ARMY RESEARCH LABORATORY

Limited User Evaluation of Enhanced Night Vision Goggles

by Charles C. Bonnett, Elizabeth S. Redden, and Christian B. Carstens

ARL-TR-3536 June 2005

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Human Research and Engineering Directorate, ARL

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14. ABSTRACT

The Human Research and Engineering Directorate of the U.S. Army Research Laboratory conducted an experiment to evaluate a prototype enhanced night vision goggle (ENVG), which combines thermal and image intensification (I^2) capability. Monocular and biocular I^2 night vision devices (NVDs) provided baseline performance measures. The experiment was executed over a period of four weeks, with one infantry squad per week acting as participants. The exercises included a wide range of environments to enable a comprehensive assessment of features. These included open field target detection trials with and without smoke, woodland patrolling and target detection trials with and without smoke, woodland individual movement techniques (IMT) course trials, military operations in urban terrain (MOUT) IMT course trials, MOUT target detection trials with and without smoke, and tunnel clearing course trials. A human factors engineering evaluation of the ENVG was also performed. Results indicated that the fused NVD enhanced target detection capability, especially through obscurants, without interfering with movement through infantry terrain. Specifically, results indicated that the ENVG significantly increased the ability of the Soldiers to detect targets in an open field both during smoke and no-smoke conditions. Fusion technology diminished the negative impact on target detection when smoke was introduced. In the woodland environment, effective fusion did not interfere with cross-country movement times and increased the range at which thermal and human targets were detected. Deep shadows, camouflage, and smoke did not mask targets when the thermal overlay was present. In the MOUT setting, fusion provided significantly greater target detection during smoke conditions than was provided by the I^2 baseline devices.

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Executive Summary

This study was conducted to evaluate a prototype enhanced night vision goggle (ENVG), which combines thermal and image intensification (I^2) capability. The experiment was executed over a period of 4 weeks, with one infantry squad per week acting as participants. Soldiers received familiarization training about two baseline devices and the prototype night vision device (NVD) and were briefed at the start of each exercise to explain what was required of them during the event. The exercises included a wide range of ENVG environments to enable comprehensive assessment of features. These included open field target detection trials with and without smoke; woodland patrolling and target detection trials with and without smoke; woodland individual movement techniques (IMT) course trials; military operations in urban terrain (MOUT) IMT course trials; MOUT target detection trials with and without smoke; and tunnel clearing course trials. A human factors engineering evaluation of the ENVG was also performed. The experiment was conducted in August and September 2003, during hours of darkness, at various sites in Fort Benning, Georgia.

Results indicated that the fused NVD enhanced target detection capability, especially through obscurants, without interfering with movement over rough terrain. Specifically, results indicated that fusion technology significantly increased the ability of the Soldiers to detect targets in an open field during smoke and no-smoke conditions. Fusion diminished the negative impact on target detection when smoke was introduced. In the woodland environment, the use of the ENVG prototype did not interfere with cross-country movement times and increased the range at which thermal and human targets were detected. Deep shadows, camouflage, and smoke did not mask targets when the thermal overlay was present. In the MOUT setting, fusion provided significantly greater target detection during smoke conditions than was provided by the I^2 baseline devices.

The configuration of the fused device did not interfere with IMT performance on the MOUT and woodland courses. On the woodland IMT course, the monocular devices (one baseline device and the prototype) resulted in quicker obstacle and course completion times than the biocular baseline device.

The fusion goggle did not hamper the ability of the Soldiers to quickly move through tunnels, and subjective reports indicated that fusion technology increased the range at which targets were first detected.

When used in the fusion mode, the ENVG device was compatible with the AN/PAQ-4C and AN/PEQ-2 laser aiming devices. Thus, Soldiers could accurately fire their weapons and receive the benefit of thermal target detection capabilities without a thermal weapon sight.

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1. Introduction

1.1 Statement of the Problem

The U.S. Army's arsenal of night vision equipment is in a state of nearly continuous evolution. Thus, new and better designs for night vision devices (NVDs) are constantly being proposed. Paragraph 2.0 of the 1998 editorial draft of the U.S. Army Infantry Center's "Own the Night Master Plan for Dismounted Systems" states that during the 1980s, the Army night vision inventory for dismounted infantry was essentially limited to image intensifiers. Technology barriers prevented low power, lightweight thermal imaging devices from being manufactured within affordable prices. Technological advancements have now addressed this limitation.

One of the newest devices undergoing consideration by the U.S. Army is the enhanced night vision goggle (ENVG). The ENVG is envisioned to be a lightweight, passive, sensor-fused, electro-optical NVD, which should increase the Soldier's ability to engage and execute close combat, combat support, and combat service support operations in all levels of illumination, adverse weather, and battlefield-obscurant conditions. It should also increase the Soldier's situational awareness. Major General Paul D. Eaton, Commandant of the U.S. Army Infantry School, sent a letter of support to the Program Executive Officer-Intelligence and Electronic Warfare in the ongoing ENVG developmental efforts being conducted by Program Manager–Reconnaissance Surveillance Target Acquisition in January 2002.

1.2 Objectives

The objective of this experiment was to document the contribution of night vision fusion capabilities in the ENVG system relative to existing NVD systems and their effect on infantry performance. Six individual field exercises and a human engineering exercise were conducted to evaluate the candidate ENVG systems. Exercises were chosen to assess particular ENVG aspects, capabilities, and characteristics (e.g., thermal capability, usability, durability, etc.). The exercises and corresponding goals are as follow:

1.2.1 Open Field Target Detection Trials

- Assess the impact of the ENVG design on detection of human targets in an open field at various distances, from 50 to more than 300 meters (m).
- Assess the impact of the ENVG design on target detection in an open field with and without smoke. Smoke manipulations were included to better assess ENVG thermal capabilities.
- We made assessments by documenting the accuracy of target detection for each target, target distance, obscurant condition (smoke or no smoke), and NVD system used.

- Subjective assessments were accomplished through Soldiers' ratings of the ease of target detection and identification with baseline and prototype goggles.

1.2.2 Woodland Target Detection Patrol Trials

- Assess the impact of ENVG design on total time patrolling in a woodland environment.
- Assess the impact of the ENVG design on target detection in a woodland environment at various distances with and without smoke.
- Assess the impact of the ENVG design on target detection in a woodland environment, of various types of targets (i.e., hard, thermal, and human targets).
- We made assessments by documenting target detection for each type of target, target location, target condition, and NVD or ENVG system. Data consisted of target detection accuracy and total time required for the exercise.
- Subjective assessments were accomplished through Soldiers' ratings of the ease of target detection and tactical movement with baseline and prototype goggles.

1.2.3 Woodland Individual Movement Technique (IMT) Trials

- Assess the impact of ENVG design on total time to complete a woodland IMT course.
- Assess the impact of ENVG design on total time to complete a woodland IMT course.
- We made assessments by documenting times for each obstacle and total time required for the exercise, for each NVD and ENVG system.
- Subjective assessments were accomplished through Soldiers' overall ratings of the woodland IMT course negotiation, for each NVD system.

1.2.4 MOUT IMT Trials

- Assess the impact of ENVG design on total time to complete a MOUT IMT course. Note any difficulties (e.g., equipment problems).
- Subjective assessments were accomplished through Soldiers' overall ratings of the MOUT IMT course negotiation, for each NVD system.

1.2.5 MOUT Target Detection Trials

- Assess the impact of ENVG design on total time for target detection in a MOUT environment.
- Assess the impact of the ENVG design on target detection in a MOUT environment with and without smoke. Assess the impact of the ENVG design on target detection in a MOUT environment, of various types of targets (i.e., hard, thermal, and human targets).

- Document target detection for each type of target, target location, target condition, and NVD system. Data consisted of target accuracy, time to detect, and total time required for the exercise.
- Document subjective assessments through Soldiers' ratings of the ease of target detection and tactical movement with baseline and prototype goggles.

1.2.6 Tunnel Clearing Trials

- Assess the impact of ENVG design on tunnel clearing tasks.
- Document target detection and time to detect for each type of target (friend or foe), target location, and NVD system. Data consisted of target accuracy, time to detect, and total time required for the exercise.
- Document subjective assessments through Soldiers' ratings of the ease of target detection and tactical movement with baseline and prototype goggles.

1.2.7 Human Factors Engineering (HFE) Trials

- Assess the impact of ENVG design on the donning and doffing of the goggles.
- Assess the ENVG design on compatibility with clothing, equipment, and firing positions.
- Document compatibility problems with clothing, equipment, and firing positions.
- Document subjective assessments through Soldiers' ratings of ease of use and compatibility with other equipment items.

---

2. Method

2.1 Overview

This experiment was executed over a period of 4 weeks, with one infantry squad per week as participants in the experiment. Soldiers first received familiarization training on two baseline devices and the prototype NVD. In addition, they were briefed at the start of each exercise to explain the nature of the exercise and what was required of them during the event. An array of field-based exercises was chosen to assess various aspects of ENVG systems. These included open field target detection trials with and without smoke; woodland patrolling and target detection trials with and without smoke; woodland IMT course trials; MOUT IMT course trials; tunnel clearing course trials; and MOUT target detection trials with and without smoke. An HFE evaluation of the ENVG equipment was also performed. The experiment was conducted in August and September 2003, during hours of darkness, at various sites in Fort Benning, Georgia.

2.2 Participants

A total of four squads (26 enlisted male Soldiers) from the Ranger Training Brigade (RTB) was used as subjects during this experiment. Each squad participated in the experiment for one week.

For the open field target detection exercise, four additional Soldiers were recruited. They were all enlisted personnel from the U.S. Army Research Laboratory (ARL).

2.2.1 Pre-test Orientation and Volunteer Agreement

All tasks planned for this experiment were tasks that are a normal part of the infantry job. A safety release was obtained by the Night Vision Electronic Sensor Directorate of for any experimental equipment that was used.

Although the RTB unit was officially requested to provide troops for this study, it was made clear to the Soldiers that participation in the experiment was voluntary. Soldiers were provided copies of the approved experimentation protocol before their experimental session began. Each group of Soldiers was assembled and given an orientation about the purpose of the study and their participation. They were briefed about the objectives and procedures for each experiment and the NVD systems they would use throughout the investigation. They were also told how the results will be used and the benefits that the military can expect from this investigation. Any questions regarding the study were answered.

Finally, the volunteer agreement affidavit was explained and its contents verbally presented. The Soldiers were given the affidavit to read and sign if they decided to volunteer. All Soldiers signed the affidavit.

2.2.2 Medical Review and Screening

Upon arriving at the experiment site, the investigators asked the Soldiers if they had a medical profile or history that would jeopardize them if they participated in the study. Each Soldier was asked if he had any history of allergic reaction or any other adverse reaction to smoke. Soldiers were also asked to complete a medical status form.

2.2.3 Demographics

Demographic data were taken for each Soldier. Data concerning their infantry experience and their experience with NVDs were included in the demographic questionnaire.

