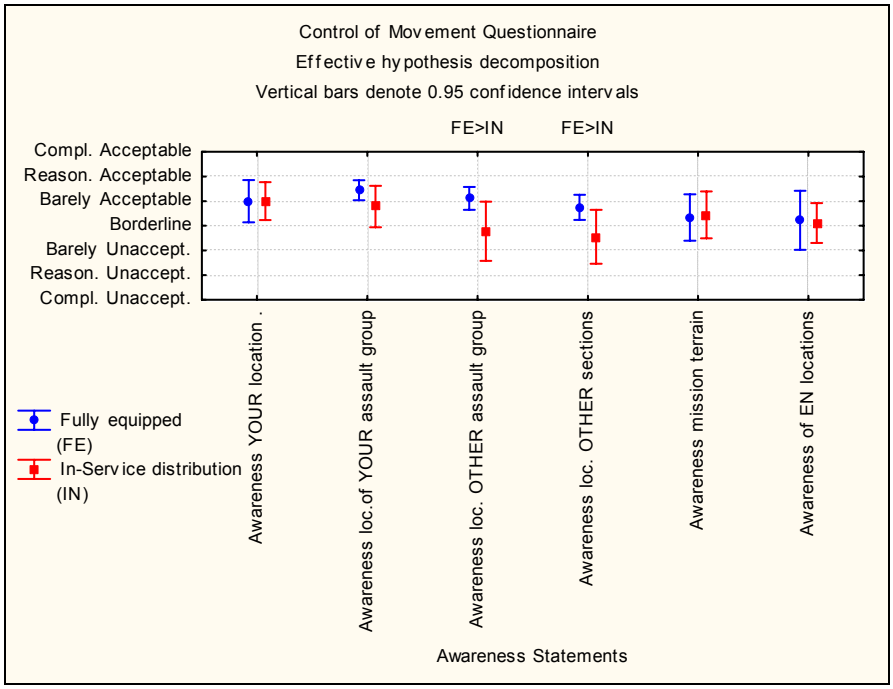



**Figure 6: Control of movement statement results (Q 6-11)**

A repeated measures analysis of variance for each criterion indicates that the fully equipped section was considered significantly more acceptable than the partially equipped section for Awareness of the location of other assault groups/s and Awareness of the location of other sections. ANOVA results are detailed in Annex B

Even though soldiers were further apart, the leaders believed that improved awareness of other assault groups and other sections occurred when all section members were equipped with NVGs.

The full use of NVGs did not improve the perception of awareness of one's own position. The missions conducted were through dense and open woods with few landmark features to guide the sections. Although the use of NVGs may have helped the soldiers view their immediate surroundings they did not help them identify exactly where they were on the ground. Map and compass or GPS and digital maps were needed to help them locate their position.

Although the full use of NVGs helped the leaders in their awareness of other assault groups, they did not significantly improve their awareness of their own assault group. During tactical movement a section is divided into two assault groups, and each assault group moves as a unit, one member behind or beside the others. Thus a leader's assault group partners would have been

in close proximity to the leader while the other assault group would have been further away. The use of NVGs significantly helped the section see the other, further away assault groups.

The use of NVGs did not significantly improve the sections' awareness of the mission terrain or enemy position. Because the sections manoeuvred over dense and open woods the soldiers moved slowly and thus NVGs did not have a significant impact. If sight lines were longer and the terrain more difficult, it is probable that NVGs would have improved the sections' awareness of the terrain, such that they could have picked better routes (please not that pre-planned routes were based on amp reconnaissance, etc. and may not have indicated dense or impassable terrain to the planner, necessitating changes on the way). The use of NVGs did not significantly improve the sections' awareness of enemy locations. The enemy was only located during the assault when muzzle flashes gave away their position. Muzzle flashes were visible without NVGs so that the use of NVGs did not significantly improve the sections awareness of enemy locations.

