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Human Factors Evaluation of Prototype Visor Attachment Sub-systems and Review of Alternative Visor Designs

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PWGSC Contract No. W7711-6-7290/01-SRV

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by

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ABSTRACT

Humansystems was tasked by DRDC Toronto (formerly DCIEM) to undertake a Human Factors (HF) controlled trial to evaluate the new Visor Attachment Sub-System (VASS) design and gather additional input to support the development of the Ballistic Visor Statement of Requirement (SOR).

A three-day field trial was undertaken at CFB Winnipeg over the period of October 6 - 8 1997. Thirteen regular force infantry soldiers completed a battery of human factors tests while wearing up to four different Visor Attachment Sub-System (VASS)/Visor conditions in a repeated measures design: two ½ face visors and a full face visor with the new VASS, and one half face visor with the old VASS. All tests included a helmet alone or no VASS condition as a baseline control. During each test, the order of conditions was balanced among participants. Human factors tests included assessments of attachment, usability, performance of select obstacle and battle tasks, marching, equipment, vehicle and clothing compatibility clash, and maintainability. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

Weapons and equipment compatibility and durability were ranked as the most important criteria for VASS design, with weapons and equipment compatibility, and visual capability as the most important visor criteria. For compatibility, there were no significant differences between the VASS designs and considerable clash observed and reported for visor compatibility with the C4 mask for all visor conditions. Most participants were unable to acquire a sight picture with the full face visor while almost all participants were able to achieve a sight picture with the ½ face visor. Several visual and thermal attributes of the visors, attached to both VASS systems, were rated as "Borderline to Barely Unacceptable": field of view, visual distortion, thermal comfort, and ventilation/fogging. For functionality and durability, there were no significant differences between the two VASS conditions. For the new VASS, both the functionality and durability of both the retaining screw and the sliding lock mechanism were rated as unacceptable and the locking spring was rated as unacceptable for the Old VASS.

The results of this trial also confirm that the speed and ease of VASS assembly and visor attachment, and bulk were rated significantly more favorably for the New VASS design than the Old VASS design. Participants also indicated that the New VASS design was now acceptable in all these categories while the Old VASS results remained unacceptable and consistent with the trial results from the previous Helmet Trial.

While the New VASS design has achieved the modification goals recommended by previous trials, a number of additional concerns have been identified with this modified VASS design.

RESUME

RDDC Toronto (anciennement l'IMED) a demandé à la société Humansystems de mener des essais comparatifs relatifs aux facteurs humains (FH) afin d'évaluer le nouveau modèle de VASS et de recueillir des commentaires supplémentaires en appui à l'élaboration de l'énoncé du besoin (SOR) concernant la visière balistique.

Un essai sur le terrain de trois jours a été mené à la BFC Winnipeg du 6 au 8 octobre 1997. On a demandé à treize soldats d'infanterie de la force régulière de participer à une série d'essais relatifs aux facteurs humains. Pour ce faire, ils devaient porter jusqu'à quatre sous-systèmes de fixation de visière (VASS) différents et effectuer des mesures répétées : deux demi-visières et une visière complète avec le nouveau VASS, et une demi-visière avec l'ancien VASS. Tous les essais incluaient un casque seulement ou aucune condition VASS comme éléments de référence. Lors de chaque essai, l'ordre des conditions était réparti également entre les participants. Les essais relatifs aux facteurs humains comportaient des évaluations de la fixation, de la facilité d'utilisation, du rendement du dispositif durant un parcours à obstacles et des aptitudes au combat lors de son port, en cours de marche, de la compatibilité avec l'équipement, le véhicule et les vêtements, ainsi que de la maintenabilité. La collecte des données s'est faite au moyen de questionnaires, de groupes de discussion, de mesures de rendement et d'évaluations des observateurs des facteurs humains.

La durabilité et la compatibilité de l'équipement et des armes ont été les critères les plus importants du VASS, alors que la compatibilité de l'équipement et des armes et la capacité visuelle ont été les critères les plus importants pour la visière. Sur le plan de la compatibilité, il n'y avait pas de différences importantes entre les différents systèmes de fixation et on a observé et signalé un problème important concernant la compatibilité de la visière avec le masque C4 pour toutes les conditions de visière. La plupart des participants n'ont pas été en mesure d'obtenir une image de visée avec la visière complète, tandis que presque tous les participants ont été capables d'obtenir une image de visée avec la demi-visière. Plusieurs attributs visuels et thermiques des visières, attachées aux deux systèmes VASS, ont été jugés comme étant de « limites à quasi-inacceptables » : le champ de vision, la distorsion visuelle, le confort thermique et la ventilation/formation de buée. Pour ce qui est de la fonctionnalité et de la durabilité, il n'y avait pas de différences importantes entre les deux systèmes de fixation. Pour le nouveau VASS, la fonctionnalité et la durabilité de la vis de fixation et du mécanisme de verrouillage à glissière ont été considérées comme étant inacceptables et le ressort de verrouillage a été jugé inacceptable pour l'ancien VASS.

Les résultats du présent essai confirment que la vitesse et la facilité d'assemblage du VASS et de fixation de la visière, de même que l'encombrement, ont été jugés beaucoup plus favorablement pour le nouveau VASS que pour l'ancien VASS. Les participants ont également mentionné que le nouveau VASS était maintenant acceptable dans toutes les catégories, tandis que les résultats obtenus pour l'ancien VASS demeuraient inacceptables et conformes aux résultats obtenus lors de l'essai antérieur réalisé avec le casque.

La nouvelle conception du VASS a atteint les objectifs recommandés lors des essais antérieurs, même si on a déterminé un certain nombre de préoccupations pour cette conception modifiée du VASS.

EXECUTIVE SUMMARY

Human Factors Evaluation of Prototype Visor Attachment Sub-systems and Review of Alternative Visor Designs

David W. Tack, HumanSystems Inc.;
DRDC Toronto CR 2007-025; Defence R&D Canada – Toronto; February 2007

The CF Land Force currently employs two in-service, ballistic eyewear protection devices: Sand/Wind/Dust Goggles with ballistic insert and Glendale Safety Spectacles. Both devices provide some degree of ballistic eye protection (V_{50}~150 m/s) but are not intended to provide protection for higher energy fragments or facial protection. There are currently two related initiatives underway to improve the eye and facial protection provided to soldiers: the Soldier's Helmet Visor Attachment Sub-system project and the Clothe-the-Soldier Ballistic Visor project.

The Visor Attachment Sub-System (VASS) was evaluated as part of the Human Factors (HF) trial of the helmet in the summer of 1996 (reference A) and the results identified a number of deficiencies and suggested several design modifications. The VASS has been subsequently modified to incorporate these recommendations.

As a result, Humansystems was tasked by DRDC Toronto (formerly DCIEM) to undertake a Human Factors (HF) controlled trial to evaluate the new VASS design and gather additional input to support the development of the Ballistic Visor Statement of Requirement (SOR).

A three-day field trial was undertaken at CFB Winnipeg over the period of October 6 - 8 1997. Thirteen regular force infantry soldiers completed a battery of human factors tests while wearing up to four different Visor Attachment Sub-System (VASS)/Visor conditions in a repeated measures design: two ½ face visors and a full face visor with the new VASS, and one half face visor with the old VASS. All tests included a helmet alone or no VASS condition as a baseline control. During each test, the order of conditions was balanced among participants. Human factors tests included assessments of attachment, usability, performance of select obstacle and battle tasks, marching, equipment, vehicle and clothing compatibility clash, and maintainability. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

Weapons and equipment compatibility and durability were ranked as the most important criteria for VASS design, with weapons and equipment compatibility, and visual capability as the most important visor criteria. Use with weapons and equipment was seen as a critical components in a soldier's ability to perform their mission effectively. For compatibility, there were no significant differences between the VASS designs with the two headsets tested or for the Carl Gustav or SRAAW. The ½ face thin visor and full face curved visors were rated significantly more favorably than the ½ face thick visor and full face angled visor. There was considerable clash observed and reported for visor compatibility with the C4 mask for all visor conditions, and most participants were unable to acquire a sight picture with the full face visor while almost all participants were able to achieve a sight picture with the ½ face visor. "One-handed Operation" was also seen as essential for use with weapons and equipment; participants did not want to drop their rifle to raise or lower their visor. The "One-handed Operation" of the Old VASS design was rated significantly more favorably than the single locking clip design of the New VASS. There were no significant

differences between VASS conditions for traversing agility obstacles and for fire and movement activities during simulated Section attacks, although helmet alone condition was rated significantly more favorably. Several visual and thermal attributes of the visors, attached to both VASS systems, were rated as "Borderline to Barely Unacceptable": field of view, visual distortion, thermal comfort, and ventilation/fogging. The thin visor was rated significantly more favorably for ventilation/fogging when compared to the thick visor with the Old VASS. For functionality and durability, there were no significant differences between the two VASS conditions. For the new VASS, both the functionality and durability of both the retaining screw and the sliding lock mechanism were rated as unacceptable and the locking spring was rated as unacceptable for the Old VASS.