2.3 Apparatus

2.3.1 Standard and Candidate Item Descriptions

2.3.1.1 AN/PVS-14 (Device A)

The AN/PVS-14 is a hand-held, helmet-mounted, head-mounted, or weapon-mounted monocular image intensification (I^2) NVD that enables walking, driving, weapon firing, short-range

surveillance, map reading, vehicle maintenance, and administering first aid in limited light conditions. Each unit allows for vertical adjustment (using head straps), fore and aft adjustment, objective lens focus, and eyepiece focus. The device is also equipped with an infrared (IR) light-emitting source with a variable gain control. The monocular NVD automatically shuts off when disconnected from the head mount or helmet mount. Equipment data are presented in table 1.

Table 1. AN/PVS-14 equipment data.

Total head-mounted weight	656 grams
Battery requirements	2 AA alkaline or 2 AA 1.5 volts direct current (VDC) lithium
Field of view	40 degrees
Operating temperature	-29° to +35 °C
Illumination required	Overcast starlight to moonlight
Optimum light level resolution	1.35 cy/mr
Forward projection	149 mm
Lateral protrusion	46 mm
Center of gravity (c.g.) from the bottom center of the front lip of helmet	(34.0 mm x, 33.1 mm y, -21.5 mm z)
Mount to PASGT[a] helmet	Yes
Mount to head harness	Yes
Distortion	<2%
Magnification	1X ± .02
Eye relief	25 mm
Exit pupil	14 mm
Diopter focus range	+2 to –6
Range focus	25 cm to infinity
Integral battery pack	Yes
Fused IR imagery	No

[a]PASGT = personal armor system for ground troops

2.3.1.2 AN/PVS-7 (Device B)

The AN/PVS-7 is a biocular NVD that can be helmet mounted or head mounted, thus enabling walking, driving, weapon firing, short-range surveillance, map reading, vehicle maintenance, and administration of first aid in limited light conditions. Each unit allows for vertical adjustment (via head straps), fore and aft adjustment, objective lens focus, and eyepiece focus. The device is also equipped with an IR light-emitting source. The goggle automatically shuts off when dismounted from the head mount or helmet mount. Equipment data are shown in table 2.

2.3.1.3 Candidate ENVG (Device C)

The candidate ENVG's design philosophy is to provide a small goggle that integrates an IR camera into an I^2 system. The primary goal of this design is "optical fusion in a small package." Limited equipment data are shown in table 3. Because of the proprietary status of this prototype, complete technical data cannot be disclosed.

Table 2. AN/PVS-7 equipment data.

Total head-mounted weight	980 grams (w/ batteries)
Battery requirements	2 AA alkaline or 2 AA 1.5V DC lithium
Field of view	40 degrees
Operating temperature	-29° to +35 ºC
Illumination required	Overcast starlight to moonlight
Optimum light level resolution	1.15 cy/mr
Forward projection	167 mm
Lateral protrusion	45 mm
c.g. from the bottom center of the front lip of helmet	
Mount to PASGT helmet	Yes
Mount to head harness	Yes
Distortion	<4%
Magnification	1X ± .04
Eye relief	15 mm
Exit pupil	7 mm
Diopter focus range	+2 to –6
Range focus	20 cm to infinity
Integral battery pack	Yes
Fused IR imagery	No

Table 3. Candidate ENVG device C equipment data.

Field of view I^2	40 degrees
Mount to PASGT helmet	Yes
Fused IR imagery	Yes – Overlay

2.3.1.4 Summary

Table 4 provides a summary of the characteristics of the prototype and baseline devices.

Table 4. Summary of NVD characteristics.

Device	**Designation**	**Thermal**	**Oculars**	**Comment**
Device A	AN/PVS-14	No	Monocular	Standard issue.
Device B	AN/PVS-7	No	Biocular	Standard issue.
Device C	ENVG	Yes	Monocular	

2.3.2 Infantry Task Courses

The following section provides a description of the environments used for this study.

2.3.2.1 Open Field Target Detection Range

The open field target detection course was selected to provide the Soldiers with the opportunity to scan an area, identify the presence of human targets, and to report the posture of the targets. The open field consisted of an unpaved airfield surrounded by wooded areas. On each side of the airfield, chemical markers indicated each 50 m of distance. Human targets were used for all detection exercises. For each target exercise, Soldiers were requested to identify each target, as

soon as possible, by specifying location, distance, and the posture of the human target (i.e., standing, kneeling, or prone) (see photo in appendix A).

2.3.2.2 Woodland Target Detection Course

The dismounted woodland patrols were conducted in an area containing six 200-m long and 50-m wide lanes in a wooded area, across different terrain features. These terrain features included wooded rolling hills, ditches, fallen logs, light vegetation, high canopy, and open areas. Hard, thermal, and human targets were dispersed throughout the course. Some of the targets were hidden behind vegetation, some were in the open, and some were next to trees. Human targets assumed standing firing positions. A map of the dismounted patrol lane is shown in appendix A.

2.3.2.3 Woodland IMT Course

The woodland IMT course design required Soldiers to use virtually all non-MOUT tactical maneuvers and IMTs. The course is situated in a field, with 10 obstacle areas. It required Soldiers to execute a variety of individual movements and to assume a variety of positions while they maneuvered through, over, under, and around obstacles. Obstacles included (a) pipe crawl area, (b) zigzag area, (c) 2-foot jump, (d) hill, (e) low crawl area, (f) combat roll station, (g) high crawl area, (h) kneeling firing position station, (i) high wall, and (j) prone firing position station. Appendix A contains a sketch of the course.

2.3.2.4 MOUT IMT Course

The MOUT IMT course is situated within the McKenna MOUT facility. A course was selected that requires Soldiers to perform a number of MOUT IMT maneuvers as quickly as possible. The route was determined to require Soldiers to execute a variety of individual movements and to assume a variety of positions while maneuvering through, under, and around urban obstacles such as windows, doorways, stairs, and mouse holes. A map of the course is provided in appendix A.

2.3.2.5 MOUT Target Detection Course

The MOUT target detection course is situated within the McKenna MOUT facility. It is a 200-m long lane that comprises a hard-top road between two rows of buildings. There were seven target positioning locations interspersed throughout the course, in places such as behind walls and windows. Hard, thermal, and human targets were placed throughout the course. Each target positioning location had one to six targets assigned to it. A map of the course is given in appendix A.

2.3.2.6 Tunnel Clearing Course

The tunnel clearing course is situated within the McKenna MOUT facility. It consists of tunnels connected in a maze-like structure that requires Soldiers to execute a variety of individual

movements while maneuvering through, under, and around tunnel obstacles. Appendix A contains a sketch of the course.

2.3.3 Common Clothing and Equipment Items

Table 5 provides a list of the common clothing and equipment items that were worn and carried during the experiment.

Table 5. Common clothing and equipment items.

Item Description
Underclothing and socks
Battle dress uniform (BDU)
Belt with buckle
Boots
PASGT helmet
Tactical load-bearing vest with pistol belt
Canteen with cover, and 1 quart of water (two each)
Hand grenades (two each, inert)
Individual first aid kit
M16 mock-up with PEQ-2
Ammunition pouches (two)
Elbow and knee pads (two each)

2.3.4 Questionnaires

Questionnaires were designed to elicit Soldiers' opinions about their performance and experiences with each of the NVD systems. The questionnaires were designed to enable Soldiers to rate the devices on a 7-point semantic differential rating scale ranging from "extremely good" to "extremely bad." Questionnaires were administered to each Soldier at the completion of each of the trials with each of the devices and at the completion of the training course for each goggle.

2.4 Procedures

2.4.1 Training

The requested Soldiers were in a military occupational specialty that requires the use of NVD, performance of mobility and portability maneuvers (movement-to-contact and assault maneuvers), and movement as a dismounted element that is associated with their profession. No specialized experience was required. However, the Soldiers were shown how to safely negotiate the various courses planned for the experiment and were trained in specific procedures as required. They were also given specialized training about the prototype ENVG system.

Before the first training presentation, experiment Soldiers received a roster number, which was used to identify them throughout the experiment. The initial NVD training was accomplished in a classroom setting. A representative from ARL presented a class on the baseline goggles based upon the RTB and the Night Fighting Training Facility programs of instruction for the AN/PVS-7s

and the AN/PVS-14s. During this presentation, the Soldiers were taught the key elements of night vision and I^2 technology, how to focus NVDs with the use of a visual acuity resolution chart, how to adjust the helmet mounts, and the fundamentals of night movement techniques.

After the completion of the baseline goggle training, the contractor representative for the prototype NVD presented a course about the system. This course included operation, adjustment, and so forth, of the prototype system, as well as suggestions for operational employment of the goggles and what settings should be used in different visibility conditions. Upon completion of the prototype ENVG training, Soldiers were given a subjective questionnaire designed to assess their perception of the training adequacy. Questions about system operating procedures, level of detail presented, adequacy of training aids, and length of training were presented.

2.4.2 Open Field Target Detection Trials

Soldiers conducted the open field target detection trials with the prototype ENVG, as well as the baseline AN/PVS-7s and AN/PVS-14s. This exercise was conducted with and without smoke. All iterations without smoke were conducted first. After they were completed, the iterations with smoke were conducted.

Each pair of iterations contained one presentation with targets that were easier to detect and one presentation with targets that were more difficult to detect. The order of presentation of the easy and difficult trials within each pair of iterations was counterbalanced.

Target personnel were in a concealed position and were instructed to move into position upon the Experiment Manager's command. The targets were rotated every iteration to prevent the detection process from being compromised. Table 6 shows the distance and stance (prone, kneeling, or standing) for each target in each iteration. The open field target detection trial course layout is shown in appendix A.

Upon command of the Experiment Manager, individuals moved up to the observation line and were equipped with the goggle type designated in tables 7 and 8. Upon the command of "observe," five Soldiers moved to the observation line and observed down range. Once a Soldier detected a target, he instructed the data collector of the target location and activity. The data collector recorded the number of targets detected, target ranges, and target activity. Each Soldier performed two iterations using the same NVD but with different target positions.

Open field target detection trials were completed with and without smoke. During the smoke trials, the smoke was deployed in the areas marked as Smoke 1 and Smoke 2 as shown in the course layout (appendix A). Two smoke sections provided the smoke produced by smoke generators.

Table 6. Target presentation order matrix.

No Smoke										
Itera - tion	**Range to Target (meters)**									
	50	**100**	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**
1A	2 Kneel		3 Prone		1 Stand		4 Kneel		5 Stand	
1B		1 Prone		2		5,8 Kneel		4 Stand		6 Stand
2A	1 Kneel 2 Prone		3 Kneel			4 Stand			5 Stand	
2B		2,3 Prone		1 Kneel		5 Kneel			6 Stand	
3A		1,3 Kneel			2 Kneel			4, 8 Stand		5 Stand
3B				1,2 Stand		6 Kneel		4,5 Stand		
Smoke										
4A		2,3 Prone		1, 7 Kneel		5 Kneel			6 Stand	
4B	1,2 Prone			3 Stand			5,6 Kneel			
5A			3 Prone		1 Kneel			4 Stand		5,6 Stand
5B				1,2 Stand		6 Kneel		4,5 Stand		
6A			2,3 Kneel			4,5 Stand		6 Stand		
6B		1,3 Prone			2 Kneel		4 Stand		5, 8 Stand	

A maximum of 1 minute per iteration was allowed. If the Soldier did not complete his detections before the 1-minute time limit, the data collector recorded any target information that the Soldier had at that time. After each iteration, questionnaires were issued to the individual to address the effectiveness of the system in detecting and identifying targets. During the smoke trials, a smoke section deployed the smoke using a smoke generator (as shown in appendix A marked as smoke 1 and smoke 2). The smoke was deployed between the target personnel and the experiment Soldiers. The Experiment Manager determined when the smoke was to be deployed.