### 4.2.3 Coordination and Overall Assessment Results

The impact on the level of NVG distribution was assessed for a variety of team and group coordination criteria and overall acceptance. The fully equipped section was judged to be "Borderline to Barely Acceptable" for the three coordination criteria and "Barely to Reasonably Acceptable" for overall acceptance. The partially equipped section (in-service) was judged to be "Borderline to Barely Acceptable" for all coordination criteria and for overall acceptance – see Figure 7.

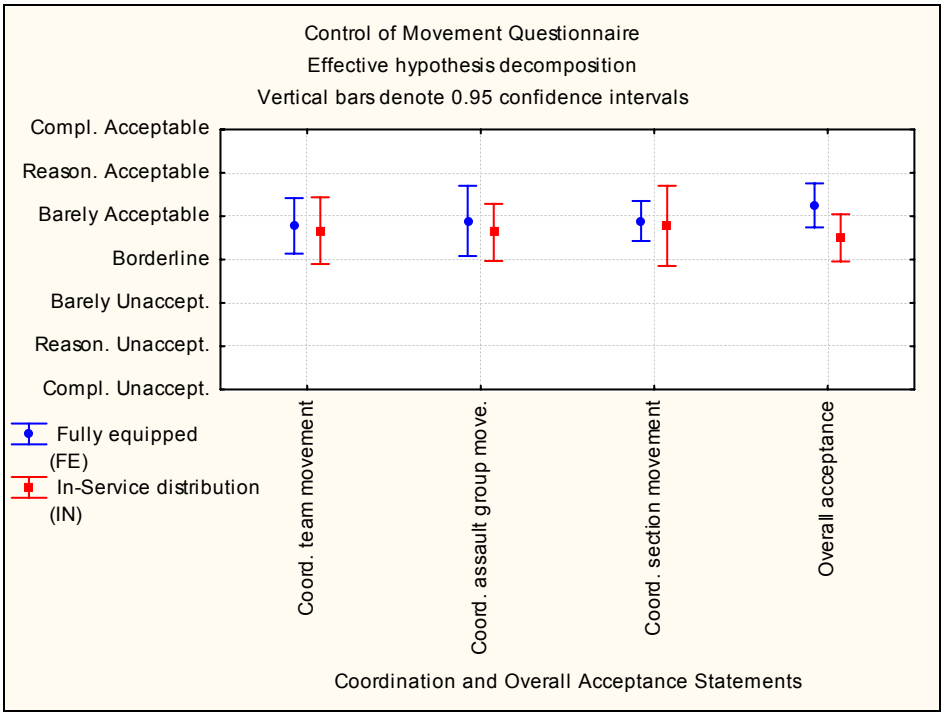



**Figure 7: Control of movement statement results (Q 12-15)**

A repeated measures analysis of variance for each criterion indicates that the fully equipped section was not considered significantly more acceptable than the partially equipped section for coordination of the different section elements. ANOVA results are detailed in Annex B

A repeated measures analysis of variance for overall acceptance indicates that the fully equipped section was considered significantly more acceptable than the partially equipped section but only at the $p = .059$ level. ANOVA results are detailed in Annex B.

Coordination of team and group movement occurs immediately prior to an attack or during the assault on an objective. Section commanders coordinate movement verbally during this phase of operations and because soldiers within teams or assault groups are relatively close, the use of NVGs has minor impacts on performance.

Overall there was strong support that a fully equipped section was more acceptable than a partially equipped section.

# 5. Discussion

This trial was conducted as one in a series of concurrent FBES VII experiments. The goal of this specific investigation was to quantify the impact of NVGs on tactical spacing and to investigate the impact of NVGs on section command and control.

The results from this trial suggest that section-level individual separation increased with the use of more NVGs during night operations. Soldiers of sections fully equipped with NVGs were spaced further apart than when they were not all equipped with NVGs. Full deployment of NVGs increased unit survivability (fewer soldiers were within single fragmentation weapon kill zone, i.e. a grenade's 5m blast zone) and the NVGs increased the unit's area of influence (the unit covered more ground).

