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Preliminary Evaluation of four Low Light Shield Designs for the Ballistic Eyewear

Location: **Fort Benning, Georgia** **Trial Date:** 26 April to 18 May, 2004

By

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Abstract

A fifteen-day field trial was performed at Fort Benning, Georgia, to evaluate the acceptability of the four low light shields (LLS) Ballistic Eyewear (BEW). The Canadian Land Forces acquired ReVision Ballistic Protective Eyewear (BEW) for the LF as part of the Clothe the Soldier (CTS) project. Currently, the BEW are issued with only a clear and a solar lens. There are a number of other lenses available for the ReVision eyewear system including "blue blockers" or amber lenses. Blue blockers commonly are sunglasses with amber lenses that block blue light. Blocking out blue light can make objects appear clearer in some situations, and for soldiers, aid in target detection and identification. This trial was broken down into a controlled portion and an uncontrolled portion. Fourteen regular force infantry soldiers participated in the controlled portion while twenty-eight regular force infantry soldiers participated in the uncontrolled portion. The controlled group performed a battery of dynamic, task-focused HF tests in a repeated measures design to assess the LLS BEW system. Assessment of the BEW system followed a progressive testing approach from an initial vision performance test to dynamic discrete twilight live fire testing to finally dynamic military battle task testing. The progressive testing approach focused user experience so that participants could make a knowledgeable assessment of overall acceptability for all four of the low-light shields. Data collection included questionnaires, focus groups, live fire performance and HF observer assessments. The uncontrolled group wore the eyewear during platoon and section attacks and section patrols as part of a Soldier Information Requirements Technology Demonstration (SIREQ-TD) experiment. Data collection for the uncontrolled group consisted of an exit focus group only. No overall difference in the number of targets engaged with the four different LLS was seen. The participants rated both the yellow and amber LLS as more acceptable than either the gradient or the orange LLS. Furthermore, most soldiers considered the low light shield BEW as a “nice to have”.

Résumé

Des essais en campagne d'une durée de quinze jours ont été menés à Fort Benning, en Georgie, pour évaluer l'acceptabilité de quatre lunettes de protection balistique (LPB) avec lentilles pour faible luminosité (LFL). Les forces terrestres canadiennes ont acquis les lunettes de protection balistique ReVision dans le cadre du projet Habillez le soldat. Présentement, les LPB sont distribuées avec une lentille claire et une lentille solaire seulement. Il existe beaucoup d'autres lentilles sur le marché, y compris les lentilles à effet « blue blocker » ou lentilles ambre. Les lentilles à effet « blue blocker » sont des lunettes de soleil ordinaires avec des lentilles de couleur ambre qui bloquent la lumière bleue. Dans certaines situations, en bloquant la lumière bleue, ces lentilles rendent les objets plus visibles, ce qui aide les soldats à détecter et à identifier l'objectif. Le présent essai a été subdivisé en deux parties, l'une avec contrôle, l'autre sans contrôle. Quatorze soldats d'infanterie de la force régulière ont participé aux essais avec contrôle alors que vingt-huit soldats ont participé aux essais sans contrôle. Le groupe des essais avec contrôle a été soumis à des essais dynamiques axés sur les tâches avec mesures répétées des facteurs humains pour évaluer le système de lunettes de protection balistique avec lentilles pour faible luminosité. Une évaluation du système LPB a été effectuée après une série d'essais progressifs allant d'un examen initial de l'acuité visuelle, à des essais dynamiques discrets effectués au crépuscule au cours d'un exercice de tir réel jusqu'à des essais dynamiques au combat. L'approche progressive était axée sur l'expérience des utilisateurs de sorte que les participants pouvaient faire une évaluation éclairée de l'acceptabilité globale des quatre lentilles pour faible luminosité. Les données ont été recueillies au moyen de questionnaires, de groupes de discussion, d'exercices de tir réel et d'une évaluation des facteurs humains. Le groupe des essais sans contrôle a porté les lunettes de protection balistique lors d'attaques menées par des pelotons et des sections et lors de patrouilles de section dans le cadre d'une expérience du Projet de démonstration technologique des besoins des soldats en matière d'information (SIREQ TD). La collecte des données, dans le cas du groupe sans contrôle, s'est réalisée uniquement au moyen d'un groupe de discussion final. Dans l'ensemble, on n'a remarqué aucune différence entre les quatre lentilles pour ce qui est du nombre d'objectifs engagés. Les participants ont accordé une meilleure cote aux lentilles de teinte jaune et ambre qu'aux lentilles de teinte graduée ou orange. De plus, la plupart des soldats a jugé que les lunettes comportant une lentille pour faible luminosité étaient « un article utile ».

Executive Summary

ReVision Eyewear has been awarded a contract to produce Ballistic Protective Eyewear (BEW) for the LF as part of the Clothe the Soldier (CTS) project. Currently, the BEW are issued with only a clear and a solar lens. There are a number of other lenses available for the ReVision eyewear system including "blue blockers" or amber lenses. Blue blockers commonly are sunglasses with amber lenses that block blue light. Blue light tends to scatter in the eye and lessens the ability of the user to see contrasts. The ability to see targets in hazy or twilight conditions is a particular concern for the LF. Thus, blocking out blue light may make objects appear clearer in some situations, aiding target detection and identification.

Although amber lenses are used extensively in shooting glasses and in aircrew visors, the need at the soldier level has not been established. To this end, DLR wishes to identify if amber lenses can improve soldier performance during twilight conditions and if so, which colour of lens provides the best performance.

The aim of this trial is to determine if low light shields can improve soldier performance and if so, which coloured lens provides the most improvements.