The results of this trial also confirm that the speed and ease of VASS assembly and visor attachment, and bulk were rated significantly more favorably for the New VASS design than the Old VASS design. Participants also indicated that the New VASS design was now acceptable in all these categories while the Old VASS results remained unacceptable and consistent with the trial results from the previous Helmet Trial.

While the New VASS design has achieved the modification goals recommended by the Soldier's Helmet Trial, a number of new concerns have been identified with this modified VASS design. These new concerns include: one-handed operation usability with gloves; durability and functionality; and over-strap adjustment horizontal clearance for thick visors. Generally, these concerns point to a need to re-design the sliding adjustment and locking mechanism provided with the New VASS design. Participants confirmed that the New VASS design was an improvement on the Old VASS and recommended that the New VASS be improved.

SOMMAIRE

Évaluation des facteurs humains liés aux prototypes de sous-systèmes de fixation de visière et critique de concepts alternatifs de visières

David W. Tack, HumanSystems Inc.;
RDDC Toronto CR 2007-025; R&D pour la défense Canada – Toronto; February 2007

La Force terrestre des FC utilise actuellement deux dispositifs de protection oculaire balistique : des lunettes étanches au sable, au vent et à la poussière (avec écran balistique amovible) et les lunettes de sécurité Glendale. Les deux dispositifs offrent un certain degré de protection oculaire balistique (V_{50}~ de 150 m/s), mais ils ne sont pas conçus pour assurer une protection contre les fragments à haute énergie, ni pour assurer la protection du visage. Deux initiatives connexes sont actuellement en cours en vue d'améliorer la protection oculaire et faciale offerte aux soldats : le projet de sous-système de fixation de la visière au casque du soldat et le projet de visière de protection balistique (Habillez le soldat).

Le sous-système de fixation de visière (VASS) a été évalué dans le cadre d'essais relatifs aux facteurs humains du casque au cours de l'été 1996 (référence A) et les résultats obtenus ont permis de déterminer un certain nombre de lacunes et de proposer plusieurs modifications à la conception. Le VASS a ultérieurement été modifié afin d'inclure ces recommandations.

RDDC Toronto (anciennement l'IMED) a donc demandé à la société Humansystems de mener des essais comparatifs relatifs aux facteurs humains (FH) afin d'évaluer la nouvelle conception du VASS et de recueillir des commentaires supplémentaires en appui à l'élaboration de l'énoncé du besoin (SOR) concernant la visière balistique.

Un essai sur le terrain de trois jours a été mené à la BFC Winnipeg du 6 au 8 octobre 1997. On a demandé à treize soldats d'infanterie de la force régulière de participer à une série d'essais relatifs aux facteurs humains. Pour ce faire, ils devaient porter jusqu'à quatre sous-systèmes de fixation de visière (VASS) différents et effectuer des mesures répétées : deux demi-visières et une visière complète avec le nouveau VASS, et une demi-visière avec l'ancien VASS. Tous les essais incluaient un casque seulement ou aucune condition VASS comme éléments de référence. Lors de chaque essai, l'ordre des conditions était réparti également entre les participants. Les essais relatifs aux facteurs humains comportaient des évaluations de la fixation, de la facilité d'utilisation, du rendement du dispositif durant un parcours à obstacles et des aptitudes au combat lors de son port, en cours de marche, de la compatibilité avec l'équipement, le véhicule et les vêtements, ainsi que de la maintenabilité. La collecte des données s'est faite au moyen de questionnaires, de groupes de discussion, de mesures de rendement et d'évaluations des observateurs des facteurs humains.

La durabilité et la compatibilité de l'équipement et des armes ont été les critères les plus importants du VASS, alors que la compatibilité de l'équipement et des armes et la capacité visuelle ont été les critères les plus importants pour la visière. L'utilisation avec les armes et l'équipement était considérée comme un élément essentiel de la capacité du soldat à exécuter efficacement ses tâches. Sur le plan de la compatibilité, il n'y avait pas de différences importantes entre les différents systèmes de fixation avec les deux casques mis à l'essai ou avec le Carl Gustav ou le SRAAW. La demi-visière mince et les visières complètes courbées ont été classées de manière beaucoup plus favorable que la demi-visière épaisse et la visière complète à angle. On a observé et signalé un problème important concernant la compatibilité de la visière avec le masque C4 pour toutes les

conditions de visière; la plupart des participants n'ont pas été en mesure d'obtenir une image de visée avec la visière complète, tandis que presque tous les participants ont été capables d'obtenir une image de visée avec la demi-visière. « L'utilisation d'une main » était également considérée comme essentielle en raison des armes et de l'équipement; les participants ne voulaient pas être obligés de déposer leur arme pour soulever ou abaisser leur visière. Avec l'ancien VASS, « l'utilisation d'une main » avait été considérée comme étant beaucoup plus facile que la conception du crochet simple autobloquant du nouveau VASS. Il n'y a pas de différences importantes entre les conditions du VASS lorsque les participants devaient traverser un parcours à obstacles et lors d'activités feu et mouvement au cours d'attaques simulées, même si le casque seul a été coté de façon beaucoup plus favorable. Plusieurs attributs visuels et thermiques des visières, attachées aux deux systèmes VASS, ont été jugés comme étant de « limites à quasi-inacceptables » : le champ de vision, la distorsion visuelle, le confort thermique et la ventilation/formation de buée. En comparaison à la visière épaisse de l'ancien VASS, la visière mince a été cotée comme étant beaucoup plus efficace pour ce qui est de la ventilation/formation de buée. Pour ce qui est de la fonctionnalité et de la durabilité, il n'y avait pas de différences importantes entre les deux systèmes de fixation. Pour le nouveau VASS, la fonctionnalité et la durabilité de la vis de fixation et du mécanisme de verrouillage à glissière ont été considérées comme étant inacceptables et le ressort de verrouillage a été jugé inacceptable pour l'ancien VASS.

Les résultats du présent essai confirment que la vitesse et la facilité d'assemblage du VASS et de fixation de la visière, de même que l'encombrement, ont été jugés beaucoup plus favorablement pour le nouveau VASS que pour l'ancien VASS. Les participants ont également mentionné que le nouveau VASS était maintenant acceptable dans toutes les catégories, tandis que les résultats obtenus pour l'ancien VASS demeuraient inacceptables et conformes aux résultats obtenus lors de l'essai antérieur réalisé avec le casque.

Le nouveau VASS a atteint les objectifs recommandés lors de l'essai du casque du soldat, et ce, même si on a déterminé un certain nombre de préoccupations relativement à cette conception modifiée du VASS. Ces nouvelles préoccupations comprennent : l'utilisation d'une main gantée; la durabilité et la fonctionnalité; le dégagement horizontal de l'ajustement au-dessus de la courroie pour les visières épaisses. Normalement, ces préoccupations devraient indiquer le besoin de redessiner l'ajustement à glissière et le mécanisme de verrouillage du nouveau VASS. Les participants ont confirmé que le nouveau système de fixation constituait une amélioration par rapport à l'ancien et ont recommandé que le nouveau VASS continue d'être amélioré.

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1. BACKGROUND

The CF Land Force currently employs two in-service, ballistic eyewear protection devices: Sand/Wind/Dust Goggles with ballistic insert and Glendale Safety Spectacles. Both devices provide some degree of ballistic eye protection (V_{50}~150 m/s) but are not intended to provide protection for higher energy fragments or provide facial protection. There are currently two related initiatives underway to improve the eye and facial protection provided to soldiers: the Soldier's Helmet Visor Attachment Sub-system project and the Clothe-the-Soldier Ballistic Visor project.