Tables 7 and 8 show the order in which the three goggles were distributed to the Soldiers. These matrices are randomized, with the restriction that each goggle appears in each order an approximately equal number of times.

Table 7. Open field target detection trials without smoke.

Soldier	Order		
	1	2	3
1	C	A	B
2	A	C	B
3	A	C	B
4	A	B	C
5	C	B	A
6	B	C	A
7	A	B	C
8	A	B	C
9	C	B	A
10	C	A	B
11	B	C	A
12	A	C	B
13	B	C	A
14	B	C	A
15	C	B	A
16	A	C	B
17	A	B	C
18	C	A	B
19	A	B	C
20	C	A	B
21	C	A	B
22	A	B	C
23	C	B	A
24	C	B	A
25	C	A	B
26	B	A	C

Table 8. Open field target detection trials with smoke.

Soldier	Order		
	1	2	3
1	B	C	A
2	C	B	A
3	B	A	C
4	A	C	B
5	A	C	B
6	C	B	A
7	B	C	A
8	A	B	C
9	C	B	A
10	C	B	A
11	A	C	B
12	B	A	C
13	A	B	C
14	C	B	A
15	C	A	B
16	A	C	B
17	C	A	B
18	C	A	B
19	B	A	C
20	A	B	C
21	C	B	A
22	A	B	C
23	B	C	A
24	B	C	A
25	B	A	C
26	B	A	C

2.4.3 Woodland Dismounted Target Detection Trials

The woodland dismounted target detection trials required each Soldier to move along a controlled route within the lane while accompanied by a data collector.

Sections of the course contained smoke. The smoke used during this trial was emitted by a fog machine and was deployed by the target personnel when the experiment Soldiers passed designated points on the course. The smoke was deployed between the experiment Soldiers and the target personnel.

When smoke was employed, it was used in designated sections of the course. The target personnel deployed the smoke only when the Soldier was nearly to the target location marked “A and B” in appendix A or when the data collector with the Soldier requested it by radio. The target positions are shown in table 9.

Table 9. Target presentation order matrix.

Target	Iteration				
	1	**2**	**3**	**4**	**5**
Human 1	4	2	2	8	10
Human 2	1	10	8	3	6
Hard Target 1	9	3	9	6	2
Hard Target 2	5	8	7	9	7
Thermal 1	6	1	10	4	5

The Soldiers used the goggle and the lanes designated in tables 10 and 11. In both tables, the order of the lanes and NVDs is randomized.

Soldiers moved along a patrol lane and told the data collector when they observed targets. The data collector recorded the target detection and target distance from the individual after ensuring that the correct identification was made.

Table 10. Woodland dismounted target detection trials without smoke

Soldier	Order		
	1	**2**	**3**
1,11	A2	C1	B5
2,12	C2	B3	A1
3,13	A1	C5	B4
4,14	B3	A2	C1
5,15	B4	A3	C2
6	A2	B4	C5
7	C5	A1	B4
8	C5	A4	B2
9	B4	C1	A5
10	A3	B5	C2
16	A3	B5	C1
17	A4	C3	B2
18	B1	C4	A2
19	B1	C2	A3

Table 11. Woodland dismounted target detection trials with smoke

Soldier	Order		
	1	**2**	**3**
1	A3	B5	C1
2	A4	C3	B2
3	B1	C4	A2
4	B1	C2	A3
5	C5	B1	A3
6	B3	C4	A1
7	B2	A4	C5
8	C3	B1	A4
9	C4	A1	B2
10	A2	B5	C1
11,16	C4	B5	A2
12,17	B4	A3	C5
13,18	C2	A4	B5
14,19	B1	A5	C3
15	A5	B3	C2

After each iteration, questionnaires were issued to the individual to address the effectiveness of the system in detecting targets in a woodland environment.

Only 19 Soldiers participated in the Woodland Dismounted Target Detection exercise. Heavy rain prevented the exercise for one squad of Soldiers.

2.4.4 Woodland IMT Course Trials

Soldiers initially walked through the course and each obstacle and position was explained before they ran the first trial. In addition, all Soldiers completed one familiarization trial wearing their

uniforms, standard fighting load, and carrying their assigned weapons. A description of each event and instructions for executing the event are provided next.

Data collectors were positioned at each obstacle in order to observe Soldiers and record starting and ending times for each event.

- Starting Point. The starting point is clearly marked with a white line that spans the width of both lanes on the course. The course requires the Soldier to begin in the upright standing position with his weapon held at "port arms." Upon the command "go" from the data collector, timing for the trial begins and the Soldier moves quickly to obstacle 1. Once the course is started, he continues at a safe pace through the entire course, executing each obstacle along the way, until the end is reached.
- Obstacle 1, Pipe Crawl. The pipe is 6.1 m long by 0.9 m in diameter and made of corrugated steel. It has a ridged surface and Soldiers wear elbow and knee pads to avoid injury. The Soldier moves as quickly as possible to complete the obstacle without causing injury to himself or damage to equipment carried or worn. Once through the pipe crawl, the Soldier moves quickly to obstacle 2.
- Obstacle 2, Zigzag. The zigzag is 1.6 m tall, 13.7 m long, and approximately 1 m wide. It consists of three turns (approximately 90 degrees each) within the lane. The framework is constructed of wood with mesh wire installed between the two lanes and on the outside framework of each lane. The zigzag requires the Soldier to proceed through the obstacle as quickly as possible without causing any injury to himself or damage to equipment. Once through the zigzag, the Soldier moves rapidly to obstacle 3.
- Obstacle 3, 2-foot Jump. The jump is a low wall, 0.6 m tall and 13 cm deep. The jump requires the Soldier to jump over the obstacle as quickly as possible without causing any injury. Once the jump is cleared, the Soldier moves rapidly to obstacle 4.
- Obstacle 4, Hill. The hill is approximately 9.8 m long, 1.8 m wide, and 3.2 m tall with a 30-degree sloped incline and decline along the route of movement. The Soldier ascends and descends the hill and then moves rapidly to obstacle 5.
- Obstacle 5, Low Crawl. The low crawl is 12.8 m long and 3 m wide with an overhead cover of mesh wire approximately 0.6 m off the ground. The Soldier completes the obstacle as quickly as possible using correct low crawl techniques. After completing the low crawl, the Soldier proceeds to obstacle 6.
- Obstacle 6, Combat Roll Station. Each lane of the combat roll station is about 6.1 m long and 1 m wide. The Soldier falls to the prone position immediately after entering the station. He then executes a full combat roll to the left or right, pushes off the ground, executes a 3- to 5-second rush, goes back to the prone, and scans the assigned sector for possible targets. Once the target is detected, the Soldier identifies the target, demonstrating

to the data collector that he has acquired the target. The data collector then gives the command and the Soldier engages the target, does a full combat roll to the left or right, pushes off the ground, and moves rapidly to obstacle 7.

- Obstacle 7, High Crawl. Each lane of the high crawl is 12.8 m long and 3 m wide with an overhead cover of mesh wire approximately 0.9 m off the ground. The Soldier moves as quickly as possible, using correct high crawl procedures to negotiate the full length of the obstacle. Once through the high crawl, the Soldier moves rapidly to obstacle 8.
- Obstacle 8, Kneeling Firing Position Station. The kneeling firing position station provides a wooden support 2 m wide, 1 m tall, and 13 cm deep for the Soldier to support the weapon against during target acquisition and engagement. Upon entering the station, the Soldier assumes a kneeling supported firing position. He then scans the assigned sector for possible targets. Once the target is detected, the Soldier identifies the target, which lets the data collector know the target has been identified. The data collector then gives the command to engage the target and complete the station. The Soldier engages the target and completes the station as quickly as possible. Once completed, the Soldier "double times" to obstacle 9.
- Obstacle 9, High Wall. The high wall is made of wood, is 1.4 m tall, 1.8 m wide, and 13 cm deep. The Soldier climbs over the obstacle as quickly as possible without causing any injury or damaging equipment while maintaining control of the weapon at all times. Once the high wall is cleared, the Soldier moves rapidly to obstacle 10.
- Obstacle 10, Prone Firing Position Station. The prone firing position station is 2 m long by 1 m wide with sandbags provided to rest the weapon. The Soldier enters the station and assumes a prone supported firing position. He then scans the assigned sector for targets. Once the target is detected, the Soldier identifies the target. The data collector then gives the command to engage the target and the Soldier does so and completes the station. The Soldier then moves as rapidly as possible to the end point of the course.
- End Point. The Soldier has completed the IMT course.

This course thus provides a standardized methodology for assessing IMT woodland performance that enables control, standardization, and repeatability. Times required to complete each obstacle and the entire course were collected by data collectors throughout the course. Trials were executed according to the matrix shown in table 12. The sequence of goggles for each Soldier was randomized with the restriction that each goggle appears in each order an approximately equal number of times. Times to complete each obstacle, as well as times to complete the total course, were recorded.

At the completion of the exercises with each of the baseline and ENVG prototypes, a subjective questionnaire was administered. In addition, data collector observations were recorded after each trial. If specific obstacles or positions were more difficult or time consuming to execute,

the reasons were determined and documented so that corrective actions could be taken in equipment design or procedures. The route in which Soldiers maneuvered the course is shown in appendix A.

Table 12. Woodland IMT course trials.

Soldier	Order		
	1	2	3
1	A	B	C
2	C	A	B
3	B	C	A
4	C	A	B
5	A	B	C
6	B	A	C
7	A	C	B
8	C	B	A
9	B	A	C
10	A	B	C
11	B	A	C
12	C	B	A
13	C	B	A
14	C	A	B
15	B	A	C
16	B	A	C
17	C	B	A
18	C	A	B
19	C	A	B
20	C	A	B
21	B	C	A
22	A	B	C
23	B	A	C
24	A	C	B
25	A	C	B
26	B	A	A

2.4.5 MOUT IMT Course Trials

Before each experimental session, Soldiers initially walked through the course. Each obstacle and position was explained before they ran the first record trial. In addition, all Soldiers completed one familiarization trial wearing their uniforms, standard fighting load, and carrying their assigned weapons. For safety and control reasons, only one Soldier at a time executed the course.