A fifteen-day field trial was undertaken at Fort Benning, Georgia over the period of 26 April to 18 May 2004. Forty-five regular force infantry soldiers from the 3rd Battalion Princess Patricia's Canadian Light Infantry regiment in Edmonton, Alberta took part in the experiment. The trial was broken down into two portions: a controlled portion and an uncontrolled portion. Twenty-eight soldiers took part in the uncontrolled portion. The uncontrolled segment consisted of wearing the eyewear during section and platoon attacks and section patrols that were part of a Soldier Information Requirements Technology Demonstration (SIREQ-TD) experiment. Data collection for this group consisted of an exit focus group. Fourteen soldiers participated in the controlled portion of the study. For this portion, the soldiers were required to undertake a battery of human factors tests while wearing four different low light or amber lens conditions in a repeated measures design. During each test, the order of conditions was balanced among participants. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

A progressive testing protocol was employed in the low lighting shield BEW trial. All low light shield eyewear was evaluated according to non-impact optical standards developed in earlier phases. Eyewear systems that met the minimum technical standards were forwarded for field evaluation. Previously developed human factors performance requirements provided the basis for field acceptance. Stage 1 begins with vision testing to determine the acceptance of each low light shield BEW on the Stereo Optical Optec 3500 system. The low light shield testing progressed from vision testing in phase 1, to dynamic discrete twilight live fire testing in phase 2A and finally dynamic military battle task testing in Phase 2B.

Human factors (HF) measures assessed the visual and task characteristic acceptability and overall acceptability. Data collection included task questionnaires, an Exit questionnaire, focus groups, live fire performance measures and HF observer assessments.

No overall difference in the number of targets engaged with the four different LLS BEW was seen. The participants rated both the yellow and amber LLS BEW as more acceptable than either the gradient or the orange LLS BEW. Furthermore, most soldiers considered the low light shield BEW as a "nice to have".

Sommaire

La société ReVision a obtenu un contrat pour fabriquer des lunettes de protection balistique (LPB) pour la Force terrestre dans le cadre du projet Habillez le soldat. Présentement, les lunettes de protection balistique ne sont distribuées qu'avec deux types de lentilles. Il existe sur le marché un certain nombre d'autres lentilles pour le système de lunettes ReVision, notamment les lentilles à effet « blue blocker » ou lentilles ambre. Les lentilles à effet « blue blocker » sont des lunettes de soleil ordinaires avec des lentilles ambre qui bloquent la lumière bleue. La lumière bleue a tendance à se disperser dans l'oeil et à atténuer les contrastes. La capacité de voir des objectifs à travers le brouillard ou dans une lumière crépusculaire est très importante pour la Force terrestre. Donc, la possibilité de bloquer la lumière bleue rendrait les objets plus visibles dans certaines conditions et contribuerait à mieux repérer et identifier l'objectif.

Bien que des lentilles ambre soient beaucoup utilisées pour les lunettes de tir et les visières des équipages d'aéronefs, pour les soldats, on n'a pas encore établi leur nécessité. À cette fin, le DBRT souhaite établir si les lentilles ambre peuvent améliorer la performance du soldat dans des conditions crépusculaires et, dans l'affirmative, avec quelle couleur de lentille on obtiendrait l'amélioration la plus prononcée.

Le but de ces essais est d'établir si les lentilles pour faible luminosité peuvent améliorer la performance des soldats et, si c'est le cas, quelle couleur de lentille est la plus efficace.

Des essais en campagne d'une durée de quinze jours ont été menés à Fort Benning, en Georgie, du 26 avril au 18 mai 2004. Quarante-cinq soldats d'infanterie de la force régulière du 3^{e} bataillon du régiment Princess Patricia's Canadian Light Infantry basé à Edmonton, en Alberta, y ont participé. Les essais ont été subdivisés en deux parties : une partie avec contrôle et l'autre sans contrôle. Vingt-huit soldats ont pris part à la partie sans contrôle. Elle consistait à porter les lunettes lors d'attaques menées par des sections et des pelotons et de patrouilles de section effectuées dans le cadre d'une expérience du Projet de démonstration technologique des besoins des soldats en matière d'information (SIREQ TD). La collecte des données dans le cas de ce groupe s'est effectuée au moyen d'un groupe de discussion final. Quatorze soldats ont participé à la partie de l'étude avec contrôle. On a demandé à ces derniers de se soumettre à divers tests des facteurs humains pendant qu'ils portaient quatre lentilles différentes pour faible luminosité ou lentilles ambre et on a procédé à des mesures répétées. Pour chaque essai, l'ordre des conditions a été réparti également entre les participants. Les données ont été recueillies à l'aide de questionnaires, de groupes de discussion, de mesures de la performance et d'évaluations des facteurs humains.

Un protocole d'essai progressif a été employé pour évaluer les LPB avec LFL. Toutes les lunettes à lentilles pour faible luminosité ont été évaluées conformément à des normes d'acuité visuelle sans impact élaborées antérieurement. Les systèmes de lunettes qui respectaient les normes techniques minimales ont été soumis aux essais en campagne. Les résultats de ces essais ont été évalués en fonction d'exigences de performance liées aux facteurs humains. La phase 1 commence avec des essais d'acuité visuelle pour déterminer l'acceptabilité de chaque LPB à LFL sur l'appareil de mesure de l'acuité visuelle Stereo Optical Optec 3500. Le protocole d'essai des lentilles comporte des tests de l'acuité visuelle à la phase 1, des essais dynamiques de tir en conditions crépusculaires effectués à la phase 2A et enfin des essais dynamiques au combat à la phase 2B.