The prototype Visor Attachment Sub-System (VASS) was developed by the project team for the new Soldier's Helmet (CG634) and was evaluated as part of the Human Factors (HF) trial of the helmet in the summer of 1996 (Reference A). The results of the field trial identified a number of deficiencies with the VASS and suggested several design modifications. These included:

1. Improve the speed and ease of VASS assembly to the helmet.
2. Improve the speed and ease of visor attachment to the VASS.
3. Reduce VASS bulk.

The VASS has been subsequently modified to incorporate these recommendations. This new prototype VASS underwent a further HF field trial evaluation with infantry soldiers to confirm the suitability and acceptance of the new design.

As part of a separate but related initiative, the Clothe-the-Soldier (CTS) project is developing an integrated two-part system to protect the eyes from low energy fragments, particles, laser, solar and UV radiation (ballistic eyewear) and to protect the eyes and face from high-energy fragments (ballistic visor). An early investigation into the efficacy of ballistic visors in soldier operations was undertaken with Subject Matter Experts (SMEs) at the Infantry School at CTC Gagetown. Several visor-related concerns were raised with respect to loss of visual capabilities, which would directly reduce a soldier's combat effectiveness in the field. These SMEs suggested that these issues be investigated with troops in the field. To provide some insight into HF visor issues and to further investigate the concerns expressed at the SME focus group at CFB Gagetown, a range of visor designs were incorporated into the VASS trial.

As a result, Humansystems has been tasked by DCIEM to undertake a Human Factors (HF) controlled trial to evaluate the new VASS design and gather additional input to support the development of the Ballistic Visor Statement of Requirement (SOR).

1.1 Report Structure

This report comprises a main body, which outlines the approach, summarizes the results, and discusses the interpretation of these results. The main body is supplemented by Annexes that provide more detailed results and analyses.

Throughout the main body, the methods, results and interpretation of results are described separately for VASS and visor issues.

2. AIM

The primary aim of this field trial was to evaluate the human factors (HF) suitability of the new VASS.

The secondary aim of this trial was to identify critical HF issues for use in the development of the Ballistic Visor SOR.

3. METHOD

3.1 Overview

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

A three-day field trial was undertaken at CFB Winnipeg over the period of October 6 - 8 1997. Thirteen regular force infantry soldiers completed a battery of human factors tests while wearing up to four different VASS/Visor conditions in a repeated measures design: two ½ face visors and a full face visor with the new VASS, and one ½ face visor with the old VASS. All tests included a helmet alone or no VASS condition as a baseline control. During each test, the order of conditions was balanced among participants. Human factors tests included assessments of attachment, usability, performance of select obstacle and battle tasks, marching, equipment, vehicle and clothing compatibility clash, and maintainability. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

3.2 VASS/Visor Conditions

To evaluate the suitability of the VASS two types of visors were used (see VASS descriptions and photographs in Annex A). This requirement to include a visor in this trial was seen as an opportunity to also evaluate the HF issues associated with different visor characteristics. The following four VASS/Visor combinations were evaluated.

- **A.** ½ Face angled visor with V_{50} of 450 m/s (new VASS), 450g.
- **B.** ½ Face angled visor with V_{50} of 220 m/s (new VASS), 220g.
- **C.** ½ Face angled visor with V_{50} of 450 m/s (old VASS and visor angles taped to simulate hinges), 450g.
- **D.** Full Face angled visor with V_{50} of 150 m/s (new VASS), ~ 200g.

Due to limitations in producing visor attachment brackets compatible with the old VASS system, only combination C included the old VASS design. For the purposes of visor assessment, the new VASS platform was used for all other visors.

These four VASS/Visor conditions differ across the following four dimensions (i.e. weight, coverage, vision, and VASS type).

1. Weight varies according to coverage area and protection level. There are three levels of weight represented by Visors A and C (heaviest), Visor B (medium), and Visor D (lightest).
2. Two areas of coverage are provided: ½ Face and Full Face.
3. Two vision conditions are included: bent clear (Visors A, B and D) and bent taped to simulate the visual obstruction associated with a hinged visor (Visor C).
4. Two VASS types: old and new.

A full repeated-measures protocol was performed for each Human Factors evaluation. Each participant trialed each of the visor conditions in each test as well as a helmet alone (i.e. the no VASS baseline control condition).

3.3 Trial Participants

Thirteen regular forces infantry soldiers (all males) were selected from a sample of twenty-four 2PPCLI soldiers at CFB Winnipeg and included four spectacle wearers. The participants selected for this trial were organized into two Sections (e.g. Sections A and B). Two senior NCOs were provided to act as Section Comd throughout the trial; the senior NCOs were participants in the trial. Each Section was balanced for helmet size and MOC, so that each Section was similar as possible (i.e. matched groups). An HF observer was assigned to work with each Section for the purposes of data collection and focus group discussions.

3.4 Data

Data collection focused on the following HF criteria. Test content is described in more detail below. The order of VASS/Visor conditions was balanced for each test.

1. Anthropometry
2. Assembly/Packing
3. Weapons/Equip. Compatibility
4. Features
5. Combat Activity Performance
6. Vehicle Compatibility
7. Thermal Load
8. User Maintainability
9. Physical Comfort
10. Acceptance

3.4.1 Anthropometry:

Each participant was measured for stature, head circumference, head length, and head breadth.

3.4.2 Assembly/Attachment:

Each participant pairing was issued an old and new prototype VASS. The relative ease of assembling and attaching the old and new VASS to the helmet was assessed. Participants rated the ease of visor and VASS assembly and attachment in the Issue Questionnaire. HF observers recorded any concerns.

3.4.3 Weapons/Equipment Compatibility:

Compatibility clash was identified and evaluated indoors at static test stands. Initially, each of the trial participant Sections were assigned to a test stand. Participants performed the required drills and HF observers collected compatibility measurement data and participant ratings. Participants were encouraged to adjust and configure their helmets to the best of their ability to accommodate the test equipment prior to each test. Each participant was evaluated separately under the close observation of the HF observer. All tests were performed first in the helmet alone or no-

VASS/Visor control condition. Once all members of a section completed a test stand they rotated to the next available stand.

The static test stands for the VASS comprised the following pieces of equipment (test stand photographs are included in Annex D).

VASS Test Stands:

Both VASS conditions were evaluated with the ½ face, thick visors.

1. **Support Weapons:** M72 SRAAW, Carl Gustav.
2. **COMMS:** SLIMGARD 1 (over-helmet strap) and SECRETTE headsets.

The static test stands for the Visors comprised the following pieces of equipment.

Visor Test Stands:

Visor compatibility was evaluated with the ½ face and full face thin visors.

1. **Personal Weapons:** C7A1 rifle, C9A1 LMG, and C6.
2. **Vision Items:** Ballistic spectacles (Uvex example), Glendale spectacles, Sand/Wind/Dust Goggles, C4 Mask.

3.4.4 Features

At the completion of the trial, participants were required to rate the suitability of selected, prototype VASS features: securements, adjustments, etc. These features were also discussed in detail during the exit focus group to identify feature concerns and suggestions for improvement.

3.4.5 Combat Activity Performance

VASS/Visor effects on the performance of military tasks were evaluated for selected combat activities (obstacle course) and tasks (fire and movement, night patrol ambush). VASS conditions were evaluated using an agility obstacle course to assess VASS effects on visor stability, helmet inertia, and balance. Visor conditions were evaluated using a balance obstacle course to compare the visor weight and vision differences between the ½ face thin (light) visor and the ½ face thick (heavy) visor. Participant performance ratings and HF observer assessments were collected following each task. Tasks were performed in each of the ½ face visor conditions.

a) Obstacle Course (agility): The following combat activities were undertaken consecutively as part of a single course. These obstacles were selected for their demands on speed, range of movement, changes of direction, and variations in whole-body posture. Subjective ratings, by trial participants, were collected for each test. Participants performed these tests in all ½ face visor conditions. At the completion of the agility obstacles for each VASS condition, participants completed a Task Questionnaire. For all obstacles, participants were required to wear webbing and carry their personal weapon.

The following agility obstacles were used. Photographs of obstacles are provided in Annex E.