A description of each event and instructions for executing the event follows:

- Starting Point and Building B4 Activities. The starting point is clearly marked with a white line. The Soldier begins in the upright standing position with his weapon held at "port arms." Upon the command "go" from the data collector, the Soldier moves at a double time pace to the "mouse hole" in the lower wall between the eastern-most rooms in the building. Once the course is started, he continues at a safe pace through the entire course,

executing each obstacle along the way, until the end is reached. Upon exiting the "mouse hole," he stands in a crouching ready position, turns left, and exits the room through the doorway in the wall between the two northern-most rooms in the building. Once in the next room, he exits through the "mouse hole" in the exterior wall and moves rapidly across the alley to the second window from the left in building B2.

- Building B2 Activities. This is the second of three buildings used for the course. The Soldier enters the building through the designated window, assumes a crouching movement position, turns left and moves at a safe pace through the doorway and across the street to building B1, entering through the second door from the left.
- Building B1 Activities. This is the last of three buildings used for the course. Upon entering the building through the specified doorway, the Soldier moves across the room and passes through the doorway directly in front of him, entering the hallway. Once in the hallway, he makes an immediate right turn and proceeds down the hallway to the intersection. He then turns left and moves a few paces to the next opening on his left, which is the stairwell. Proceeding up the stairs to the third floor and exiting the stairwell, he then makes an immediate right turn, crosses the hallway, and enters the door directly in his path. Once inside this room, he proceeds to the doorway in the corner to his left front and passes through this door. From this position, he crosses the room to the ladder in the corner to his right front and climbs it to the rooftop. He then moves to a designated spot along the roof parapet and assumes a standing supported firing position. Once in the firing position, the Soldier yells "here" to let the data collector know the course is finished and to stop timing the trial.

Times required to complete the entire course were recorded. Soldiers also provided ratings of the level of difficulty experienced with specific movement tasks or in negotiating specific types of obstacles. If specific obstacles or positions on the route were more difficult or time consuming to execute with particular NVD systems, events and rationale were documented to facilitate corrective actions in equipment design. This MOUT IMT enables control, standardization, and repeatability, while maintaining operational relevance of maneuvers.

Soldiers negotiated the MOUT IMT course one at a time with each of the baseline and prototype goggles as shown in table 13. The sequence of the goggles was randomized, with the restriction that each goggle appears in each order an approximately equal number of times.

After each iteration, questionnaires were issued to the individual to address the effectiveness of the system during the MOUT IMT trials.

Only 19 Soldiers participated in the MOUT IMT event. Range-scheduling conflicts prevented one squad from participating in this event.

Table 13. MOUT IMT course trials.

Soldier	Order		
	1	2	3
1	C	B	A
2	A	B	C
3	A	B	C
4	C	A	B
5	C	A	B
6	C	B	A
7	A	C	B
8	B	A	C
9	C	A	B
10	C	B	A
11	C	B	A
12	C	A	B
13	A	B	C
14	B	C	A
15	C	A	B
16	A	B	C
17	B	A	C
18	A	B	C
19	A	C	B

2.4.6 MOUT Target Detection Trials

Thirty target locations were situated at various places throughout the MOUT target detection course. Target locations were assigned to target positions so that each position had one to six specific target locations. Soldiers encountered ten targets in each iteration. Target assignments are indicated in table 14. Targets included hard, thermal, and human targets. Each Soldier used each of the three NVDs in smoke and non-smoke conditions.

Before the experimental trials, Soldiers were escorted through the course and shown each target position and its associated scan sector. Targets varied in type and location each session. Data collectors positioned at each of the target positions observed Soldier performance and radioed target detection information to the data recorder.

The course layout is presented in appendix A. Soldiers negotiated the course according to table 14. Targets were rotated every iteration to prevent compromise of the detection process according to table 15.

This event was conducted with the two baseline goggles and with the prototype goggles. Each Soldier moved along the control route, stopping at each target position to scan his assigned sector. When the Soldier detected a target, he identified the target by placing his aiming light on it and telling the data collector. Soldiers were given 60 seconds to detect targets at each target position.

Table 14. MOUT target detection lane positions.

Position	Soldier's Stance	Position Location	Target Sector	Movement/Negotiation
Start	Prone	Ready Line	West end A2	• Rush • Arrive position 1
1	Kneeling	West end A1	Southwest side A2	• Enter NW doorway • Through first mouse hole • Through second mouse hole • Arrive position 2
2	Kneeling	North side A1 window	South side A2	• Through window • Rush • Arrive position 3
3	Prone	Northwest end A3	Southeast side A2	• Rush to A4 • Through window west end • Arrive position 4
4	Kneeling	South side A4 window	West end B1	• Through window • Rush • Arrive position 5
5	Prone	Northwest corner B1	South side B2	• Rush • Arrive position 6
6	Kneeling	Southwest corner B2	West side B3	• Rush • Enter SE doorway B2 • Through window • Rush • Through mouse hole west side • Rush • Arrive position 7
7	Prone	Southeast B4 mouse hole	North side B5	• Finished

Table 15. Target location order matrix.

Start/Position 1					Position 2				
Trial	**Therm**	**Hard**	**Human**	**Human**	**Trial**	**Therm**	**Hard**	**Human**	**Human**
1					**1**	10		12	9
2				2	**2**		10	7	
3	3	5		1	**3**	12		8	
4	2		5		**4**		9		
5	4			5	**5**		11		12
Position 3					**Position 4**				
1		13			**1**	18	22		17
2			13	15	**2**	19	17		
3			13		**3**	20			
4	14				**4**		20	17	21
5	16	13			**5**		21		22
Position 5					**Position 6**				
1		26			**1**				
2	26			24	**2**		28		
3		24			**3**			27	28
4			23		**4**	28		27	
5	24	23		26	**5**				

Position 7				
1	30			
2				
3				
4			30	
5				

Each data collector was in radio contact with a data recorder at the starting point. As soon as a Soldier completed his scanning at a particular target position, the data collector told the data recorder whether the Soldier detected each target and the time to detect each target.

These trials were executed with and without smoke. Because of the limited number of smoke generators available, not all the targets were effectively obscured by smoke. The smoke did not adequately obscure targets at the starting position or at positions 1 and 2. Only targets at positions 3 through 7 were masked by smoke.

Trials were executed according to the matrices shown in tables 16 and 17. In each of these matrices the order of goggles was randomized, with the restriction that each goggle appears in each order an approximately equal number of times.

After each iteration, questionnaires were issued to the individual to address the effectiveness of the system in detecting targets in an urban environment.

Table 16. MOUT target detection trials without smoke.

Soldier	Order		
	1	2	3
1	B	C	A
2	A	C	B
3	A	B	C
4	A	B	C
5	A	B	C
6	B	A	C
7	C	A	B
8	C	A	B
9	B	A	C
10	A	C	B
11	B	C	A
12	C	B	A
13	A	B	C
14	C	B	A
15	C	B	A
16	C	B	A
17	C	A	B
18	C	A	B
19	C	A	B
20	C	B	A
21	B	C	A
22	C	B	A
23	C	B	A
24	A	C	B
25	B	A	C
26	B	C	A

Table 17. MOUT target detection trials with smoke.

Soldier	Order		
	1	2	3
1	B	A	C
2	A	B	C
3	B	C	A
4	A	C	B
5	B	C	A
6	C	A	B
7	C	A	B
8	B	C	A
9	A	B	C
10	B	C	A
11	B	C	A
12	B	C	A
13	B	A	C
14	A	B	C
15	A	B	C
16	C	A	B
17	A	B	C
18	B	A	C
19	B	C	A
20	C	A	B
21	C	B	A
22	C	A	B
23	B	A	C
24	C	A	B
25	C	B	A
26	C	B	A

2.4.7 Tunnel Clearing Trials

The purpose of the tunnel clearing course was to compare individual Soldier performance based on different equipment or procedures used during each trial. The route was selected because it requires Soldiers to execute a variety of individual movements while maneuvering through, under, and around tunnel obstacles. Times required to complete the entire course were collected. In addition, Soldier ratings of the level of difficulty experienced with specific movement tasks or in negotiating specific types of obstacles were recorded after each trial. If specific obstacles or positions on the route were more difficult or time consuming to execute, the reasons were documented so that corrective actions in equipment design or procedures could be implemented.

Soldiers initially walked through the course, and each obstacle and position were explained before they ran the first record trial. All Soldiers completed one familiarization trial wearing their uniforms, standard fighting load, and carrying their assigned weapons. For safety and control reasons, only one Soldier at a time executed the course.

The starting point is clearly marked with a white line. The Soldier begins in the upright standing position with his weapon held at "port arms." Upon the command "go" from the data collector, the Soldier moves at a double-time pace to the small hole at the tunnel entrance. Once the course is started, he continues at a safe pace through the entire course, executing each obstacle along the way, until the end is reached. Targets were randomly placed along the route in the positions indicated in table 18 and rotated every iteration to prevent compromise of the detection.

Table 18. Target presentation matrix.

Soldiers	**Iteration**	**Human Target Number**			
		1	**2**	**3**	**4**
1 through 9	**1**	7	4	14	8
	2	5	2	10	11
	3	1	7	8	8
10 through 18	**1**	5	4	12	10
	2	2	7	11	13
	3	3	5	12	8
19 through 26	**1**	1	6	8	13
	2	4	3	14	10
	3	7	5	14	12

This event was conducted with the baseline and prototype goggles. An individual Soldier moved along the control route and scanned for targets. When the Soldier detected a target, he halted and identified the target to the data collector. The data collector recorded the target detection after ensuring that the correct identification was made. The data collector then instructed the Soldier to move.

These trials were executed without smoke. The Soldier was presented four targets throughout the course. Trials were executed according to the matrix shown in table 19. The order of

presentation of goggles was randomized, with the restriction that each goggle appears in each order an approximately equal number of times.

After each iteration, questionnaires were issued to the individual to address the effectiveness of the system in a tunnel environment.

Table 19. Tunnel target detection.

Soldier	Order		
	1	2	3
1	B	A	C
2	A	C	B
3	B	A	C
4	A	B	C
5	C	B	A
6	C	A	B
7	B	A	C
8	C	A	B
9	A	B	C
10	B	A	C
11	A	C	B
12	B	A	C
13	A	C	B
14	B	C	A
15	B	C	A
16	C	B	A
17	A	C	B
18	C	A	B
19	A	C	B
20	C	B	A
21	C	A	B
22	B	C	A
23	B	A	C
24	B	A	C
25	A	C	B
26	B	C	A

2.4.8 HFE Trials

The HFE trials consisted of donning and doffing trials and compatibility trials with clothing, equipment, and firing positions. The form, fit, and function exercise included attaching and detaching the prototype devices to the helmet of the Soldier.

Compatibility with clothing and equipment and the ability to assume standard (stationary) firing positions was also assessed. Dismounted firing positions, which were assessed with the prototype devices, were sitting, kneeling, prone, and standing positions. Soldiers wore their standard fighting loads during all trials. Trials also included accessing and operating weapon and prototype device controls while the Soldiers were in the various firing positions and while they wore different ensembles.