Les mesures des facteurs humains (FH) ont permis d'évaluer l'acceptabilité sur le plan de l'acuité visuelle et de la performance en situation réelle de travail et l'acceptabilité globale. La collecte des

données s'est effectuée au moyen de questionnaires axés sur les tâches et d'un questionnaire final, de groupes de discussion, de mesures de la performance pendant un exercice de tir réel et d'évaluations des facteurs humains.

Dans l'ensemble, aucune différence dans le nombre d'objectifs engagés n'a été constatée avec les quatre différentes LPB avec LFL. Les participants ont accordé une meilleure cote aux lentilles de teintes jaune et ambre qu'à celles de teinte graduée et orange. De plus, la plupart des soldats ont jugé que les lunettes de protection balistique avec lentilles pour luminosité faible étaient « un article utile ».

Table of Contents

List of Figures and Tables

FIGURE

TABLES

1. Background

ReVision Eyewear has been awarded a contract to produce Ballistic Eyewear (BEW) for the LF as part of the Clothe the Soldier (CTS) project. Currently, the BEW are issued with only a clear and a solar lens. There are a number of other lenses available for the ReVision eyewear system including "blue blockers" or amber lenses. Blue blockers commonly are sunglasses with amber lenses that block blue light. Blue light tends to scatter in the eye and lessens the ability of the user to see contrasts. The ability to see targets in hazy or twilight conditions is a particular concern for the LF. Thus blocking out the blue light may make objects appear clearer in some situations, aiding target detection and identification.

Although amber lenses are used extensively in shooting glasses and in aircrew visors, the need at the soldier level has not been established. To this end, DLR wishes to identify if amber lenses can improve soldier performance during twilight or low light conditions and if so, which colour of lens provides the best performance.

2. Aim

The aim of this trial is to determine if low light shields can improve soldier performance and if so, which colour lens provides the most improvement.

3. Method

3.1 Overview

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

A fifteen-day field trial was undertaken at Fort Benning, Georgia over the period of 26 April to 18 May 2004. Regular force infantry soldiers from 3rd Battalion Princess Patricia's Canadian Light Infantry, Edmonton, Alberta, participated in this investigation. This preliminary investigation included several levels of testing. A subset of the soldiers completed range tests (n=14) and evaluated every tint of low light lens in a controlled test approach, while the remainder (n=28) assessed the amber lenses in an uncontrolled trial approach. The soldiers performing the range tests completed task questionnaires, exit questionnaires and participated in an exit focus group discussion. The remainder of the soldiers participated only in an exit focus group discussion. During the controlled test, the order of conditions was balanced among participants and controlled by an HF observer. Data collection included questionnaires, focus groups, performance measures and assessments by an HF observer.

The aim of the trial was to assess the eyewear during low light and twilight conditions. For the purposes of this investigation the following definitions for low light and light conditions were used. Further definitions are contained in Annex A.

Low lighting conditions

Definition:

From sunset to Nautical twilight in the evening (approximately 46 min in April and 47 min in May)

From Nautical twilight to sunrise in the morning (approximately 46 min in April and 47 min in May)

Light conditions

Definition:

From the beginning of sunrise in the morning and end of sunset in the evening

Night Conditions

Definition:

After the beginning of Nautical twilight in the evening and before the end of Nautical twilight in the morning.

3.2 Trial Structure

This preliminary investigation included several levels of testing. A subset of the soldiers participating in the trial completed range tests (n=14). The soldiers who completed the range test also assessed the amber lenses daily through task questionnaires. The remainder of the participants (n=28) assessed the amber lenses throughout the trial in an uncontrolled fashion; these soldiers participated only in an exit focus group discussion.

The uncontrolled group performed the following tasks as part of the concurrent SIREQ-TD study:

- Section level patrols; and
- Section and Platoon attacks (fire and movement) in wooded and urban environments.

3.3 Trial Participants

Controlled:

Fourteen regular force infantry soldiers, with 6/6 uncorrected vision were required for the duration of the trial. The participants selected for this trial were members of regular infantry sections, each with seven or eight soldiers. Senior non-commissioned officers (NCOs) acted as Section Commanders throughout the trial.

Uncontrolled:

Twenty-eight regular force infantry soldiers previously tasked to participate in the SIREQ-TD study were selected for this portion of the trial. This uncontrolled portion was completed as a simultaneous addition to the SIREQ trial. Senior non-commissioned officers (NCOs) acted as Section Commanders throughout the trial.

3.4 Low Light Shield Ballistic Eyewear Designs (LLS BEW)

The following four Low Light Shield (LLS) lenses were evaluated in the trial:

3.4.1 Yellow Lens

Figure 1: Yellow Lens

3.4.2 Amber Lens

Figure 2: Amber Lens

3.4.3 Orange Lens

Figure 3: Orange Lens

3.4.4 Gradient Orange Lens

Figure 4: Gradient Orange Lens

3.5 Questionnaire Rating Scale

Participants rated acceptability in all questionnaires using the following seven-point scale (Figure 5).

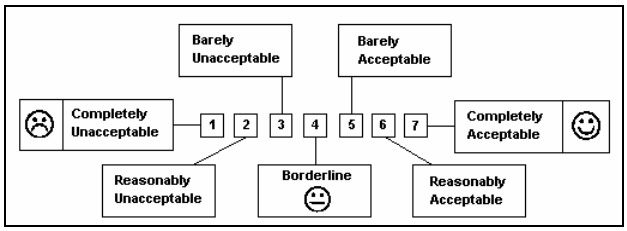


Figure 5: Standard Rating Scale

3.6 Data

Data collection focused on the HF requirements detailed below. The order in which trial participants were exposed to the different low light shields was balanced.