Pipe Crawl: Crawl through 25m zig-zag pipe 0.5 meters in diameter.

Run: Run 100m.

Over and Under Obstacle: Climb over and under successive poles mounted 1.0 meter from the ground, 0.5 meters apart.

Low Wire Crawl: Perform a Leopard crawl while traversing a 10m low wire obstacle.

b) Obstacle Course (balance): The following combat activities were undertaken consecutively as part of a single course. These obstacles were selected for their demands on participant balance. Subjective ratings, by trial participants, were collected for each test. Participants performed these tests in all ½ face visor conditions. At the completion of the balance obstacles for each visor condition, participants completed a Task Questionnaire. For all obstacles, participants were required to wear webbing and carry their personal weapon.

The following balance obstacles were used.

Stump Jumping (**Irish Stones):** Leap one-footed from stone to stone to cross a sandpit.

Ladder Obstacle: Ascend a 10m ladder, straddle and traverse the top bar, then descend the ladder to the ground.

Balance Beam: Walk along a zigzag balance beam mounted 0.5 m above the ground.

c) Fire and Movement: Participants were required to engage in a Section attack simulation. Participants rated their effectiveness in all ½ face visor conditions. HF observers evaluated stability, field movement, and weapons effects.

The two Sections performed fire and movement testing concurrently. Members of one Section simulated an enemy force in a defensive position while the other section performed standard advance to contact, until bumped, and then skirmishing fire and movement to advance and assault the enemy position. Both sections were issued blank ammunition and provided with smoke and pyrotechnics (i.e. artillery simulators and thunderflashes). At the completion of each VASS/Visor condition, participants were required to complete a Task Questionnaire. The order of conditions was balanced within each Section. At the completion of the fire and movement task, the Sections exchanged roles and repeated the drill.

d) Night Patrol Ambush: Participants were required to engage in a night patrol simulation. Participants rated their effectiveness in all ½ face visor conditions. HF observers evaluated stability, field movement, and weapons effects.

The two Sections performed patrol and ambush concurrently during black-out conditions at night along a wood line. Members of one Section simulated enemy ambush positions in the wood line while the other Section performed a standard wood line patrol, until bumped, and then reacted to enemy fire by return fire and use of cover. Both sections were issued blank ammunition. At the completion of each VASS/Visor condition, participants were required to complete a Task Questionnaire. The order of conditions was balanced within each Section. At the completion of the patrol ambush task, the Sections exchanged roles and repeated the drill.

3.4.6 Vehicle Compatibility

The two VASS conditions were evaluated for compatibility with the M113 driver crewstation. Order of conditions was balanced. Participant driving performance, for M113 qualified drivers only, was evaluated using a slalom course along a dirt road and around obstacles in open ground.

Participants were required to rate their performance in vehicle operation in each VASS condition for both hatches-up and hatches down configurations. Photographs of the hatches-up configuration are including in Annex I. HF observers evaluated participants during vehicle operation for any postural, range of movement, crewstation obstruction, and vision effects.

3.4.7 User Maintainability/Durability

The ease and effectiveness with which a participant can effect minor VASS/Visor repairs and cleaning in the field was evaluated through focus group discussion and questionnaire ratings. HF observers noted any maintenance tasks as they occur in the field. All repairs were logged and reviewed for durability issues. All prototype VASS were inspected for wear and damage at the completion of the trial.

3.4.8 Thermal Load:

The thermal demands associated with a ½ and a full face VASS/Visor condition were evaluated and compared to the demands of a no VASS/Visor control. Participants were required to repeat a standardized 5 km march route three times over the course of the trial. The order of conditions were balanced among participants during each march.

Following each route march, participants were required to complete a thermal comfort questionnaire. This questionnaire comprised drawings of all sides of the head. Participants were required to indicate the location of any heat build-up and rate the amount of thermal discomfort using the five point rating scale provided.

3.4.9 Physical Comfort:

Following each route march, participants were also required to complete a head discomfort survey indicating the locations and levels of discomfort experienced during the march. Discomfort could include, but was not limited to, contact irritation or pressure points. HF staff investigated any reports of discomfort through interviews with affected participants.

3.4.10 User Acceptance

To assess user acceptance, participants were required to rate their overall acceptance of each VASS/Visor condition, including their perceived level of protection, and ease of use, general appearance, durability and functionality, using the exit questionnaire.

3.5 Statistical Analyses

Repeated measures analyses of variance, for VASS/Visor effect, were undertaken for all questionnaire acceptability scale and performance results. Differences were identified at $p \leq 0.5$.

3.6 Trial Schedule

Table 1 outlines the three-day trial schedule.

TRIAL WEEK: October 6 – 8			
Time	**Monday**	**Tuesday**	**Wednesday**
A.M.	Initial Briefing Anthropometry Issue Assemble/Attach	Compatibility (Test Stands) Obstacle Course	Fire & Move't 5 km March
Lunch			
P.M.	Compatibility (Test Stands) 5 km March	Obstacle Course Vehicle Compat. 5 km March Night Patrol	Feature Quest. Exit Quest. Exit Focus Group

Table 1: Trial Schedule

The trial schedule included focus group discussions at the completion of each data collection block, typically at the end of the day. These focus groups were held with each Section, led by their respective HF observer.

The following two meetings bracketed the trial schedule:

Initial Briefing: Initially, participants were welcomed and introduced to the trial team. Participants were briefed on the trial schedule and data collection methods (ie. questionnaires, focus groups, etc.). Questionnaire briefings explained the standard rating scale, the data scoring method and rules of questionnaire completion. All VASS/Visor conditions were introduced and participants were provided with a demonstration of assembly, adjustment, and features.

Exit Focus Group: At the completion of the last trial day, participants were issued an Exit Questionnaire. Participants were required to rate the acceptability of each VASS/Visor condition used during the trial. A Features Questionnaire was then completed for the Old and New prototype VASS. Participants rated each feature in terms of functionality and durability. Following the completion of all questionnaires, focus group discussions were held.

4. RESULTS

Following a review of the participant sample head anthropometry and the helmet sizing distribution, the results section has been divided into VASS results (Section 4.2) and Visor results (Section 4.3).

Statistically significant differences are described in this section for $p \leq 0.05$.

4.1 Anthropometry

Standard head anthropometry measurements were determined for each participant to ensure proper helmet and visor sizing: head circumference, head length, and head breadth. Summary descriptive statistics of these measures are detailed in Table 2 below, for both the trial sample of participants and the larger Land Force Anthropometry Survey (DCIEM, 1997).

	Head Circumference		Head Length		Head Breadth	
	Mean	s.d.	Mean	s.d.	Mean	s.d.
Trial Sample	57.38	1.21	19.95	0.58	15.30	0.55
1997 LF Survey	57.64	1.53	19.89	0.68	15.28	0.55

Table 2: Comparison of Head Dimensions

A statistical comparison of the head size distribution of the trial sample of participants with the LF Survey found no statistically significant differences for these three measures. Participant head length x head breadth data are indicated in the associated bivariate graph in Figure 1 below.