The separation findings are constrained somewhat by the limitations in the approach used to measure separation. Because this study was undertaken within a bigger program of investigation it was impossible to stop section movement for long periods of time. Thus it was impossible to precisely measure distances between individuals at a number of different occasions. The utility of precise measurement is also questionable given that soldiers maintain their separations based on the thickness of brush and their ability to see the man or trail they are following. While exact separation distances were not identified, the tactical impact (i.e. individual separation) of fully equipping all soldiers with NVGs was demonstrated.

Equipping all soldiers with NVGs improved intra-section visual communications. Even though soldiers were further apart, the leaders believed that their soldiers were much more capable of observing hand signals, passing on messages, etc. Speed of information passage improved when all soldiers were equipped with NVGs. The full use of NVGs also improved the section's awareness of the location of other assault groups within the section and with the location of other adjacent sections.

In conclusion, this trial provides additional support that soldiers using NVGs have better tactical separation than units not fully equipped with NVGs and that NVGs improve intra-section communications.

If precise measurement of tactical spacing is required for modelling efforts, then further studies will be required using accurate measurement tools. Future studies could also examine the impact of different terrain types, vegetation densities and illumination conditions on individual separation.

# 6. References


A. 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*.

B. ANGEL, H.A., and VILHENA, P.V. (2005). Preliminary Evaluation of Distributed Sensors. Report CR2005-034. Toronto:ON, *Defence Research and Development Canada*.

# Annex A:
# Control of Movement Questionnaire

| PERSONAL DATA | Clearly print your Subject Number in the boxes provided. |
|---|---|

**NAME:** _____ **SUBJECT NUMBER:** _____

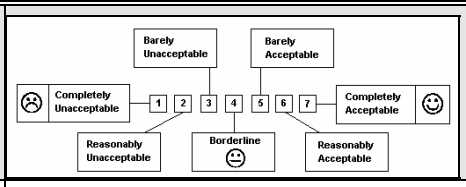
**PLATOON NUMBER:** _____ **SECTION NUMBER:**_____

**ASSULT GROUP NUMBER:** _____ **DATE:** _____

**TASK:** Wood O MOUT O

**N VG TYPE: NONE** O 504A O AN/PVS-14 O KITE O THERMAL O OTHER_____ O

After using the NVG, please provide ratings of acceptance, using the 7-point scale below. In addition to the space provided for comments, please use the back of the questionnaire for further elaboration and comments. If you make a mistake on the rating assessment, circle the correct answer. Write N/A if not appropriate

| **INFORMATION TRANSFER** |  | | | | | | |
|---|---|---|---|---|---|---|---|
| Ability to observe hand signals | O | O | O | O | O | O | O |
| Time needed to pass information | O | O | O | O | O | O | O |
| Ease of passing information | O | O | O | O | O | O | O |
| Accuracy of information passed | O | O | O | O | O | O | O |
| Noise discipline | O | O | O | O | O | O | O |
| **AWARENESS** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| Awareness of YOUR location | O | O | O | O | O | O | O |
| Awareness of the location of YOUR Assault Group members | O | O | O | O | O | O | O |
| Awareness of the location of the OTHER Assault Group(s) | O | O | O | O | O | O | O |
| Awareness of the location of OTHER Sections | O | O | O | O | O | O | O |
| Awareness of the mission terrain | O | O | O | O | O | O | O |
| Awareness of the enemy location(s) | O | O | O | O | O | O | O |

| COORDINATION | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Coordination of team movement | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Coordination of assault group movement | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Coordination of section movement | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| **OVERALL ACCEPTANCE** | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| COMMENTS |
|---|
| |