- Objective data
  - Visual performance with Stereo Optical Optec 3550
  - Live fire performance
- Subjective data
  - Daily range questionnaire
  - Fighting patrol and MOUT daily questionnaire
  - Exit questionnaire
- Focus group discussion on acceptability of the Low Light Shield Ballistic Eyewear for dismounted infantry

3.6.1 Objective Data

3.6.1.1 Vision Performance

The extent to which LLS BEW interferes with acuity, colour perception and stereo depth was assessed. Subjects were tested for the following:

- Near Acuity
- Far Acuity
- Far Colour Perception
- Far Stereo Depth

3.6.1.2 Target engagement Performance

14 participants performed a live fire test using the C7 rifle on a 300m firing range during twilight conditions. A target controller ran controlled target serials and firing accuracy data was collected. Participants engaged 7 pop-up targets at different ranges (50m left, 50m right, 100m, 150m, 200m, 250m, 300m) with a single shot for each target. Targets were raised until each participant completed his 7 shots; then any remaining targets were dropped. Serials remained the same for each condition of low-light shield.

3.6.2 Subjective Data

3.6.2.1 Daily Range Questionnaire

The degree to which the low light shields affected a soldier's performance of dynamic discrete military live fire activities was assessed via a daily range questionnaire. The participants were required to rate their perception of acceptability – see Annex B. Subjects rated each low light shield design for the following acceptability criteria:

- Visual Characteristics
- Task Characteristics
- Overall

3.6.2.2 Daily fighting and MOUT Questionnaire

The degree to which the low light shields affected a soldier's performance of dynamic military tasks was gathered through a Daily Fighting and MOUT questionnaire. Typical tasks included:

- MOUT (Military Operation in Urban Terrain);
- Platoon attacks (fire and movement) in a wide range of environments; and
- Section attacks (fire and movement) in a wide range of environments.

The participants were required to rate their perception of acceptability. Subjects rated three features for all four low light shield designs for acceptability:

- Overall Visual Characteristics
- Overall Task Performance

- Overall

3.6.2.3 Exit Questionnaire

The soldiers ranked the four low light shields in order of merit - see Annex C. Subjects ranked each low light shield design for the following criteria:

- Visual characteristics
- Task Characteristics
- Overall

3.6.3 Focus Group

A final focus group discussion was held with all participants from both the controlled and uncontrolled trials at the completion of the testing. Participants were encouraged to describe and discuss the suitability and usability of the various ballistic eyewear low light shields used in this trial

3.7 Data Collection

The percentage of participants rating each low light shield 'acceptable' (i.e. ≥ 4 on the seven point acceptance scale) was analysed for each item. An item was considered acceptable if ≥80% of participants rated it acceptable.

3.8 Limitations

ALTHOUGH THE AIM OF THIS INVESTIGATION WAS TO ASSESS THE EYEWEAR UNDER TWILIGHT OR LOW LIGHT CONDITIONS, MOST OF THE EVALUATION WAS DONE IN HIGH ILLUMINATION (SUNNY) CONDITIONS. WHILE OPERATIONS INVOLVING MOVEMENT IN AND OUT OF DARK INTERIOR ROOMS WERE CONDUCTED, LIMITED AVAILABILITY OF THE MOUT SITE RESULTED IN LESS OF THIS ACTIVITY THAN ORIGINALLY PLANNED.

4. Results

Fourteen participants carried out an evaluation of four colours of low light BEW. The results of the trial were organized as follows:

- Objective data
  - Visual performance with Stereo Optical Optec 3550
  - Live fire performance
- Subjective data
  - Daily range questionnaire
  - Fighting patrol and MOUT daily questionnaire

- Exit questionnaire
  - Low light shield ranking
- Focus Group discussion

4.1 Objective Results

4.1.1. Live Fire Performance

Table 1 summarizes the live fire performance results for the 14 participants who performed this component of the study. The percentages show the on-target percentage by range for each shield colour.

Low Light Shield	Range Bands							Overall Hits
	300 m	250 m	200 m	150 m	100 m	50 m Left	50 m Right	
Yellow	31%	58%	73%	82%	76%	97%	88%	72%
Amber	29%	58%	72%	82%	67%	95%	90%	70%
Gradient	41%	56%	69%	**64%**	73%	91%	87%	69%
Orange	37%	54%	**59%**	82%	71%	88%	92%	69%
Clear	38%	59%	61%	72%	63%	89%	89%	67%

Table 1: Live fire Performance Results

There was no overall difference seen between the four low light shields or the clear BEW shield across most of the target ranges. There were differences observed at the 200 and 150m ranges for the Orange and the Gradient lenses respectively (shaded cells) but these differences were not significant.

In conclusion, all four LLS BEW performed similarly to each other in twilight live fire target engagements. No quantifiable improvement was noted with the use of low light lenses.

4.1.2 Visual performance with Stereo Optical Optec 3500

Testing was conducted with each participant and low light tint.

- **Near Acuity**
  - Subjects had either 6/9 or 6/6 acuity and no overall difference between the low light shields was seen.
- **Far Acuity**
  - Subjects had either 6/9 or 6/6 acuity and no overall difference between the low light shields was seen.
- **Far Colour Perception**
  - Overall most subjects passed and no overall difference between the low light

shields was seen.

- **Far Stereo Depth**
    - Subjects had either acceptable or normal depth perception; no overall difference between the low light shields was seen.

In conclusion, all four LLS had similar visual performance scores. The low light shields did not adversely affect near or far visual acuity, colour perception or depth perception.