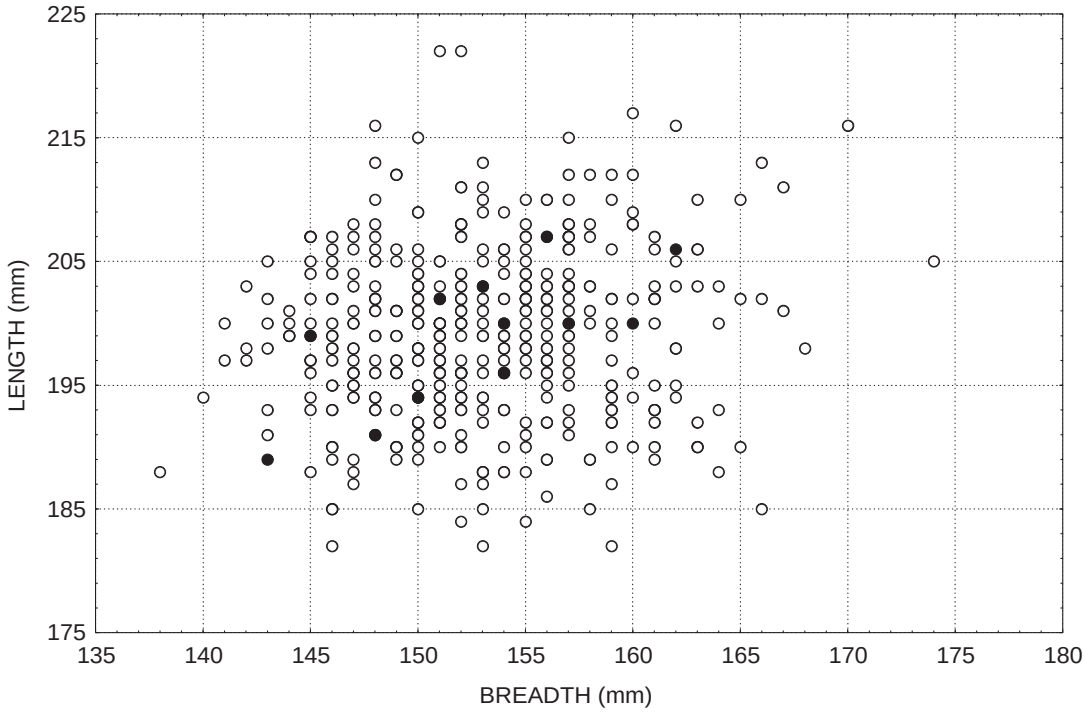

Figure 1: Head Size of Trial Sample and CF Survey

The distribution of the participant sample of helmet sizes, and therefore visor sizes, is indicated below in Table 3. While the head size range of the trial sample of participants was not significantly different than the Land Force Anthropometry Survey, small helmet wearers are clearly under-represented in this trial. Given the nature of the VASS designs, the lack of small helmet sizes in this trial will likely not affect the interpretation of results and the conclusions for VASS suitability. If anything, since the VASS units are one size, some factors relating to moment of inertia and bulk may have been reported as less satisfactory for smaller versus larger helmets.

	Helmet Size		
	Small	**Medium**	**Large**
Tariff % (n)	8% (1)	62% (8)	30% (4)
Head Circumference	51 - 55 cm	55 - 59 cm	59 - 62 cm

Table 3: Helmet Sizing and Sample Distribution

4.2 VASS Results

Trial results for the VASS are summarized in the following sections.

4.2.1 VASS Importance Criteria

4.2.2 Initial Assembly

4.2.3 VASS Compatibility

4.2.4 Combat Activities

4.2.5 VASS Features

4.2.6 VASS Exit Questionnaire

4.2.1 VASS Importance Criteria

In order to better interpret and prioritize the results of this trial, participants were required to rate the importance of various VASS design criteria. This questionnaire was issued at the trial to ensure that importance ratings were based on informed judgement. Summary results are tabulated in Annex B.

“Weapons and Equipment Compatibility” and “Durability” were ranked as the most important criteria for VASS design. Use with weapons and equipment were seen as critical components in a soldier’s ability to perform their mission effectively. Any benefits afforded by a VASS design should not be at the expense of weapon and equipment effectiveness. Emphasis on field durability is consistent with this requirement. “One-handed Operation” was also seen as essential for use with weapons and equipment; participants did not want to drop their rifle to raise or lower their visor.

“Physical Comfort” also ranked highly and could be associated with the moderately important rankings assigned to "Weight" and “Stability on the Helmet”. “Bulk”, “Clothing Compatibility”, and “Use with Gloves” were also ranked as moderately important.

Several criteria, that we would have expected to rank highly, were ranked as having only “Some Importance”: “Ease and Speed of Visor Attachment”, and “Ease and Speed of VASS Assembly”. These lower than expected rankings may have resulted from two factors. Firstly, participants believed that, in most instances, they would have plenty of time to assemble the VASS and attach the visor and, as such, speed and ease would not be critical. Secondly, participants may have judged that the new prototype VASS sufficiently addressed these criteria and that these were no longer the most important criteria when taken in context.

4.2.2 Initial Assembly

Summary results from the Initial Assembly of the Old and New VASS designs are provided in Annex C. Statistically higher mean ratings are shaded and bolded in the summary tables.

Following the initial assembly session, participants rated the New VASS significantly more favourably than the Old VASS for speed and ease of assembly and visor attachment. For speed and ease of assembly, the New VASS was rated as "Barely Acceptable" and the Old VASS as just "Unacceptable". Generally, participants found the Old VASS assembly to be more time consuming and the helmet attachment screws were too small and easily lost. The New VASS required fewer assembly parts and required less fiddling. Differences between VASS designs were more marked for speed and ease of visor attachment. The New VASS was rated much more favourably ("Reasonably Acceptable") than the Old VASS ("Reasonably" to "Barely Unacceptable") for visor attachment. Since the Old VASS design required disassembly of the VASS housing with tools to change the visor and the New VASS employed a quick-release Fastex connector, these differences are not surprising. While these assembly and attachment differences between VASS designs were significant, participants did not rate these criteria as very important for VASS effectiveness.

The "One-handed Operation" of the Old VASS design was rated significantly more favourably than the single locking clip design of the New VASS. The New VASS was slower and more awkward to operate with one hand since it required a locking mechanism to be engaged and disengaged to raise and lower the visor; the Old VASS design used an internal spring to secure the visor position and did not require any User intervention to operate. Most participants indicated that they were unable to unlock, extend, rotate the visor, retract, and lock the New VASS mechanism with only one hand.

Participants rated the "Stability", "Balance", and "Range of Vertical Visor Positions" of both VASS designs as "Barely" to "Reasonably Acceptable". "Overall Ratings" for both VASS were "Borderline" to "Barely Acceptable".

4.2.3 VASS Compatibility

VASS compatibility test stand photographs and descriptions are included in Annex D-1. Summary statistics are provided in Annex D-2.

Secrette Headset: There were no significant compatibility differences between the Old and New VASS designs with the secrette headset. The mean ratings of "Borderline" to "Barely Acceptable" tend to reflect the general compatibility conflicts between the helmet harness straps and the Secrette microphone and do not reflect a clash with either VASS.

SLIMGARD 1 Headset: No significant VASS differences were reported for compatibility with the SLIMGARD headset and overall ratings were high: "Reasonably Acceptable". Some concerns were noted during focus group discussions. The Velcro over-helmet strap tended to slip off of the smooth sides of the Old VASS cover (39% of participants). Some minor over-helmet strap clash was reported when raising the New VASS into the "up" position (31%).

Carl Gustav: For compatibility with the Carl Gustav anti-armour weapon, the helmet alone condition was rated significantly more favourably ("Reasonably Acceptable") than the two VASS

conditions ("Borderline"). There were no differences between the old and new VASS conditions. In both VASS conditions, with the visors in the "up" position there was some clash between the side of the VASS and the firing tube. In most cases, this clash could be overcome by re-adjusting the helmet harness to enable the helmet to cant higher on the firing tube side. With the visor in the "down" position, most VASS users were unable to acquire a sight picture due to significant clash between the edge of the visors and the side or top of the firing tube.

M72 SRAAW: With the visor in the "up" position there were no significant M72 compatibility differences identified between the VASS or helmet alone conditions. Rating also tended to be at or near "Reasonably Acceptable". With the visor in the "down" position, however, several participants reported visor clash with the firing tube, as evidenced by difficulty in acquiring a sight picture and problems with turning their head to check the blast-back zone.

4.2.4 Combat Activities

VASS results are described below for traversing agility obstacles and for fire and movement activities during simulated Section attacks.

4.2.4.1 Agility Obstacles

Agility obstacles were selected to emphasize gross body movement, speed, sudden change of direction, and a wide range of body and head/neck postures (prone, standing, and crawling). Agility obstacle photographs are included in Annex E-1. Summary statistics are provided in Annex E-3.

Generally, the Helmet Alone condition was rated significantly more favourably ("*Reasonably to Wholly Acceptable*") than the two VASS conditions ("*Barely Acceptable*") for all task criteria. No statistical differences were identified between VASS conditions, although considerably more participants rated the Old VASS as unacceptable (31%) for "Stability" and "Overall Rating" than the New VASS (8%).

4.2.4.2 Fire and Movement

Fire and Movement photographs are included in Annex F-1. Summary statistics are provided in Annex F-2.