Protective eyewear and environmental protective clothing were alternated for different firing positions, as shown in table 20. Eyewear and protective clothing included the M40 nuclear, biological, and chemical (NBC) mask, the ballistic laser eye protection system (BLEPS), and sun, wind, and dust (SWD) goggles. The order of presentation of goggles was randomized within the six possible orders of equipment.

Soldiers completed a subjective questionnaire after they performed the tasks using the clothing and equipment combinations before the attaching and detaching event and after the compatibility event.

Table 20. Equipment compatibility trials.

Soldier	**M40 Mask**			**BLEPS**			**SWD Goggles**		
1	A	C	B	C	A	B	A	C	B
3	C	A	B	A	C	B	A	C	B
22	B	C	A	B	A	C	A	C	B
23	B	C	A	B	C	A	C	B	A
	SWD Goggles			**M40 Mask**			**BLEPS**		
5	A	C	B	B	A	C	A	C	B
9	C	A	B	B	C	A	C	B	A
12	B	A	C	A	C	B	A	C	B
16	A	C	B	A	B	C	B	A	C
18	B	C	A	C	A	B	C	B	A
25	B	A	C	C	A	B	C	A	B
	BLEPS			**SWD Goggles**			**M40 Mask**		
8	B	A	C	C	A	B	B	C	A
20	C	A	B	B	C	A	A	B	C
26	A	B	C	C	B	A	B	C	A
	M40 Mask			**SWD Goggles**			**BLEPS**		
6	B	C	A	B	A	C	C	A	B
10	A	B	C	A	B	C	A	C	B
13	A	B	C	C	A	B	C	B	A
19	A	C	B	B	C	C	A	C	B
	SWD Goggles			**BLEPS**			**M40 Mask**		
2	B	A	C	A	C	B	B	A	C
15	C	B	A	B	A	C	B	A	C
17	C	B	A	A	B	C	C	B	A
21	B	C	A	A	C	B	A	C	B
	BLEPS			**M40 Mask**			**SWD Goggles**		
4	C	A	B	A	B	C	B	A	C
7	B	C	A	C	B	A	A	C	B
11	C	B	A	A	C	B	C	B	A
14	C	A	B	C	B	A	B	C	A
24	A	B	C	C	B	A	A	C	B

2.5 Experimental Design

2.5.1 Independent Variable

The independent variable is the type of NVD (two baseline devices and one prototype device) used in the various exercises.

2.5.2 Dependent Variables

2.5.2.1 Open Field Target Detection Trials

- Percent targets detected at various ranges with and without smoke
- Soldier evaluations of each NVD

2.5.2.2 Woodland Dismounted Target Detection Patrol Lane

- Time to complete the Woodland Patrol Lane Course
- Percent targets detected with and without smoke
- Distance from targets when detected
- Soldier evaluations of each NVD

2.5.2.3 Woodland IMT Course

- Time to complete each of ten events (pipe crawl, zigzag, 2-foot jump, hill, low crawl, combat roll, high crawl, kneel, high wall, prone)
- Number of targets acquired in three events (combat roll, kneel, prone)
- Time to complete total IMT course
- Soldier evaluations of each NVD

2.5.2.4 MOUT IMT Course

- Time to complete course
- Soldier evaluations of each NVD

2.5.2.5 MOUT Target Detection Lane

- Time to complete course with and without smoke
- Percent targets detected with and without smoke
- Time to detect targets with and without smoke
- Soldier evaluations of each NVD

2.5.2.6 Tunnel Clearing Course

- Time to clear tunnel
- Number of targets identified as friend or foe
- Soldier evaluations of each NVD

2.5.2.7 Human Factors Engineering Trials

- Soldier evaluations of ease of donning and doffing NVDs with M40 mask, BLEPS, and SWD goggles
- Soldier evaluations of ease of attaching and detaching NVDs with M40 mask, BLEPS, and SWD goggles
- Soldier evaluations of each NVD with respect to donning and doffing, attaching and detaching
- Soldier evaluations of NVD compatibility while assuming standard firing positions (standing, sitting, kneeling, and prone)

2.6 Limitations

Because of a heavy rainfall, one squad of Soldiers was unable to participate in the Woodland Target Detection event. Another squad did not complete the MOUT IMT course because of a range scheduling conflict. The resulting attenuated sample sizes decrease statistical power.

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3. Results

3.1 Training and Demographics

3.1.1 Training

All but seven of the Soldiers had received previous training in focusing the night vision goggles (NVGs). Three of the Soldiers had previously fired their weapons while wearing NVGs and using a laser aiming light.

3.1.2 Demographics

The weight of the Soldiers ranged from the 13th to the 99th percentile. Their height ranged from the 14th to the 98th percentile. The detailed results from the demographic questionnaire are presented in appendix B.

3.2 Open Field Target Detection

The fusion goggle significantly increased the ability of the Soldiers to detect targets in an open field during smoke and no-smoke conditions. The fusion technology was effective in diminishing the negative impact of battlefield obscurants. Soldiers reported that a thermal overlay with a contrasting color to the I^2 screen made the human targets "pop out" and decreased target acquisition time.

The Soldiers were presented between seven and eight targets on each iteration. Table 21 shows the percentage of targets detected without smoke at a range of less than 100 m. Because the first smoke deployment point was at 100 m, targets at a range of less than 100 m were not obscured. A repeated measures analysis of variance (ANOVA) revealed a significant effect for NVDs: $F(2,58) = 5.24$, $p = .008$.

Table 21. Percentage of targets detected during open field target detection, <100 m.

Device	No Smoke	
	Mean	SD
A	75.6	33.8
B	70.0	43.2
C	94.2	18.2

Ensuing comparisons were made with Holm's Sequential Bonferroni procedure to control for family-wise error rates. The ensuing comparisons for the no-smoke data are shown in table 22. Significantly more targets were detected with device C than with the A and B devices.

Table 22. Ensuing comparisons, percent targets detected, no smoke, <100 m.

Comparison	df	t	Required p	Obtained p
A vs. B	29	.64	.05	.525
A vs. C	29	2.73	.025	.011*
B vs. C	29	3.06	.017	.005*

$p < .05$, two-tailed

The target detection results for a range of 100 to 300 m are shown in table 23. The effect for NVDs was significant in the no-smoke condition: $F(2,58) = 10.7$, $p < .001$. There was also a significant effect in the repeated measures ANOVA on the smoke data: $F(2,58) = 9.38$, $p < .001$.

Table 23. Percentage of targets detected during open field target detection, 100 m to 300 m.

Device	No Smoke		Smoke	
	Mean	SD	Mean	SD
A	43.3	34.8	27.1	32.5
B	58.9	31.4	33.9	36.4
C	71.6	30.9	67.0	40.1

The ensuing comparisons for the no-smoke data are summarized in table 24. The C device performed significantly better than the A and B devices.

Table 24. Ensuing comparisons, percent targets detected, no smoke, 100 m to 300 m.

Comparison	df	t	Required p	Obtained p
A versus B	29	2.58	.025	.015*
A versus C	29	4.13	.017	<.001*
B versus C	29	2.37	.05	.025*

Table 25 shows the ensuing comparisons for the smoke conditions. Again, significantly more targets were detected with device C than with devices A and B.

Table 25. Ensuing comparisons, percent targets detected, with smoke, 100 m to 300 m.

Comparison	df	t	Required p	Obtained p
A versus B	29	.70	.05	.489
A versus C	29	4.46	.017	<.001*
B versus C	29	3.05	.025	.005*

Table 26 shows the detection percentages for targets presented beyond 300 m. The repeated measures ANOVA on the no-smoke data indicated that there was not a significant effect: $F(2,58) = 1.80$, $p = .174$. There was, however, a significant effect for NVDs in the smoke data: $F(2,58) = 24.7$, $p < .001$.

Table 26. Percentage of targets detected during open field target detection, >300 m.

Device	No Smoke		Smoke	
	Mean	SD	Mean	SD
A	28.4	38.1	4.4	14.0
B	32.9	39.6	5.6	19.2
C	41.6	38.9	51.6	44.5

Table 27 shows the ensuing comparisons for the smoke data. The C device performed significantly better than the baseline NVDs in detecting targets beyond 300 m.

Table 27. Ensuing comparisons, percent targets detected, with smoke, >300 m.

Comparison	df	t	Required p	Obtained p
A versus B	29	.24	.05	.808
A versus C	29	5.86	.017	<.001*
B versus C	29	4.83	.025	<.001*

$p < .05$, two-tailed

3.2.1 Open Field Target Detection Questionnaire Results

Smoke did not significantly degrade the ability of the Soldiers to detect targets on the open field range with the prototype ENVG used in the fusion or thermal modes. Soldiers detected significantly more targets with the C device during smoke conditions than they did with the baseline goggles. In addition, their subjective ratings of the ease of target detection with the C device were higher than for the baseline devices.

Soldiers found the C device to be very easy to focus and to understand. They stated that the device was extremely user friendly. The orange thermal overlay made the targets "pop out." The fusion goggle was reported to be easy to use in smoke and when no smoke was present. One Soldier did complain about lag with the thermal overlay when the C device was used to scan a sector.

Detailed results from the Soldier questionnaires are given in appendix B.

3.3 Woodland Target Detection

The use of the fusion goggle did not interfere with cross-country movement times and marginally increased the range at which thermal and human targets were detected. Deep shadows, camouflage, and smoke did not mask targets when the thermal overlay was present.

Table 28 displays the mean times to complete the Woodland Patrol Course. A repeated measures ANOVA shows that there was no significant difference among the night vision devices: $F(2,36) = .75$, $p = .482$.

Table 28. Mean times to complete woodland patrol lanes (min:sec).

Device	Mean	SD
A	9:19	3:29
B	8:46	3:08
C	10:46	3:17

Each Soldier was presented with a total of five targets on each of the five woodland target detection lanes. Table 29 shows the percentage of targets detected with and without smoke. A repeated measures ANOVA for the no-smoke condition revealed no significant difference among the night vision devices: $F(2,36) = .52$, $p = .600$. A repeated measures ANOVA could not be run on the Smoke data because only six Soldiers encountered smoke targets with all three NVDs.

Table 29. Percentage of targets detected, woodland patrol lanes.

Device	No Smoke		Smoke	
	Mean	SD	Mean	SD
A	89.5	22.5	78.8	35.9
B	83.4	22.7	80.2	37.2
C	82.1	33.8	97.9	7.22

Table 30 shows the average estimated distance at which Soldiers detected targets. The effect for goggle type is statistically significant: $F(2,36) = 3.90$, $p = .029$.

Table 30. Estimated target detection distance (m), woodland patrol lanes

Device	Mean	SD
A	19.9	10.6
B	19.2	10.6
C	30.5	19.1

The ensuing comparisons for the estimated detection distance are shown in table 31. None of the comparisons reached the Holm's Bonferroni criteria for statistical significance.

Table 31. Ensuing comparisons, estimated target detection distance (m).