4.2 Subjective Results

4.2.2 Daily Range Questionnaire

Following each serial of the live fire task, participants completed a Daily Range task questionnaire regarding the visual characteristics, task performance and overall ratings. Using the standard seven-point scale of acceptance, participants rated the acceptance of the low light shields. The results below indicate the percentage of participants rating the items greater than 4 ("borderline").

Overall	User Acceptance Rating ≥ 4				
	Yellow	Amber	Gradient	Orange	Clear
Visual Characteristics					
Distortion of colour	92%	92%	**75%**	**75%**	91%
Degree of tint	92%	92%	83%	83%	91%
Consistency of tint	83%	92%	**75%**	92%	90%
Depth perception	92%	83%	**75%**	83%	91%
Visual acuity	92%	92%	**75%**	83%	91%
Visual sharpness (side)	92%	92%	**75%**	83%	91%
Visual sharpness (fwd)	83%	83%	**75%**	83%	91%
Task Characteristics					
Close-in target engagement	92%	91%	92%	91%	92%
Intermediate target engagement	92%	91%	**75%**	**73%**	92%
Far target engagement	83%	**64%**	**58%**	**64%**	92%
Search for targets	92%	83%	**67%**	75%	92%
Detect targets	92%	83%	**67%**	**75%**	92%
Overall					
Visual characteristics	83%	83%	83%	83%	92%
Task performance	83%	83%	**75%**	**75%**	83%

Overall	83%	83%	**67%**	**75%**	83%

Table 2 Daily Range Questionnaire Results

On the Daily Range questionnaire, greater than 80% of the participants rated the clear, yellow and amber low-light shields as acceptable for visual and task characteristics. The only exception seen was for the amber lenses, which were rated less than 80% acceptable for far target engagements. Less than 80% of the participants rated the gradient and orange low light shields acceptable for overall task performance and overall acceptance.

In conclusion, participants preferred clear, yellow and amber low light shields over both gradient and orange for the range tasks.

4.2.3 Daily Fighting Patrol and MOUT Questionnaire

Each participant, after every two days of fighting and MOUT tasks, completed a series of questions regarding the overall visual characteristics, overall task performance and overall ratings. Using the standard seven-point scale of acceptance, participants rated the acceptance of the low light shields for the three questions. The results below indicate the percentage of participants rating the items greater than or equal to 4 ("borderline").

Overall	**User Acceptance Rating ≥ 4**				
	Yellow	**Amber**	**Gradient**	**Orange**	**Clear**
Visual Characteristics	85%	100%	80%	100%	100%
Task Performance	85%	92%	80%	92%	100%
Overall	85%	92%	**73%**	92%	100%

Table 3 Fighting Patrol and MOUT Daily Questionnaire Results

On the Daily Fighting Patrol and MOUT questionnaire, greater than 80% of the participants rated the yellow, amber, gradient, orange and clear lenses acceptable for visual and task characteristics. The only exception seen was for gradient with a less-than-80% rating for overall acceptance.

In conclusion, participants preferred the clear, yellow, amber and orange low light shields over the gradient LLS for daily fighting patrol and MOUT tasks.

4.2.4 Exit Questionnaire

After completing the serials, each participant in the controlled trial completed a series of questions and rankings. Each participant ranked all four low light shields in order of merit. The results from these questionnaires are presented in Figures 4a, 4b and 4c.

Questions	**answers**
Should the land forces issue low light shields?	64% "yes"
If yes, to whom?	72% "combat arms"
Is low light shield BEW a "must have" or "nice have"?	16% "must have"

If yes, what tint?	
Low light shield	**Percentage**
Yellow	**43%**
Amber	**31%**
Orange	**16%**
Gradient	**10%**

Table 4a and 4b Exit Questionnaire Results

The majority of participants believed the army should buy low light shields for combat arms personnel on operational deployments. When asked if low light lenses are a 'must have' or a 'nice to have', only 10.7 % responded that low light lenses are a 'must have'.

The majority of the participants believed that the yellow tint would be the best tint for operational uses.

4.2.4.1 Low Light Shield Ranking

The participants evaluated the four low light shields by ranking them in order from best (1) to worst (4) for a number of eyewear features. The mean and standard deviation values from all participants' evaluations are presented in Table 4c.

		Yellow	Amber	Orange	Gradient
Visual Characteristics					
Distortion of Colour	**Mean**	1.6	2.2	2.7	3.2
	Stdev	1.1	0.8	0.8	1.1
Degree of Tint (is it dark enough?)	**Mean**	1.9	2.0	3.1	2.4
	Stdev	1.2	0.8	1.0	1.2
Consistency of Tint	**Mean**	1.9	1.9	2.9	2.8
	Stdev	1.2	0.6	0.8	1.3
Depth Perception	**Mean**	1.4	1.9	2.6	3.1
	Stdev	0.9	0.9	0.9	1.1
Visual Acuity	**Mean**	1.6	1.9	2.7	3.4
	Stdev	0.9	0.7	0.6	0.9
Visual Sharpness (side)	**Mean**	1.6	1.7	2.6	2.9
	Stdev	1.0	0.7	0.9	1.1
Visual Sharpness (fwd)	**Mean**	1.6	1.7	2.6	3.0