Generally, the Helmet Alone condition was rated significantly more favourably ("*Reasonably to Wholly Acceptable*") than the two VASS conditions ("*Barely Acceptable to Barely Unacceptable*") for all task criteria. No statistical differences were identified between VASS conditions. Several visual and thermal attributes of the visors, attached to both VASS systems, were rated as "Borderline to Barely Unacceptable": "Field of View" (~ 45% rated unacceptable), "Visual Distortion" (~36 – 55% rated unacceptable), "Thermal Comfort" (~36% rated unacceptable), and "Ventilation/Fogging" (~36 – 45% rated unacceptable).

Overall, both VASS systems were rated as unacceptable. Inspection of the Task Questionnaire results suggests that the unacceptable rating were likely due to visor and not VASS effects, although VASS specific ratings were typically "Borderline".

4.2.5 VASS Features

Drawings of VASS features are included in Annex G-1. Summary statistics are provided in Annex G-2 (feature functionality) and Annex G-3 (feature durability).

4.2.5.1 Functionality

New VASS: The functionality of both the retaining screw and the sliding lock mechanism were rated as unacceptable. Participants found the retaining screws too small and fiddly to handle, and tools were necessary to secure the screw. The sliding lock mechanism was considered unacceptable for two reasons. Firstly, some participants were unable to determine if the lock had been successfully engaged or had difficulty in securing the back tab. Secondly, with the locking mechanism on only one side of the VASS, many participants reported that the single locking mechanism was insufficient for stabilizing and securing the visor assembly from movement.

While the Velcro straps used to secure the VASS over the helmet were rated as "*Reasonably Acceptable*", many of the large helmet wearers noted that the single strap length was too short for an effective Velcro overlap. Inspection of the one small helmet indicated that the Velcro strap overlap may be excessive. Participants requested that the VASS straps be sized to match the three helmet sizes.

Old VASS: The functionality of the locking spring was rated as unacceptable for the Old VASS. Participants reported that the spring was too weak to be able to effectively secure the visor assembly and, while not proving a hindrance to VASS operation, did not prove useful.

4.2.5.2 Durability

New VASS: The durability of both the retaining screw and the sliding lock mechanism were rated as unacceptable. Participants found the retaining screw slot too shallow and the material too soft, causing it to be easily scored or misshapened during tightening. The sliding lock evidenced several durability problems. The metal slide could be easily bent during use, enabling the slide to twist out of its track and restrict slider movement. In several cases, the molded backstop or lock on the slider fractured or broke off when impacted by dropping the helmet on the slider or when striking the slider with the palms of the hand in an effort to seat the lock.

Old VASS: The durability of the locking spring was rated as unacceptable for the Old VASS. Participants reported that the spring was too compliant and likely to break or become functionally too weak for its purpose.

4.2.6 Vehicle Compatibility

VASS conditions were evaluated for compatibility with M113 driving performance, using a slalom course along a dirt road and around obstacles in open ground. Participants rated VASS compatibility for both hatches-up and hatches down configurations. Photographs of the hatches-up configuration are including in Annex I-1 and summary statistics are provided in Annex I-2.

Hatches Up: No significant differences were identified between VASS conditions (i.e. helmet alone, Old VASS, and New VASS) for driving with hatches-up. While participants did note the field of view obstruction posed by both the taped and bent visors, most indicated that it could be easily overcome with additional side-to-side head movement.

Hatches Down: The helmet alone condition was rated significantly more favourably ("*Reasonably to Wholly Acceptable*") than both of the two VASS conditions ("*Barely Acceptable*"). There was no significant difference between the two VASS conditions. Participants indicated that the field of view obstructions associated with the taped and bent visor, which could be overcome with head movement while hatches up, were more difficult to overcome when trying to look through the episcope vision ports. Since the driver must look through and integrate three separate episcope views to create a collective field of view while hatches down, the addition of field of view obstructions from the visor compounds the visual integration problem. The end result is considerably more side-to-side head movements to compensate for the obstructions.

4.2.7 VASS Exit Questionnaire

An exit questionnaire was completed at the end of the trial, following three days of experience with the two VASS designs. Exit questionnaire data are summarized in Annex H.

Exit results confirmed that the New VASS was significantly easier and faster to both assemble and attach visors than the Old VASS. Due to the easier assembly of the New VASS, participants rated it significantly more favourably for maintainability than the enclosed Old VASS design. While these criteria were not judged by participants to be a high priority for VASS design acceptance, the Old VASS was rated as unacceptable.

The weight and bulk of the New VASS was rated significantly more favourably than the Old VASS and likely accounted for the significantly higher New VASS ratings for physical comfort.

The New VASS design did fall significantly short of the Old VASS design for a number of criteria. The Old VASS was rated significantly more favourably (*Reasonably Acceptable*) for one-handed operation than the New VASS (*Reasonably to Barely Unacceptable*). Participants noted that one-handed operation was critical to enable a soldier to carry their rifle while adjusting their visor. Similarly, the Old VASS was rated significantly more favourably for use with gloves than the New VASS.

Both VASS designs rated very poorly (*Reasonably to Barely Unacceptable*) for weapons compatibility, largely due to clash with shoulder mounted anti-armour weapons. Since participant's ranked weapons compatibility as the most important VASS criteria, these unacceptable ratings for both VASS designs are cause for concern.

4.3 Visor Results

Trial results for the visor conditions (i.e. helmet alone, ½ face thin, ½ face taped, and full face) are summarized in the following sections.

4.3.1 Visor Importance Criteria

In order to better interpret and prioritize the results of this trial, participants were required to rate the importance of various visor design criteria. This questionnaire was issued at the trial to ensure that importance ratings were based on informed judgement.

Participants emphasized weapons and equipment compatibility, and visual capability as the most important visor criteria. As with the VASS priorities, participants ranked weapons compatibility as the most important criteria, owing largely to their emphasis on mission performance and the critical role of the personal weapon in an infantry context. Visual capability was also judged to be a very high priority to mission performance and individual lethality and protection, as indicated by the rankings for vision, ventilation/fogging, field of view, range of head movement, and scratch resistance. Both ballistic and impact protection were ranked as moderately important but these were clearly viewed as secondary to the need for weapon/equipment compatibility and visual capability.

Durability was also ranked highly, consistent with the emphasis that soldiers typically place on field ruggedness. Thermal comfort was ranked reasonably highly based on concerns with restricted airflow ventilation, which would increase the likelihood of fogging and greatly increase the thermal load generated under the helmet. Based on participant observations of glare reflectance off visor surfaces, many participants indicated that stealth/concealment issues would be critical.

Several criteria, that we would have expected to rank highly, were ranked as having only “Some Importance”: “Weight”, “Balance”, “Stability”, and “Physical Comfort”. These criteria are closely correlated, suggesting that participant experience with the weight and bulk of visors trialled did not exceed the limits of User acceptance. Had any of the visor conditions been unacceptably heavy or bulky, then these criteria would likely have been ranked much higher.

4.3.2 Visor Compatibility

C4 Respirator: While the ½ face thin visor and full face curved visors were rated significantly more favourably ("Borderline" to "Barely Acceptable") than the ½ face thick visor and full face angled visor ("Barely Unacceptable"), considerable clash was observed and reported for visor compatibility with the C4 mask for all visor conditions. In all visor conditions, clash resulted from visor contact with the speech transmitter assembly, canister mounts, and the attached canister. This clash resulted in noticeable pressure and discomfort on the bridge of the nose, loss of mask seal in several cases, and difficulty in securing the visor in the "down" position.

A curved full face visor was assessed at this test stand to investigate the design opportunities for reducing visor clash with the C4 mask. Both the ½ face thin and the curved visors produced less clash than the thicker and longer, angled visors.

Sand/Wind/Dust Goggles: There were no significant differences identified between the ½ face and full face visors and the no visor (helmet alone) baseline. This lack of significant differences is somewhat misleading given the compatibility clash that already exists between the new Soldier's Helmet (CG634) and the goggles. Several participants reported noticeable discomfort on the bridge of the nose caused by the downward pressure of the helmet brim on the top of the goggle frame. Both the ½ face and full face visor resulted in some increased reporting of nose bridge discomfort resulting from visor contact pressure with the top of the goggle frame.

Spectacles: No significant differences were identified between visor conditions for the Glendale spectacles or the Ballistic Spectacles (i.e. UVEX Eye Armour). Generally, no visor or VASS compatibility clash was reported or observed and all spectacle conditions were rated as "Reasonably Acceptable".