Comparison	df	t	Required p	Obtained p
A versus B	18	.22	.05	.826
A versus C	18	2.14	.025	.046
B versus C	18	2.16	.017	.045

The benefit of fusion technology should be most pronounced with heat-generating targets. Therefore, we did a second analysis of target detection distances using only thermal and human targets, with hard targets excluded. The summary statistics for human and thermal target detection distances are shown in table 32. A repeated measures ANOVA yields a significant effect for NVDs: $F(2,34) = 9.23$, $p = .001$.

Table 32. Estimated target detection distance (m), woodland patrol lanes, human and thermal targets only

Device	Mean	SD
A	21.6	9.80
B	18.4	10.3
C	34.7	15.7

Ensuing t-tests for the human and thermal target detection distances are shown in table 33. Soldiers were able to detect targets at significantly greater distances using the C prototype than with either of the baseline NVDs.

Table 33. Ensuing comparisons, estimated target detection distance (m), human and thermal targets only.

Comparison	df	t	Required p	Obtained p
A versus B	18	.83	.05	.415
A versus C	17	2.88	.025	.010*
B versus C	17	4.28	.017	.001*

$p < .05$, two-tailed

3.3.1 Woodland Target Detection Questionnaire Results

Soldiers reported that target detection with smoke in the target vicinity was very easy with the C device and neutral to easy with the A and B baseline devices. They reported that fusion helped them see the targets (human and thermal) farther out while moving through the dense terrain. Soldiers were able to detect heat-generating targets with the C device at a greater range than with the baseline I^2 devices. No differences were found between the course completion times with the A and C goggles. Even though smoke was present on some sections of the course, it did not appear to affect the completion times with the A device.

Detailed results from the Soldier questionnaires are shown in appendix B.

3.4 Woodland IMT Course

The configuration of the C prototype had no negative impact on IMT. In general, the monocular devices (A and C) resulted in quicker obstacle and course completion times than the biocular device (B).

The mean times for each of the 10 events in the woodland IMT are shown in table 34. The entry for "Total Events" does not include the data from the three target acquisition events (combat roll, kneel, and prone) since these three events included target acquisition times and the large variances in the acquisition times tended to obscure the times required to complete the physical obstacles. The "Total Course" entry does contain the target acquisition events, plus the time spent moving from one event to the next.

Table 34. Mean times to complete the woodland IMT course events.

Device	**A**		**B**		**C**	
Event	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Pipe Crawl	8.30	2.05	9.15	9.15	9.56	4.11
Zigzag	7.63	1.79	9.63	9.63	7.65	1.47
2-foot Jump	1.85	0.94	2.75	2.75	2.21	1.04
Hill	6.35	1.99	7.54	7.54	6.71	2.19
Low Crawl	30.0	9.82	34.7	34.7	35.0	12.1
Roll	26.2	6.87	30.5	30.5	29.8	10.3
High Crawl	26.0	10.3	27.4	27.4	26.5	8.00
Kneel	10.6	13.3	7.59	11.3	11.1	7.24
High Wall	4.92	5.81	1.45	2.05	5.32	1.54
Prone	16.9	14.1	7.92	7.10	14.2	7.28
Total Events	85.1	97.0	23.0	22.7	92.6	24.8
Total Course	188.1	214.0	45.5	51.4	202.0	55.1

Table 35 is a summary of the repeated measures ANOVAs for the woodland IMT times. There were no significant differences among the night vision devices on the pipe crawl, low crawl, combat roll, high crawl, kneel, high wall, and prone events. There were statistically significant differences in the zigzag, 2-foot jump, and hill events. There were also significant differences among the devices for total event times and total course times.

Table 35. Summary of repeated measures ANOVAs.

Event	n	F	p
Pipe Crawl	25	1.95	.153
Zigzag	24	10.8	<.001*
2-foot Jump	25	8.24	.001*
Hill	25	6.27	.004*
Low Crawl	25	2.45	.097
Combat Roll	25	2.23	.118
High Crawl	25	0.47	.628
Kneel	25	1.25	.296
High Wall	25	2.89	.065
Prone	25	0.85	.435
Total Events	25	4.45	.017*
Total Course	25	5.12	.010*

*$p < .05$

For each significant repeated measures ANOVA, ensuing comparisons were conducted with Holm's Sequential Bonferroni procedure to control for family-wise error rates.

The ensuing comparisons for zigzag are shown in table 36. Soldiers were significantly slower when using the biocular B device as compared with both the A and C monocular devices.

Table 36. Ensuing comparisons, zigzag.

Comparison	df	t	Required p	Obtained p
A versus B	24	3.61	.025	.001*
A versus C	23	.06	.05	.955
B versus C	24	3.72	.017	.001*

$p < .05$, two-tailed

Table 37 contains the ensuing comparisons for the 2-foot jump. Soldiers completed this event significantly faster with the A device than with either the B or C devices.

Table 37. Ensuing comparisons, 2-foot jump.

Comparison	df	t	Required p	Obtained p
A versus B	24	3.75	.017	.001*
A versus C	24	2.49	.025	.020*
B versus C	25	2.01	.05	.055

$p < .05$, two-tailed

Table 38 shows the ensuing comparisons for the hill event. Performance was significantly faster with both the A and C monocular NVDs as compared with the binocular B device.

Table 38. Ensuing comparisons, hill.

Comparison	df	t	Required p	Obtained p
A versus B	24	3.47	.017	.002*
A versus C	24	1.01	.05	.321
B versus C	25	2.72	.025	.012*

$p < .05$, two-tailed

The ensuing comparisons for the total event times (minus the three target acquisition events) are shown in table 39. The events were completed significantly faster with device A than with device B.

Table 39. Ensuing comparisons, total events.

Comparison	df	t	Required p	Obtained p
A versus B	24	2.93	.017	.007*
A versus C	24	1.68	.025	.106
B versus C	25	1.57	.05	.129

$p < .05$, two-tailed

Finally, the ensuing comparisons for the total course times are shown in table 40. The mean time to complete the entire course was significantly slower with the B device as compared with the A device.

Table 40. Ensuing comparisons, total course times

Comparison	df	t	Required p	Obtained p
A versus B	24	3.33	.017	.003*
A versus C	24	1.50	.05	.146
B versus C	25	1.98	.025	.059

$p < .05$, two-tailed

In three of the woodland IMT events (combat roll, kneel, and prone), the Soldiers were directed to acquire a human target. The summary statistics on targets acquired are presented in table 41. A repeated measures ANOVA indicated that there was a significant difference among the devices: $F(2,50) = 3.19$, $p = .050$.

Table 41. Mean targets acquired (of 3) in woodland IMT.

Device	Mean	SD
A	2.19	1.20
B	2.50	0.95
C	2.62	0.80

The Holm's Sequential Bonferroni ensuing comparisons are summarized in table 42. None of the comparisons reached statistical significance, although the difference between the A and C devices approached significance.

Table 42. Ensuing comparisons, woodland IMT target acquisition.

Comparison	df	t	Required p	Obtained p
A versus B	25	1.87	.025	.073
A versus C	25	2.19	.017	.038
B versus C	25	.72	.05	.478

3.4.1 Woodland IMT Questionnaire Results

Soldiers rated the ease of negotiating the woodland IMT course obstacles the highest when using the A and C devices. The Soldiers relied a great deal on their unaided eyes to negotiate this course. Thus, course completion times could have been more heavily influenced by the balance of the device on the head and by the design of the helmet mount than by the visual characteristics of the devices. The Soldiers may have been unaware of the effect of the helmet mount configuration on course completion times, which could have resulted in subjective ratings that were inconsistent with the objective course completion times.

Some of the Soldiers reported having trouble with the A device fogging while traversing the course. (Relative humidity levels are typically high in Georgia during August and September.) The eyecup of this device contributed to the fogging. There were no reports of fogging with the fusion devices, probably because none of them had eyecups.

Several Soldiers commented that the biocular design of the B device hindered their depth perception and reduced their field of view (peripheral vision), thus hindering their ability to complete the woodland IMT course. The monocular design of the other devices was reported to be much better for the negotiation of obstacles that rely on depth perception to easily complete (i.e., the mound and the 2-foot wall). Soldiers also reported that the weight of the B device and the long forward protrusion caused it to bounce around when mounted to the helmet mount, which they stated had too many loose joints.

Soldiers rated the C device the highest for IMT course negotiation. The short forward projection and the visual characteristics were cited as aiding in easy negotiation of the course.

Detailed results from the Soldier questionnaires are presented in appendix B.

3.5 MOUT IMT Course

The configuration of the C prototype had no adverse impact on the ability of the Soldiers to quickly negotiate the MOUT IMT course.

Table 43 shows the mean MOUT IMT course completion times. A repeated measures ANOVA yielded no significant effect for NVDs: $F(2,36) = .69$, $p = .509$.

Table 43. Course completion times, MOUT IMT (seconds).

Device	Mean	SD
A	92.1	18.7
B	96.2	19.8
C	95.3	16.1

3.5.1 MOUT IMT Questionnaire Results

Most of the Soldiers set their devices on the "I^2 with IR illumination" mode because the thermal capability of the prototype ENVG was not considered to be as helpful for negotiating the course as the IR illumination enhancement of available light. In other words, the detail provided by the I^2 was needed for course negotiation.

Climbing the ladder was reported to be difficult with all the devices because the Soldiers generally had their focuses set at infinity and they needed to readjust the devices to near focus adjustment to see the ladder rungs.

Detailed results from the Soldier questionnaires are given in appendix B.

3.6 MOUT Target Detection

The fusion prototype had no adverse impact on the completion times of the MOUT target detection exercise. Fusion technology provided significantly greater target detections during smoke conditions than were provided by the I^2 baseline.

Table 44 shows the mean times to complete the MOUT target detection course. For the no-smoke runs, there was no significant effect for goggle type: $F(2,50) = 1.28$, $p = .287$, nor was there a significant effect in the analysis of the smoke data: $F(2,50) = .08$, $p = .925$.

Table 44. Course completion times, MOUT target detection (minutes:seconds).

	No Smoke		Smoke	
Device	**Mean**	**SD**	**Mean**	**SD**
A	4:57	1:46	6:35	1:24
B	5:04	1:35	6:31	1:39
C	5:25	1:40	6:27	1:21

Table 45 shows the mean number of targets detected with each goggle. As mentioned earlier, the smoke generators were not effective in obscuring targets in the starting position or in positions 1 and 2. Each Soldier encountered a total of ten targets on each run; the first five targets that each Soldier encountered were in the starting position or in positions 1 or 2. Therefore, the first five targets were deleted from the "smoke" data presented next. The smoke figures represent targets 6 through 10 only, presented in positions 3 through 7. A repeated measures ANOVA yielded no significant effect for the no-smoke runs: $F(2,50) = .80$, $p = .456$. There was, however, a significant effect for goggles in the smoke runs: $F(2,50) = 9.08$, $p = <.001$.

Table 45. Number of targets detected, MOUT target detection.

	No Smoke (10 targets possible)		Smoke (5 targets possible)	
Device	**Mean**	**SD**	**Mean**	**SD**
A	9.54	0.76	3.00	1.55
B	9.69	0.74	3.35	1.23
C	9.42	0.86	4.35	0.85

Table 46 contains the ensuing comparisons for the number of targets detected with smoke. Significantly more targets were detected with the C fusion device than with either of the I^2 baseline devices.