	Stdev	1.0	0.7	0.9	1.2
Task Performance					
Target detection far (Open/range)	**Mean**	1.3	2.1	2.9	3.5
	Stdev	0.6	0.7	0.8	0.8
Target detection near (Open/range)	**Mean**	1.1	2.1	2.9	3.4
	Stdev	0.4	0.9	0.9	0.9
Target detection far (MOUT)	**Mean**	1.6	1.9	3.0	3.1
	Stdev	0.9	0.7	0.9	1.1
Target detection near (MOUT)	**Mean**	1.4	2.0	2.8	3.4
	Stdev	0.9	0.8	0.8	0.9
Target detection far (Woods)	**Mean**	1.4	2.0	2.9	3.4
	Stdev	0.8	0.7	0.8	0.9
Target detection near (Woods)	**Mean**	1.5	2.0	2.9	3.4
	Stdev	0.9	0.8	0.9	0.8
Transition outside to inside buildings	**Mean**	1.6	1.8	3.1	3.4
	Stdev	0.9	0.7	0.8	0.8
Day task	**Mean**	3.2	2.2	2.2	1.8
	Stdev	0.9	0.9	1.1	1.3
Twilight tasks	**Mean**	1.5	2.4	3.3	3.9
	Stdev	1.1	1.1	0.7	0.4
Night tasks	**Mean**	1.9	2.5	3.3	3.9
	Stdev	1.4	1.2	0.7	0.3
Close-in target engagement (less than 100m)	**Mean**	1.4	2.2	2.9	3.5
	Stdev	0.9	1.0	0.9	0.9
Intermediate targets engagement (100m to 300m)	**Mean**	1.4	2.3	3.0	3.6
	Stdev	0.8	1.0	0.9	0.9
Far target engagement (greater than 300m)	**Mean**	1.5	2.4	3.2	3.6
	Stdev	0.9	1.0	0.7	0.7
Search for targets	**Mean**	1.4	2.3	2.9	3.4
	Stdev	0.9	1.1	0.9	0.9
Overall	**Mean**	1.6	1.9	3.0	3.3
	Stdev	1.1	0.9	0.9	1.0

Table 4c Low Light Shield Ranking Results

The results show no significant difference between rankings for the yellow and amber lenses, however, the gradient and orange lenses were ranked significantly lower than both the yellow and amber lenses.

In conclusion, the participants preferred the yellow and amber low light shields over the gradient and orange low light shields.

4.3 Focus Group Results

At the end of the trial all participants completed a focus group regarding the low light shield ballistic eyewear protection. The exit focus group occurred following the trial at the McKenna MOUT site, on May 18, 2004. Therefore, the discussion took place after all participants had exposure to all four of the different low light shields. A summary of the comments made by the participants during the focus group discussion is presented below.

Three participants were unable to attend the focus group, putting the attendance at 28 instead of 31. Most of the uncontrolled-trial participants (24 out of 28) agreed that the low light shields should be acquired for the army. Most of these soldiers (27 out of 28) agreed that the low light shields are needed for operational use only. Only 3 out of 28 uncontrolled-trial participants considered the low light shields a 'must have' piece of equipment. Soldiers' preferences for the low light shields were:

Low light shield	Percentage
Yellow	46.4%
Amber	28.6%
Gradient	3.6%
Orange	3.6%
Did not vote	17.9%

Most of the exit focus group participants (17 out of 28) reported that the defogging mist did not work. Most participants (26 out of 28) reported scratches on their lenses.

In conclusion, participants preferred the yellow and amber low light shields over the gradient or orange LLS eyewear. However, most participants did not consider there is a 'must have' need for any low light shield BEW.

5.Discussion

A battery of scientific human factors performance tests were conducted at Fort Benning, Georgia as part of a low light shield design evaluation. Four different submissions were tested to determine if they met the HF performance specifications.

The live fire results showed little difference between tints or any quantifiable improvement over clear lenses. It may be possible that the short detection ranges eliminated any variation in performance or that variations in detection were not manifested in the accuracy scores (performance was based on hits, not detection). Thus it is possible that performance differences between tints would be observed if a longer range and a detection-only trial protocol were conducted.

The daily range questionnaire identified issues with both gradient and orange low light shield designs with rifle task compatibility and overall acceptability. Both yellow and amber LLS BEW designs were rated acceptable for visual and task characteristics by most (80% +) of the participants. This study suggests that both the yellow and amber LLS BEW were preferred over the gradient and orange LLS BEW for live fire target engagement.

The participants preferred the yellow, amber and orange low light shields over the gradient LLS for overall acceptability in the fighting patrol and MOUT operations. Accordingly, most participants rated the yellow, amber and orange LLS BEW acceptable for fighting patrol and MOUT tasks.

The exit questionnaire identified the preference of the participants for both yellow and amber LLS designs over the gradient and orange LLS designs. However, most participants (84%) considered the LLS BEW lens as a “nice to have” and not a required item of equipment.

In the focus group discussion with the uncontrolled trial participants, both yellow and amber tints were preferred over gradient and orange LLS BEW designs by most of the participants. However, most participants again did not consider there was a “must have” need for any low light shield BEW.

6. Recommendations

The utility of LLS was not demonstrated in this preliminary study. It is recommended that a detection-only study utilizing longer ranges be undertaken to examine the utility of LLS. As well, the utility of LLS in MOUT operations was not adequately assessed in this preliminary study. The LLS should be examined in a dedicated MOUT trial involving multi-story buildings with unlit interior rooms and hallways.

Reference

A. Definitions (P.K. Seidelmann) Retrieved April 3, 2004, from http://aa.usno.navy.mil/faq/docs/RST_defs.html#top

Annex A – Rise, Set and Twilight Definitions

Rise, Set, and Twilight Definitions:

Horizon: Wherever one is located on or near the Earth's surface, the Earth is perceived as essentially flat and, therefore, as a plane. The sky resembles one-half of a sphere or dome centered at the observer. If there are no visual obstructions, the apparent intersection of the sky with the Earth's (plane) surface is the horizon, which appears as a circle centered at the observer. For rise/set computations, the observer's eye is considered to be on the surface of the Earth, so that the horizon is geometrically exactly 90 degrees from the local vertical direction.