# Annex B:
# Significant Difference and Means for Control of Movement Questionnaire

**Table 3: Average and standard deviation for control of movement statement acceptability ratings**

| Control of Movement Statements | | Night Vision Goggles | |
|---|---|---|---|
| | | Fully Equipped | In-service distributed |
| **INFORMATION TRANSFER** | | | |
| Ability to Observe hand Signals | Mean | 5.7 | 4.8 |
| | STDev | 0.7 | 1.0 |
| | Number (N) | 9.0 | 9.0 |
| Time needed to pass information | Mean | 5.6 | 3.9 |
| | STDev | 0.7 | 1.1 |
| | Number (N) | 9.0 | 9.0 |
| Ease of passing information | Mean | 5.8 | 3.9 |
| | STDev | 0.7 | 0.9 |
| | Number (N) | 9.0 | 9.0 |
| Accuracy of information passed | Mean | 5.8 | 4.4 |
| | STDev | 0.7 | 1.4 |
| | Number (N) | 9.0 | 9.0 |
| Noise discipline | Mean | 5.3 | 4.6 |
| | STDev | 1.2 | 1.3 |
| | Number (N) | 9.0 | 9.0 |
| **AWARENESS** | | | |
| Awareness of YOUR location | Mean | 5.0 | 5.0 |
| | STDev | 1.1 | 1.0 |
| | Number (N) | 9.0 | 9.0 |
| Awareness of the Location of YOUR assault group members | Mean | 5.4 | 4.8 |
| | STDev | 0.5 | 1.1 |
| | Number (N) | 9.0 | 9.0 |
| Awareness of the Location of the OTHER assault group (s) | Mean | 5.1 | 3.8 |
| | STDev | 0.6 | 1.6 |
| | Number (N) | 9.0 | 9.0 |
| Awareness of the Location of OTHER sections | Mean | 4.8 | 3.6 |
| | STDev | 0.7 | 1.4 |
| | Number (N) | 8.0 | 9.0 |
| Awareness of the mission terrain | Mean | 4.3 | 4.4 |
| | STDev | 1.2 | 1.2 |
| | Number (N) | 9.0 | 9.0 |

| | | | |
|---|---|---|---|
| **Awareness of enemy location (s)** | **Mean** | **4.2** | **4.1** |
| | **STDev** | **1.6** | **1.1** |
| | **Number (N)** | **9.0** | **9.0** |
| **COORDINATION** | | | |
| **Coordination of team movement** | **Mean** | **4.8** | **4.7** |
| | **STDev** | **0.8** | **1.0** |
| | **Number (N)** | **9.0** | **9.0** |
| **Coordination of assault group movement** | **Mean** | **4.9** | **4.6** |
| | **STDev** | **1.1** | **0.9** |
| | **Number (N)** | **9.0** | **9.0** |
| **Coordination of section movement** | **Mean** | **4.9** | **4.8** |
| | **STDev** | **0.6** | **1.2** |
| | **Number (N)** | **9.0** | **9.0** |
| **OVERALL ACCEPTANCE** | | | |
| **Overall acceptance** | **Mean** | **5.3** | **4.5** |
| | **STDev** | **0.7** | **0.8** |
| | **Number (N)** | **8.0** | **8.0** |

Significant differences in statement acceptability ratings between conditions were found ($F_{(14, 112)} = 2.782$, MS = 1.87, $p = 0.001$) and a summary is presented below.

Univariate Tests of Significance for **Ability to Observe hand Signals**, Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 490.8889 | 1 | 490.8889 | 679.6923 | 0.000000 |
| **NVG type** | 3.5556 | 1 | 3.5556 | 4.9231 | **0.041310** |
| **Error** | 11.5556 | 16 | 0.7222 | | |

Univariate Tests of Significance for **Time needed to pass information,** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 401.3889 | 1 | 401.3889 | 489.8305 | 0.000000 |
| **NVG type** | 12.5000 | 1 | 12.5000 | 15.2542 | **0.001259** |
| **Error** | 13.1111 | 16 | 0.8194 | | |

Univariate Tests of Significance for **Ease of passing information** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 420.5000 | 1 | 420.5000 | 644.1702 | 0.000000 |
| **NVG type** | 16.0556 | 1 | 16.0556 | 24.5957 | **0.000142** |
| **Error** | 10.4444 | 16 | 0.6528 | | |

Univariate Tests of Significance for **Accuracy of information passed** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 470.2222 | 1 | 470.2222 | 380.4045 | 0.000000 |
| **NVG type** | 8.0000 | 1 | 8.0000 | 6.4719 | **0.021665** |
| **Error** | 19.7778 | 16 | 1.2361 | | |