Small Arms: The pattern of ratings was similar for all small arms evaluated (i.e. C6, C9A1 LMG, and C7A1). Generally, the helmet alone condition was rated significantly more favourably than the two visor conditions ("Reasonably Acceptable" to "Wholly Acceptable"). The ½ face visor was rated significantly more favourably than the full face visor for all small arms. With the exception of the C6 ("Reasonably Unacceptable"), the C9A1 LMG and C7A1 were rated as "Borderline" to "Barely Acceptable" for the ½ face visor. For the C6, participants were unable to achieve a sight picture with the full face visor (100%). While some participants could acquire a partial sight picture with the ½ face visor through the use of awkward, hyper-extended neck postures, more than 50% were unable to achieve a sight picture at all.

For the C9A1 and C7A1 rifles, most participants were unable to acquire a sight picture with the full face visor (75% - 90%) while almost all participants were able to achieve a sight picture with the ½ face visor (92%) by resting the visor on the rifle and extending their necks.

4.3.3 Combat Activities

Visor results are described below for traversing balance obstacles, fire and movement activities during simulated Section attacks, and night patrol activities. Only the helmet alone and the ½ face visors were assessed for combat activities. The full face visor was not included due to identified problems with weapons compatibility.

4.3.3.1 Balance Obstacles

Balance obstacles were selected to emphasize controlled gross body movement, while adopting typical head down postures to view the obstacle and careful foot placement. The ½ face thin and taped visors were included in this test.

Generally, the Helmet Alone condition was rated significantly more favourably ("*Reasonably to Wholly Acceptable*") than the two VASS conditions for all task criteria. Several of the weight-related criteria favoured the thin visor over the heavier, thicker (taped) visor: "Physical Comfort", "Stability", and "Weight". As well, the thin visor was rated significantly more favourably for "Ventilation/Fogging", possibly owing to the slightly larger airflow opening between the thin visor and the helmet when compared to the thick visor with the Old VASS. Overall, both visors were rated as "*Barely Acceptable*" for obstacles requiring balance and constant visual attention.

4.3.3.2 Night Patrol Ambush

The ½ face thin and taped visors were included in this test.

Generally the Helmet Alone condition was rated significantly more favourably ("*Reasonably to Wholly Acceptable*") than the two visor conditions ("*Reasonably Unacceptable to Borderline*") for all task criteria. With the exception of "Ease of Movement", no statistical differences were identified between visor conditions. The thin visor condition was rated significantly more favourably for ease of movement than the thick, taped visor, although both visors were still rated as unacceptable.

Several visual and thermal attributes of both visors were rated as "*Reasonably Unacceptable to Barely Unacceptable*": "Field of View" (~ 58 - 67% rated unacceptable), "Visual Distortion" (75% rated unacceptable), "Thermal Comfort" (50 - 75% rated unacceptable), and "Ventilation/Fogging" (67 – 92% rated unacceptable). As well, both visors were rated very unfavourably for "Weapons Use" (67 – 92% rated unacceptable) and the "Overall Rating" (75 – 92% rated unacceptable).

A statistical comparison of the thermal, visual, weapons use, and overall ratings for Fire and Movement and Night Patrol Ambush indicated that visor rating were significantly less favourable for night operations. Participants perceived a noticeable decrease in operational effectiveness when wearing a visor during night operations. The loss of operational effectiveness was associated with visor-related encapsulation effects (e.g. reduced situation awareness, reduced verbal communications) and reduced visual performance due to high levels of glare and reflectance, and reduced transmission of light in low light conditions.

5. DISCUSSION

5.1 VASS Disposition

The primary aim of this field trial investigation was to determine whether the new prototype VASS design had fulfilled the modifications recommended for the old VASS prototype, following the field trial investigation of the New Soldiers Helmet. In short, Figure 2 summarizes the findings of this study.

Proposed Modifications from the Soldier's Helmet Trial	New VASS
1. Improve speed and ease of assembly.	✓
2. Improve speed and ease of visor attachment.	✓
3. Reduce bulk.	✓

Figure 2: Comparison of New VASS to Modification Objectives

The results of this trial confirm that the speed and ease of VASS assembly and visor attachment, and bulk were rated significantly more favourably for the New VASS design than the Old VASS design. Participants also indicated that the New VASS design was now acceptable in all these categories while the Old VASS results remained unacceptable and consistent with the trial results from the previous Helmet Trial.

While the New VASS design has achieved the modification goals recommended by the Soldier's Helmet Trial, a number of new concerns have been identified with this modified VASS design. These new concerns include:

- **One-handed Operation:** The ability to raise, lower, and lock the visor into position with one hand was judged to be critical; no participants were willing to release their personal weapon to adjust their visor. Most participants (62%) rated the one-handed operation of the New VASS as unacceptable.
- **Usability with Gloves:** As with one-handed operation, participants reported that the New VASS adjustment and locking mechanism was difficult to manipulate while wearing combat gloves. Many participants (39%) rated use with gloves as unacceptable, largely owing to the same design problems associated with one-handed operation.
- **Durability and Functionality:** The sliding lock, retaining screw and attachment bracket proved problematic both in terms of durability and functionality. The sliding lock was difficult to use and engage the lock, the sliding mechanism jammed when the metal slide

plate turned out of its track, and several participants reported fracturing and breakage of the locking tab.

- **Over-strap Adjustment:** The single size of the over-the-helmet strap proved problematic. The strap length was too short for the large helmet size, resulting in inadequate Velcro overlap and was too long for the small helmet size, leaving too much strap overlap. Participants recommended that three strap sizes be made available to match the three helmet sizes.
- **Horizontal Clearance for Thick Visors:** Participants with larger noses were observed to have a horizontal clearance problem with the thicker visor design (i.e. their noses contacted or were compressed by the visor). While the VASS design could be modified to provide some horizontal adjustability, new problems with gaps in over-head coverage would likely result. This concern is probably best addressed by altering the visor design to include a nasal cutout.

Generally, these concerns point to a need to re-design the sliding adjustment and locking mechanism provided with the New VASS design. Participants confirmed that the New VASS design was an improvement on the Old VASS and recommended that the New VASS be improved.

5.2 Modified VASS Design Assessment

Following on from the results of this field trial, the project team endeavoured to resolve the identified concerns with the New VASS design. The resulting modified or re-designed New VASS was subsequently trialled for one day with seven 2PPLCI soldiers at CFB Winnipeg. Two new VASS prototypes were developed to resolve the one-handed operation concerns identified with the New VASS design: independent springs in each slider (prototype 1) and sliders secured with elasticized straps (prototype 2). In both cases, no locking mechanism was provided based on the assumption that constant tensioning would be sufficient to retain and secure the sliders during visor use. As well, thumbscrews were provided to secure the VASS to the helmet, in place of the problematic screws used in the field trial.

The aims of the one-day trial were to investigate the following.

- **One-handed Operation:** Determine whether the performance requirements for one-handed operation are achieved by the two tensioning mechanisms.
- **Ease of Attachment:** Assess the ease of attachment implications of the two prototype designs.
- **Stability and Visor Retention:** Determine whether the tensioning capabilities of the two prototypes are sufficient to warrant not having a locking mechanism.
- **Durability and Stowage:** Investigate the durability and stowage issues associated with the two prototype designs.

The two prototype designs were evaluated for speed and ease of assembly, and visor attachment in a classroom environment. Stability and visor retention were evaluated by having participants traverse the base obstacle course in each visor condition. For all test stands, the initial New VASS design from the field trial was used as the baseline test condition.

Test stand photographs are included in Annex J-1 and summary statistics are provided in Annex J-2.

Overall, participants preferred the spring-tensioned VASS design (overall rating of *Reasonably Acceptable*) to both the elasticized strap VASS design (*Barely Acceptable*) and the trial VASS (*Barely Unacceptable to Borderline*). The trial VASS was rated as unacceptable and judged to be significantly less favourable than the other two VASS prototypes. Both prototype VASS designs proved to be sufficiently stable and capable of securing the visor. All participants indicated that a separate locking mechanism was not required if the VASS slider was under continuous tension; a separate locking mechanism would also require an additional, unnecessary, time consuming manipulation of the VASS during adjustment.