Rise, Set: During the course of a day the Earth rotates once on its axis causing the phenomena of rising and setting. All celestial bodies, stars and planets included, seem to appear in the sky at the horizon to the East of any particular place, then to cross the sky and again disappear at the horizon to the West. The most noticeable of these events, and the most significant in regard to ordinary affairs, are the rising and setting of the Sun and Moon. Because the Sun and Moon appear as circular disks and not as points of light, a definition of rise or set must be very specific, for not all of either body is seen to rise or set at once.

> **Sunrise and sunset** conventionally refer to the times when the upper edge of the disk of the Sun is on the horizon, considered unobstructed relative to the location of interest. Atmospheric conditions are assumed to be average, and the location is in a level region on the Earth's surface.

> **Moonrise and moonset** times are computed for exactly the same circumstances as for sunrise and sunset. However, moonrise and moonset may occur at any time during a 24 hour period and, consequently, it is often possible for the Moon to be seen during daylight, and to have moonless nights. It is also possible that a moonrise or moonset does not occur relative to a specific place on a given date.

Transit: The transit time of a celestial body refers to the instant that its center crosses an imaginary line in the sky - the observer's meridian - running from north to south. For observers in low to middle latitudes, transit is *approximately* midway between rise and set, and represents the time at which the body is highest in the sky on any given day. At high latitudes, neither of these statements may be true - for example, there may be several transits between rise and set. The transit of the Sun is local solar (sundial) noon. The difference between the transit times of the Sun and Moon is closely related to the Moon's phase. The New Moon transits at about the same time as the Sun; the First Quarter Moon transits about 6 hours after the Sun; the Full Moon transits about 12 hours after/before the Sun; and the Last Quarter Moon transits about 6 hours before the Sun.

Annex A:

Rise, Set and Twilight definitions

Twilight: Before sunrise and again after sunset there are intervals of time, twilight, during which there is natural light provided by the upper atmosphere, which does receive direct sunlight and reflects part of it toward the Earth's surface. Some outdoor activities may be conducted without artificial illumination during these intervals, and it is useful to have some means to set limits beyond which a certain activity should be assisted by artificial lighting. The major determinants of the amount of natural light during twilight are the state of the atmosphere generally and local weather conditions in particular. Atmospheric conditions are best determined at the actual time and place of events. Nevertheless, it is possible to establish useful, though necessarily approximate, limits applicable to large classes of activities by considering only the position of the Sun below the local horizon. Reasonable and convenient definitions have evolved.

> **Civil twilight** is defined to begin in the morning, and to end in the evening when the center of the Sun is geometrically 6 degrees below the horizon. This is the limit at which twilight illumination is sufficient, under good weather conditions, for terrestrial objects to be clearly distinguished; at the beginning of morning civil twilight, or end of evening civil twilight, the horizon is clearly defined and the brightest stars are visible under good atmospheric conditions in the absence of moonlight or other illumination. In the morning before the beginning of civil twilight and in the evening after the end of civil twilight, artificial illumination is normally required to carry on ordinary outdoor activities. Complete darkness, however, ends sometime prior to the beginning of morning civil twilight and begins sometime after the end of evening civil twilight.

> **Nautical twilight** is defined to begin in the morning, and to end in the evening, when the center of the sun is geometrically 12 degrees below the horizon. At the beginning or end of nautical twilight, under good atmospheric conditions and in the absence of other illumination, general outlines of ground objects may be distinguishable, but detailed outdoor operations are not possible, and the horizon is indistinct.

> **Astronomical twilight** is defined to begin in the morning, and to end in the evening when the center of the Sun is geometrically 18 degrees below the horizon. Before the beginning of astronomical twilight in the morning and after the end of astronomical twilight in the evening the Sun does not contribute to sky illumination; for a considerable interval after the beginning of morning twilight and before the end of evening twilight, sky illumination is so faint that it is practically imperceptible.

Definitions (P.K. Seidelmann) Retrieved April 3, 2004, from http://aa.usno.navy.mil/faq/docs/RST_defs.html#top

> This information is derived from the *Explanatory Supplement to the Astronomical Almanac*, ed. P. K. Seidelmann (1992), pp 482ff.

Annex B – Daily Range Questionnaire

Daily Range Questionnaire: Low Light Shield

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

NAME: _____ SUBJECT NUMBER: _____

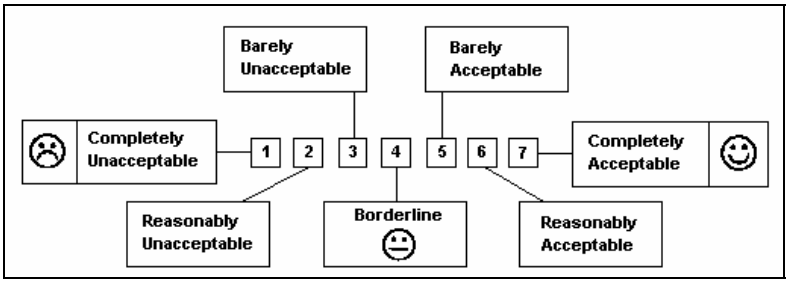
PLATOON NUMBER: _____ SECTION NUMBER:_____

DATE: _____ TASK: _____

LOW LIGHT SHIELD: Yellow ○ Amber ○ Gradient ○ Orange ○

DIRECTIONS:

After using the low light shield, please provide ratings of acceptance for visual characteristics, task performance, compatibility and overall acceptance, using the 7-point scale below.