Table 46. Ensuing comparisons, MOUT target detection, number of targets detected, smoke.

Comparison	df	t	Required p	Obtained p
A versus B	25	1.07	.05	.294
A versus C	25	3.75	.017	.001*
B versus C	25	3.35	.025	.003*

$p < .05$, two-tailed

Table 47 shows the mean times to detect the targets with and without smoke. Each undetected target was encoded as having a 60-second detection time. As in the previous analysis, the smoke data include only targets 6 through 10, presented in target positions 3 through 7. There was no significant effect for goggles in the no-smoke conditions: $F(2,50) = 1.32$, $p = .275$. There was, however, a significant effect in the smoke data: $F(2,50) = 6.04$, $p = .004$.

Table 47. Detection times (seconds), MOUT target detection.

	No Smoke		Smoke	
Device	Mean	SD	Mean	SD
A	7.37	5.86	29.9	14.2
B	7.00	5.87	28.6	13.4
C	9.14	5.94	18.9	11.5

The ensuing comparisons for the smoke runs are shown in table 48. Target detection was significantly faster with the C than with the A or B devices.

Table 48. Ensuing comparisons, MOUT target detection times, smoke.

Comparison	df	t	Required p	Obtained p
A versus B	25	.436	.05	.667
A versus C	25	2.91	.017	.007*
B versus C	25	2.77	.025	.101*

$p < .05$, two-tailed

3.6.1 MOUT Target Detection Questionnaire Results

Soldiers' subjective ratings of their ease of movement through the MOUT target detection course and their ease of target detection when smoke was present were much higher for the C device than for the other devices. When available, fusion was the primary mode used for this exercise. Soldiers commented that fusion allowed them to see the detail for movement through the MOUT course and to also easily see targets in dark areas of the course.

The C device was preferred to the baseline devices in smoke conditions. One Soldier complained that when running through the course, he had trouble keeping the device in line with his eye

because it constantly shifted positions because of the "play" in the helmet mount. Another Soldier complained that the thermal capability cut on and off when he was running.

Detailed results from the Soldier questionnaires are shown in appendix B.

3.7 Tunnel Clearing Course

The C device did not interfere with the ability of the Soldiers to quickly move through the tunnels. Subjective reports indicated that effective fusion increased the range at which targets were first detected.

Table 49 summarizes the time needed to clear the tunnel. A repeated measures ANOVA found no significant effect for NVDs: $F(2,50) = .24$, $p = .785$.

Table 49. Tunnel clearing times (seconds).

Device	Mean	SD
A	161.7	78.4
B	155.4	94.5
C	170.0	65.8

Table 50 shows the mean number of targets recognized as friend or foe (of four) during the tunnel clearing course. There were no significant differences among the night vision devices: $F(2,50) = 2.01$, $p = .144$.

Table 50. Targets recognized (of 4), tunnel clearing course

Device	Mean	SD
A	3.65	1.02
B	4.00	0
C	3.62	0.94

3.7.1 Tunnel Clearing Course Questionnaire Results

During this exercise, the Soldiers' subjective ratings for the C device were very similar to their ratings for the A and B devices. No significant differences were found between the devices in terms of the number of targets detected. However, according to subjective reports, the type of device used did have an effect on the range at which the targets were seen. However, range-to-target data were not collected during this exercise. The Soldiers who did use fusion with the C device were able to detect the targets at long ranges.

Soldiers reported that the weight and moment arm of the B device was a problem in the tunnel. Their crouched body position resulted in their having to hold their heads at an angle and this magnified the weight and balance problem of the B device.

Detailed results from the Soldier questionnaires are given in appendix B.

3.8 HFE Trials

3.8.1 Compatibility

When used in the fusion mode, the C device was compatible with the AN/PAQ-4C and AN/PEQ-2 laser aiming devices. Thus, Soldiers can accurately fire their weapons and get the benefit of thermal target detection capabilities without a thermal weapon sight.

The C device was reported to be compatible with the NBC mask and with the SWD goggles. One Soldier complained that the lanyard for the lens hung on his nose and was an annoyance. Many Soldiers indicated that the balance (provided by the battery box attached to the back of the helmet) and the shorter moment arm made the C device more comfortable than the A and B devices, despite its increased weight over the A device. The helmet mount had a lot of play in it and needed to be locked into position in front of the eye more tightly.

3.8.2 Adjustment

Adjustment and focus of the C device was reported to be extremely easy and the Soldiers praised the human engineering design. The only negative comments were that the IR flash was too time consuming to use and the low battery indicator should be redesigned.

3.8.3 Visual Characteristics

Soldiers commented that the fusion provided by the C device was excellent and gave them an extremely good sight picture. The only negative comments reported were that the red IR illuminator indicator light on the C device was so bright that it interfered with vision, and during quick scanning, there appeared to be a lag in the thermal overlay.

3.8.4 Usage During Movement

A few Soldiers reported that the C device's thermal mode cut off while they were running.

Soldiers preferred a monocular over the biocular device when ambient light levels made it easy to use the image presented by the unaided eye as well as the image presented by the aided eye. They reported that the biocular device greatly decreases depth perception and field of view.

3.8.5 Safety

No safety issues emerged with respect to the C prototype.

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4. Conclusion

The ENVG prototype enhanced target detection capability, especially through obscurants, without interfering with movement. Overall results indicate that the fusion capability in ENVG

systems significantly increased the ability of the Soldiers to detect targets in an open field during smoke and no-smoke conditions. Fusion technology diminished the negative impact on target detection when smoke was introduced. In the woodland environment, the fusion goggle did not interfere with cross-country movement times and increased the range at which thermal and human targets were detected. Deep shadows, camouflage, and smoke did not mask targets when Soldiers used the thermal overlay. In the MOUT setting, effective fusion provided significantly greater target detection during smoke conditions than was provided by the I^2 baseline devices.

The configuration of the C device did not interfere with IMT performance on the MOUT and woodland courses. On the woodland IMT course, the monocular devices (the A and C NVDs) resulted in quicker obstacle and course completion times than the biocular B baseline device.

Effective fusion did not hamper the ability of the Soldiers to quickly move through the tunnels, and subjective reports indicated that effective fusion increased the range at which targets were first detected.

When used in the fusion mode, the ENVG prototype was compatible with the AN/PAQ-4C and AN/PEQ-2 laser aiming devices. Thus, Soldiers can accurately fire their weapons and get the benefit of thermal target detection capabilities without a thermal weapon sight.

The results of this experiment indicate that a fusion NVD can enhance the ability of the dismounted infantryman to conduct night tactical operations.

5. Recommendations

This experiment demonstrated the capability of fusing I^2 and thermal imaging in a single head-mounted NVD. Combining I^2 and thermal in a head-mounted NVD enhances the ability to detect targets at extended ranges without sacrificing the detailed visual information normally associated with I^2 alone. With the addition of thermal technology, the target detection capabilities were enhanced during battlefield obscurants conditions.

This study also showed that the ENVG device can be configured so that it does not interfere with IMT and the traversal of rough terrain. The monocular design facilitates movement and Soldier acceptance. While the ENVG slightly increases the total weight of the helmet assembly, the placement of the battery pack at the back of the helmet counterbalances the weight distribution, thus reducing head and neck strain.

The mixing and adjusting of the I^2 and thermal images are critical to the effective operation of the ENVG. It is important that the thermal overlay not obscure the detail provided by the I^2 image. Complex menu systems for fusion adjustment consume time and decrease Soldier acceptance. The incorporation of internal adjustment algorithms, on the other hand, increases

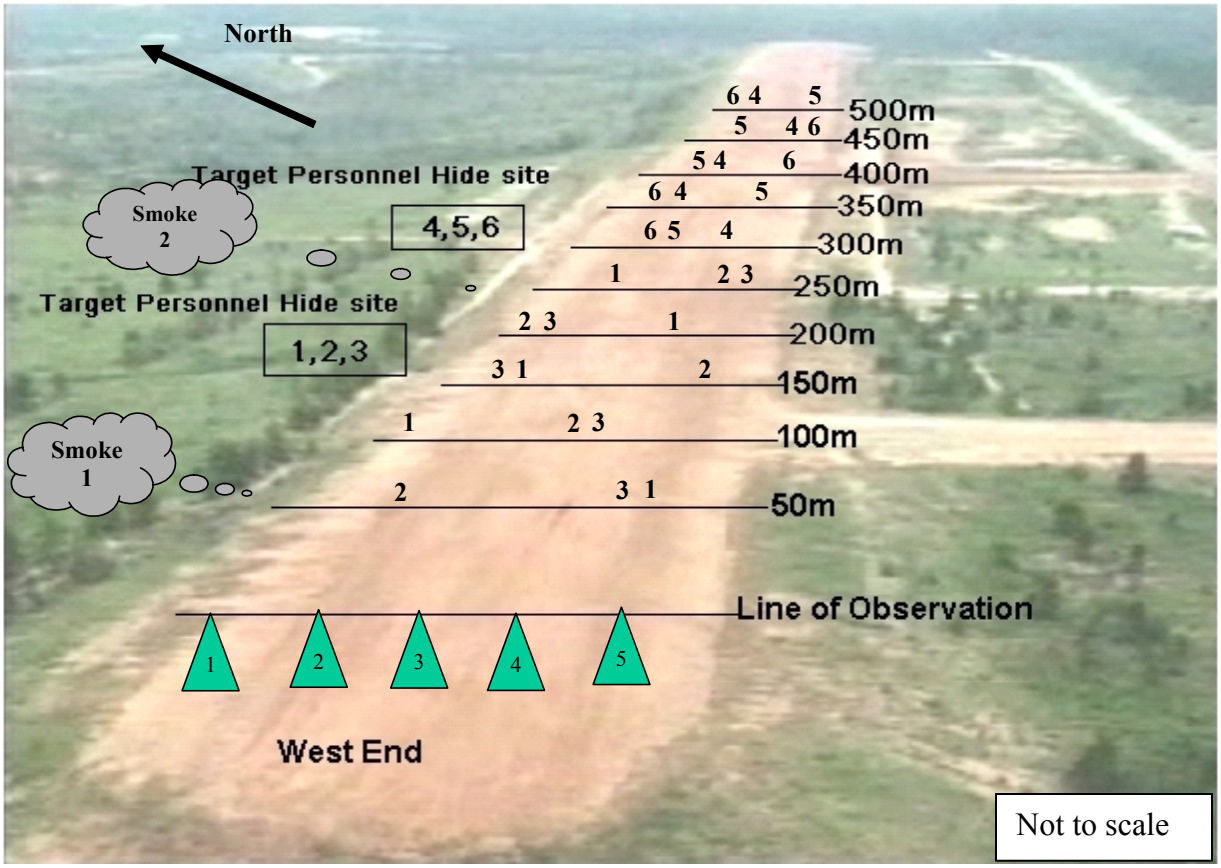
performance efficiency. The Soldiers in this study preferred adjustment knobs over buttons or menu adjustment systems. A Soldier should be able to operate all controls with a single hand.