The spring-tensioned VASS design was preferred over the elasticized VASS for several reasons:

- **One-handed Operation:** The spring-tensioned VASS was easily to manipulate and adjust using one hand. The elasticized strap VASS could be used with one hand with difficulty. The elasticized strap did not tend to pull uniformly on each slider, causing jamming and sticking. Since the elasticized strap was one size for all three helmet sizes, this problem was worse for the large helmet since the strap was stretch quite tight.
- **Use with Gloves:** The preference for the spring-tensioned VASS was also evidenced when using gloves, likely for the same reasons as those indicated for one-handed operation.
- **Durability:** While the durability and maintainability of the enclosed spring-tensioned design was seen as acceptable, there were a number of concerns with using an elasticized strap. Participants were concerned that the elasticized strap would lose its tensioning capability over time, could become frayed through abrasion, and poses a snagging hazard.

This investigation also reviewed the new thumbscrew securement for the VASS. The participants reported that the thumbscrews were a considerable improvement over the previous retaining screws used in the trial VASS; all participants found the thumbscrews to be faster to use, easier to manipulate, and could be assembled without tools. Participants were also asked to comment on requirements for a stowage container. All participants agreed that a soft cloth case was preferred, with integral storage for extra thumbscrews, and a cleaning solution and non-abrasive cloth for cleaning the visor.

5.3 Visor Disposition

The secondary aim of this trial was to identify critical HF issues to consider in the development of the Ballistic Visor SOR. The following issues can be drawn from the trial data.

- Personal Weapons Compatibility.
- Visual Performance.
- Thermal Demands.
- C4 Mask Compatibility.
- Battle Task Performance.
- Full vs ½ Face Coverage. (1/2 vs ¾)
- Night Operations.
- Camouflage.
- Facial Stand-off.

Role:

- IS / Riot Control.
- FIBUA (IS context only).

Design:

- Full Face (All soldiers in contact).
- ½ Face (Comd for verbal comms, weapons use, and FIBUA).

Outstanding Visor Design Issues:

- Angled versus Curved Visor.
- Protection Level Required.
- C4 Mask Accommodation (VASS?).
- Horizontal Adjustment (VASS?).

6. REFERENCES:

A Tack, D. and Gaughan, P. 1996. Final Human Factors Compatibility Trial of the New Canadian Soldier's Helmet. Humansystems Inc. contractor report submitted in partial fulfillment of DCIEM Contract No. W7701-3-7197-05/XSE, 29 November 1996.

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Human Factors Evaluation of Prototype Visor Attachment Sub–systems and Review of Alternative Visor Designs (U)
Évaluation des facteurs humains liés aux prototypes de sous–systèmes de fixation de visière et critique de concepts alternatifs de visières (U)

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

David W. Tack; Philip Gaughan

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(U) Humansystems was tasked by DRDC Toronto (formerly DCIEM) to undertake a Human Factors (HF) controlled trial to evaluate the new Visor Attachment Sub–System (VASS) design and gather additional input to support the development of the Ballistic Visor Statement of Requirement (SOR).

A three–day field trial was undertaken at CFB Winnipeg over the period of October 6 – 8 1997. Thirteen regular force infantry soldiers completed a battery of human factors tests while wearing up to four different Visor Attachment Sub–System (VASS)/Visor conditions in a repeated measures design: two ½ face visors and a full face visor with the new VASS, and one half face visor with the old VASS. All tests included a helmet alone or no VASS condition as a baseline control. During each test, the order of conditions was balanced among participants. Human factors tests included assessments of attachment, usability, performance of select obstacle and battle tasks, marching, equipment, vehicle and clothing compatibility clash, and maintainability. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

Weapons and equipment compatibility and durability were ranked as the most important criteria for VASS design, with weapons and equipment compatibility, and visual capability as the most important visor criteria. For compatibility, there were no significant differences between the VASS designs and considerable clash observed and reported for visor compatibility with the C4 mask for all visor conditions. Most participants were unable to acquire a sight picture with the full face visor while almost all participants were able to achieve a sight picture with the ½ face visor. Several visual and thermal attributes of the visors, attached to both VASS systems, were rated as “Borderline to Barely Unacceptable”: field of view, visual distortion, thermal comfort, and ventilation/fogging. For functionality and durability, there were no significant differences between the two VASS conditions. For the new VASS, both the functionality and durability of both the retaining screw and the sliding lock mechanism were rated as unacceptable and the locking spring was rated as unacceptable for the Old VASS.

The results of this trial also confirm that the speed and ease of VASS assembly and visor attachment, and bulk were rated significantly more favorably for the New VASS design than the Old VASS design. Participants also indicated that the New VASS design was now acceptable in all these categories while the Old VASS results remained unacceptable and consistent with the trial results from the previous Helmet Trial.

While the New VASS design has achieved the modification goals recommended by previous trials, a number of additional concerns have been identified with this modified VASS design.

(U) RDDC Toronto (anciennement l’IMED) a demandé à la société Humansystems de mener des essais comparatifs relatifs aux facteurs humains (FH) afin d’évaluer le nouveau modèle de VASS et de recueillir des commentaires supplémentaires en appui à l’élaboration de l’énoncé du besoin (SOR) concernant la visière balistique.

Un essai sur le terrain de trois jours a été mené à la BFC Winnipeg du 6 au 8 octobre 1997. On a demandé à treize soldats d’infanterie de la force régulière de participer à une série d’essais relatifs aux facteurs humains. Pour ce faire, ils devaient porter jusqu’à quatre sous systèmes de fixation de visière (VASS) différents et effectuer des mesures répétées : deux demi–visières et une visière complète avec le nouveau VASS, et une demi visière avec l’ancien VASS. Tous les essais incluaient un casque seulement ou aucune condition VASS comme éléments de référence. Lors de chaque essai, l’ordre des

conditions était réparti également entre les participants. Les essais relatifs aux facteurs humains comportaient des évaluations de la fixation, de la facilité d'utilisation, du rendement du dispositif durant un parcours à obstacles et des aptitudes au combat lors de son port, en cours de marche, de la compatibilité avec l'équipement, le véhicule et les vêtements, ainsi que de la maintenabilité. La collecte des données s'est faite au moyen de questionnaires, de groupes de discussion, de mesures de rendement et d'évaluations des observateurs des facteurs humains.

La durabilité et la compatibilité de l'équipement et des armes ont été les critères les plus importants du VASS, alors que la compatibilité de l'équipement et des armes et la capacité visuelle ont été les critères les plus importants pour la visière. Sur le plan de la compatibilité, il n'y avait pas de différences importantes entre les différents systèmes de fixation et on a observé et signalé un problème important concernant la compatibilité de la visière avec le masque C4 pour toutes les conditions de visière. La plupart des participants n'ont pas été en mesure d'obtenir une image de visée avec la visière complète, tandis que presque tous les participants ont été capables d'obtenir une image de visée avec la demi visière. Plusieurs attributs visuels et thermiques des visières, attachées aux deux systèmes VASS, ont été jugés comme étant de « limites à quasi–inacceptables » : le champ de vision, la distorsion visuelle, le confort thermique et la ventilation/formation de buée. Pour ce qui est de la fonctionnalité et de la durabilité, il n'y avait pas de différences importantes entre les deux systèmes de fixation. Pour le nouveau VASS, la fonctionnalité et la durabilité de la vis de fixation et du mécanisme de verrouillage à glissière ont été considérées comme étant inacceptables et le ressort de verrouillage a été jugé inacceptable pour l'ancien VASS.

Les résultats du présent essai confirment que la vitesse et la facilité d'assemblage du VASS et de fixation de la visière, de même que l'encombrement, ont été jugés beaucoup plus favorablement pour le nouveau VASS que pour l'ancien VASS. Les participants ont également mentionné que le nouveau VASS était maintenant acceptable dans toutes les catégories, tandis que les résultats obtenus pour l'ancien VASS demeuraient inacceptables et conformes aux résultats obtenus lors de l'essai antérieur réalisé avec le casque.

La nouvelle conception du VASS a atteint les objectifs recommandés lors des essais antérieurs, même si on a déterminé un certain nombre de préoccupations pour cette conception modifiée du VASS.

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) Ballistic Visor; Visor Attachment Sub–systems; visor; helmet; facial protection

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