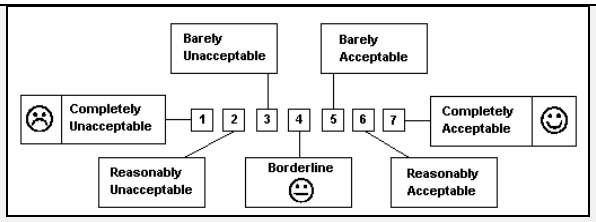


In addition to the space provided for comments, please use the back of the questionnaire for further elaboration and comments. If you make a mistake on the rating assessment, circle the correct answer. Check N/A if not appropriate

COMMENTS

Annex B:

Daily Range Questionnaire

								N/A
Visual Characteristics	1	2	3	4	5	6	7	
Distortion of colour	○	○	○	○	○	○	○	○
Degree of tint (is it dark enough?)	○	○	○	○	○	○	○	○
Consistency of tint	○	○	○	○	○	○	○	○
Depth perception	○	○	○	○	○	○	○	○
Visual acuity	○	○	○	○	○	○	○	○
Visual sharpness (side)	○	○	○	○	○	○	○	○
Visual sharpness (fwd)	○	○	○	○	○	○	○	○
Task performance	1	2	3	4	5	6	7	
Close-in target engagement (less than 100 m)	○	○	○	○	○	○	○	○
Intermediate targets engagement (100m to 300m)	○	○	○	○	○	○	○	○
Far target engagement (greater than 300m)	○	○	○	○	○	○	○	○
Search for targets	○	○	○	○	○	○	○	○
Detect targets	○	○	○	○	○	○	○	○
Compatibility	1	2	3	4	5	6	7	
Compatibility with night vision goggles (NVG)	○	○	○	○	○	○	○	○
Compatibility with laser aiming devices (LAD)	○	○	○	○	○	○	○	○
	○	○	○	○	○	○	○	○

Annex B:

Daily Range Questionnaire

Overall Acceptance	1	2	3	4	5	6	7
Visual characteristics	○	○	○	○	○	○	○
Task performance	○	○	○	○	○	○	○
Overall	○	○	○	○	○	○	○

Annex C – Exit Questionnaire

Annex C:

Exit Questionnaire

Exit Ranking Questionnaire: Low Light Shield

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

NAME: _____ SUBJECT NUMBER: _____

PLATOON NUMBER: _____ SECTION NUMBER:_____

DATE: _____

DIRECTIONS:

After using all four low light shields, please rank the low light shields in order of merit for each criteria, using the following for ranking system.

Score the low light shield which performed best in your evaluation as one (1), the next best as two (2) the next best as three (3) and the worst as four (4) for each

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 ranking assessment, circle the correct answer. N/A if not appropriate.

COMMENTS

Annex C:

Exit Questionnaire

Please rank the four low light shields in order of merit for the criteria below. Score the low light shield which performed best in your evaluation as one (1), the next best as two (2) the next best as three (3) and the worst as four (4).

	Yellow	Amber	Gradient	Orange
Visual Characteristics				
Distortion of Colour				
Degree of Tint (is it dark enough?)				
Consistency of Tint				
Depth Perception				
Visual Acuity				
Visual Sharpness (side)				
Visual sharpness (fwd)				

Annex C:

Exit Questionnaire

Task Performance				
Target detection far (Open/range)				
Target detection near (Open/range)				
Target detection far (MOUT)				
Target detection near (MOUT)				
Target detection far (Woods)				
Target detection near (Woods)				
Transition outside to inside (buildings)				
Day tasks				
Twilight tasks				
Night tasks				
Close-in target engagement (less than 100 m)				
Intermediate target engagement (100m to 300m)				
Far target engagement (greater than 300m)				
Search for targets				
Overall				

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Preliminary evaluation of four low light shield designs for the ballistic eyewear (U)
L'evaluation préliminaire de quatre conceptions de protection légères basses pour les lunettes balistiques

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

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(U) A fifteen−day field trial was performed at Fort Benning, Georgia, to evaluate the acceptability of the four low light shields (LLS) Ballistic Eyewear (BEW). The Canadian Land Forces acquired ReVision Ballistic Protective Eyewear (BEW) for the LF as part of the Clothe the Soldier (CTS) project. Currently, the BEW are issued with only a clear and a solar lens. There are a number of other lenses available for the ReVision eyewear system including "blue blockers" or amber lenses. Blue blockers commonly are sunglasses with amber lenses that block blue light. Blocking out blue light can make objects appear clearer in some situations, and for soldiers, aid in target detection and identification. This trial was broken down into a controlled portion and an uncontrolled portion. Fourteen regular force infantry soldiers participated in the controlled portion while twenty−eight regular force infantry soldiers participated in the uncontrolled portion. The controlled group performed a battery of dynamic, task−focused HF tests in a repeated measures design to assess the LLS BEW system. Assessment of the BEW system followed a progressive testing approach from an initial vision performance test to dynamic discrete twilight live fire testing to finally dynamic military battle task testing. The progressive testing approach focused user experience so that participants could make a knowledgeable assessment of overall acceptability for all four of the low−light shields. Data collection included questionnaires, focus groups, live fire performance and HF observer assessments. The uncontrolled group wore the eyewear during platoon and section attacks and section patrols as part of a Soldier Information Requirements Technology Demonstration (SIREQ−TD) experiment. Data collection for the uncontrolled group consisted of an exit focus group only. No overall difference in the number of targets engaged with the four different LLS was seen. The participants rated both the yellow and amber LLS as more acceptable than either the gradient or the orange LLS. Furthermore, most soldiers considered the low light shield BEW as a “nice to have”.

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) low light shield; ballistic eyewear; eye protection; amber lens; solar lens; ballistic sunglasses; twilight