Univariate Tests of Significance for **Noise discipline** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 440.0556 | 1 | 440.0556 | 268.5085 | 0.000000 |
| **NVG type** | 2.7222 | 1 | 2.7222 | 1.6610 | 0.215790 |
| **Error** | 26.2222 | 16 | 1.6389 | | |

Univariate Tests of Significance for **Awareness of YOUR location** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 450.0000 | 1 | 450.0000 | 400.0000 | 0.000000 |
| **NVG type** | 0.0000 | 1 | 0.0000 | 0.0000 | 1.000000 |
| **Error** | 18.0000 | 16 | 1.1250 | | |

Univariate Tests of Significance for **Awareness of the Location of YOUR assault group members**) Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 470.2222 | 1 | 470.2222 | 638.7925 | 0.000000 |
| **NVG type** | 2.0000 | 1 | 2.0000 | 2.7170 | 0.118779 |
| **Error** | 11.7778 | 16 | 0.7361 | | |

Univariate Tests of Significance for **Awareness of the Location of the OTHER assault group (s)**Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 355.5556 | 1 | 355.5556 | 253.4653 | 0.000000 |
| **NVG type** | 8.0000 | 1 | 8.0000 | 5.7030 | **0.029613** |
| **Error** | 22.4444 | 16 | 1.4028 | | |

Univariate Tests of Significance for **Awareness of the Location of OTHER sections** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 292.1601 | 1 | 292.1601 | 222.2063 | 0.000000 |
| **NVG type** | 6.0425 | 1 | 6.0425 | 4.5957 | **0.048849** |
| **Error** | 19.7222 | 15 | 1.3148 | | |

Univariate Tests of Significance for **Awareness of the mission terrain** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 346.7222 | 1 | 346.7222 | 229.0275 | 0.000000 |
| **NVG type** | 0.0556 | 1 | 0.0556 | 0.0367 | 0.850493 |
| **Error** | 24.2222 | 16 | 1.5139 | | |

Univariate Tests of Significance for **Awareness of enemy location (s)** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 312.5000 | 1 | 312.5000 | 175.7813 | 0.000000 |
| **NVG type** | 0.0556 | 1 | 0.0556 | 0.0312 | 0.861902 |
| **Error** | 28.4444 | 16 | 1.7778 | | |

Univariate Tests of Significance for **Coordination of team movement** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 401.3889 | 1 | 401.3889 | 473.7705 | 0.000000 |
| **NVG type** | 0.0556 | 1 | 0.0556 | 0.0656 | 0.801157 |
| **Error** | 13.5556 | 16 | 0.8472 | | |

Univariate Tests of Significance for **Coordination of assault group movement** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 383.3538 | 1 | 383.3538 | 389.4845 | 0.000000 |
| **NVG type** | 0.2949 | 1 | 0.2949 | 0.2997 | 0.592153 |
| **Error** | 14.7639 | 15 | 0.9843 | | |

Univariate Tests of Significance for **Coordination of section movement** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 420.5000 | 1 | 420.5000 | 465.7846 | 0.000000 |
| **NVG type** | 0.0556 | 1 | 0.0556 | 0.0615 | 0.807236 |
| **Error** | 14.4444 | 16 | 0.9028 | | |

Univariate Tests of Significance for **Overall acceptance** Sigma-restricted parameterization Effective hypothesis decomposition

| | SS | Degr. of | MS | F | p |
|---|---|---|---|---|---|
| **Intercept** | 380.2500 | 1 | 380.2500 | 709.8000 | 0.000000 |
| **NVG type** | 2.2500 | 1 | 2.2500 | 4.2000 | 0.059646 |
| **Error** | 7.5000 | 14 | 0.5357 | | |

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The results of this trial indicated that tactical spacing between individuals increased significantly when participants used night vision goggles (NVGs). NVGs also improved intra−section visual communications.

If precise measurement of tactical spacing is required for modelling efforts, then further studies will be required using accurate measurement tools. Future studies could also examine the impact of different terrain types, vegetation densities and illumination conditions on individual separation.

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