Placement of the exit pupil optic or eyepiece must be flexible and accommodate variations in head size and avoid potential injury to the Soldier's eye. Optics and eyepieces must be compatible with eyeglasses. There must be a good locking mechanism in the exit pupil optic or eyepiece to prevent displacement during movement. The eyepiece design should incorporate eyecups to provide eye protection and light security.

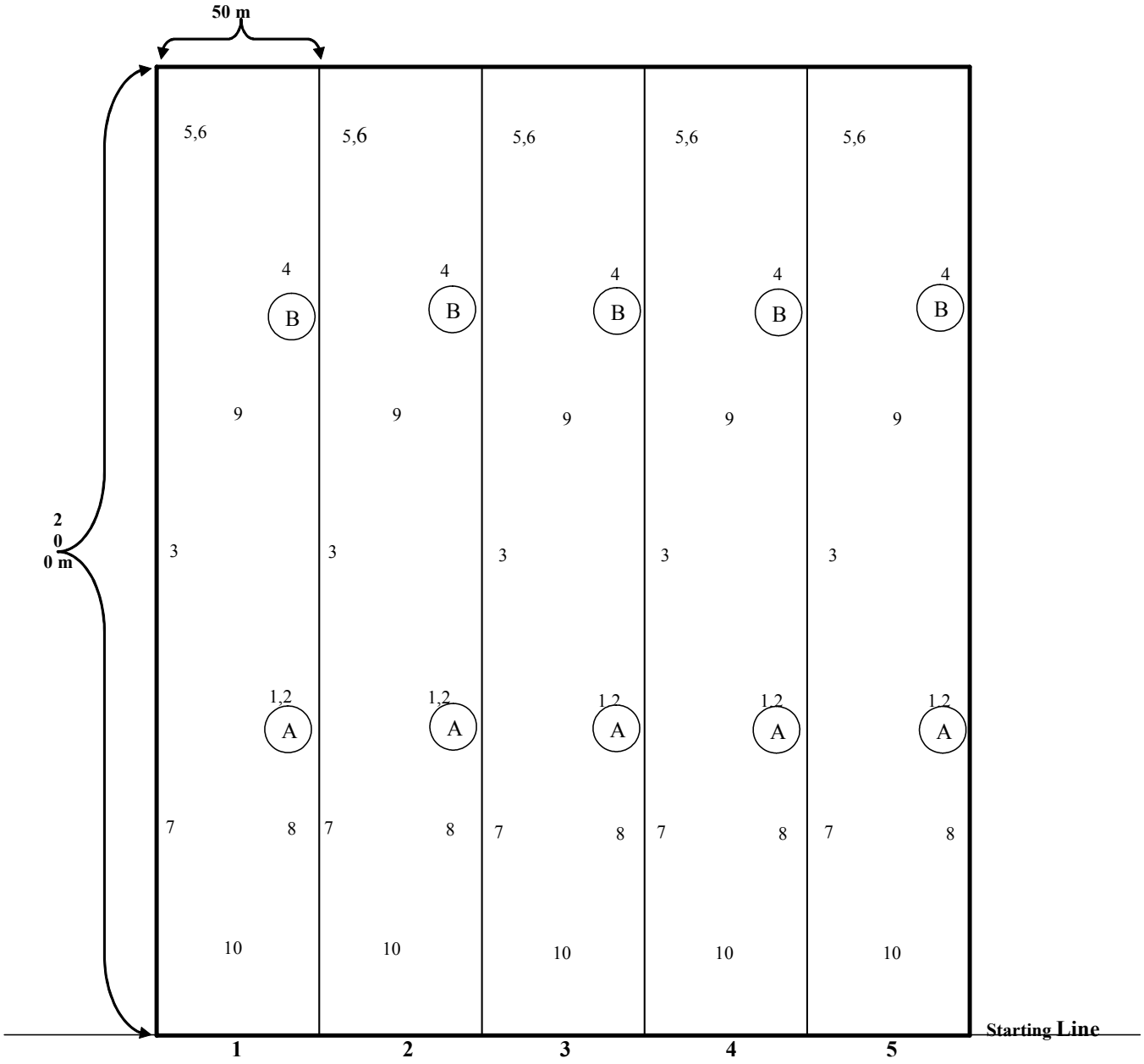
Care should be taken to ensure that the battery connectors are durable enough to withstand field operation.

Appendix A. Course Layouts

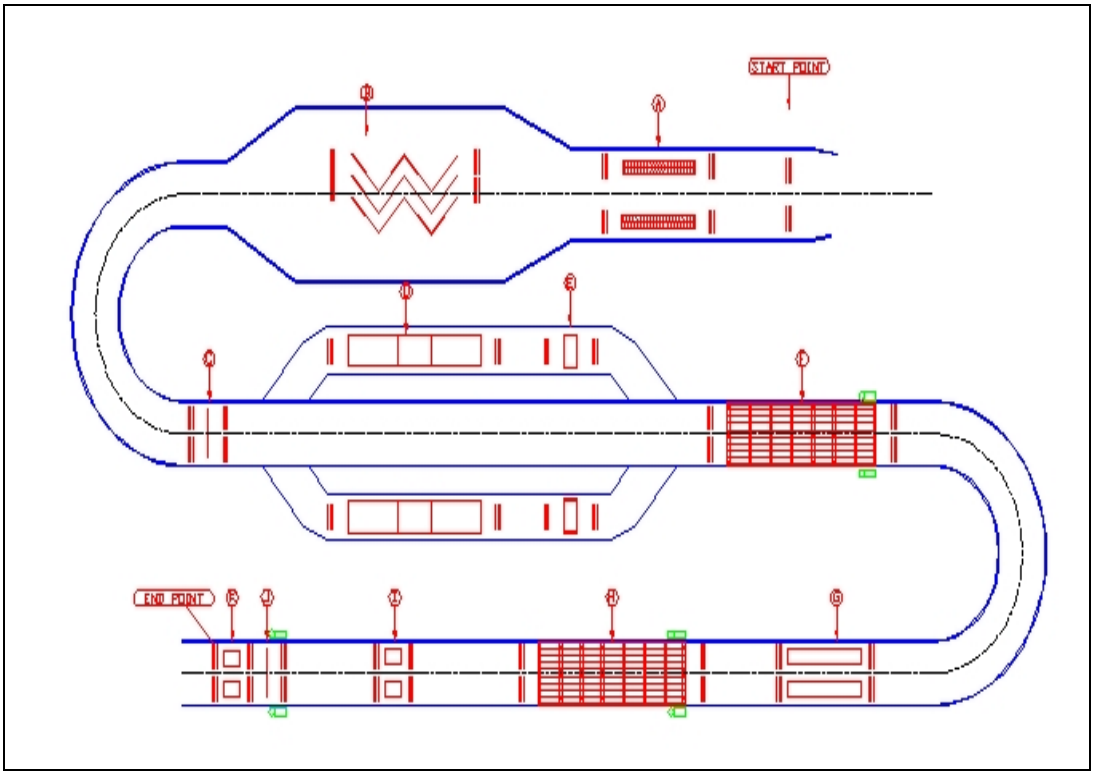
Open Field Target Detection Target Position



Woodland Dismounted Target Detection Lane Course Layout

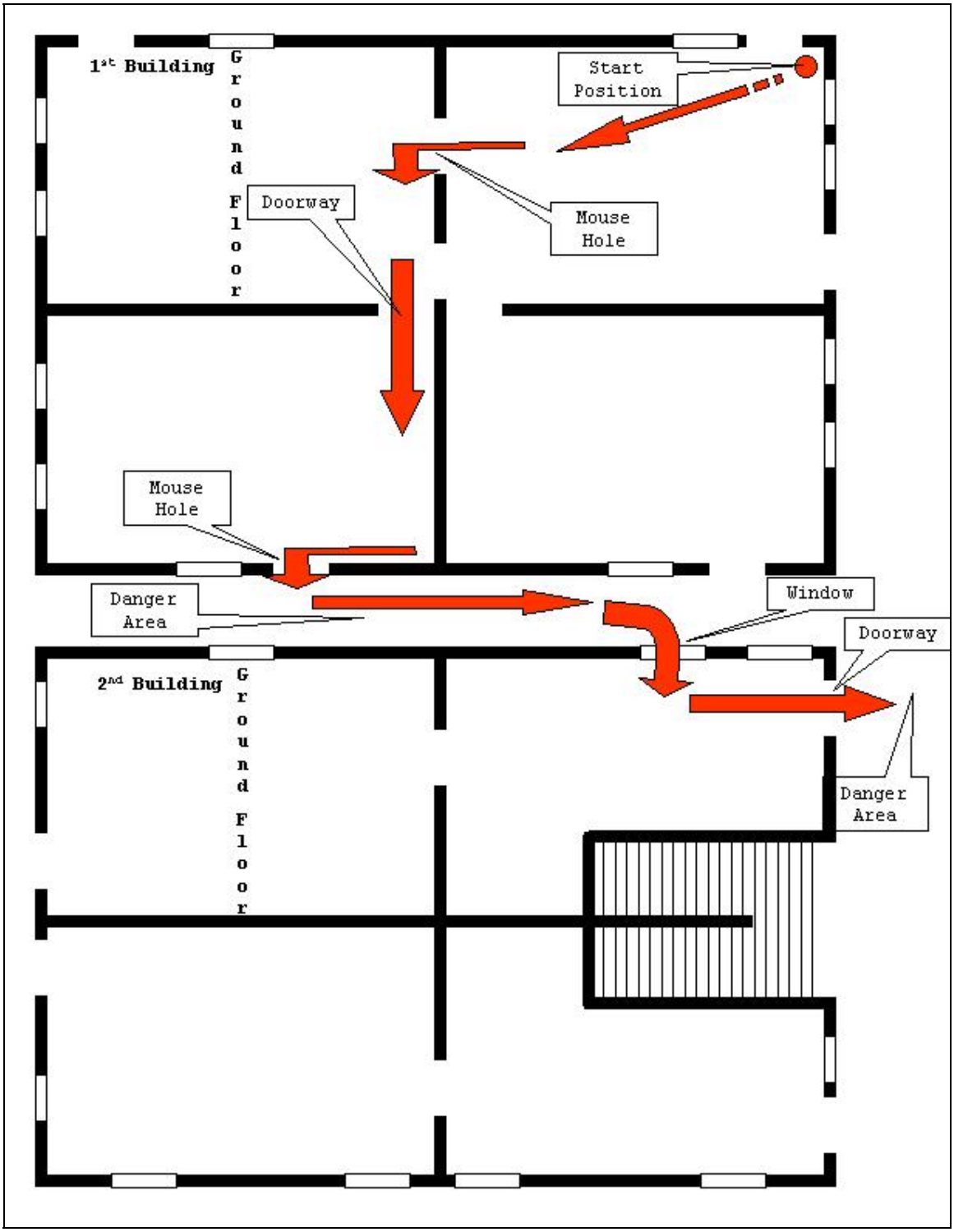


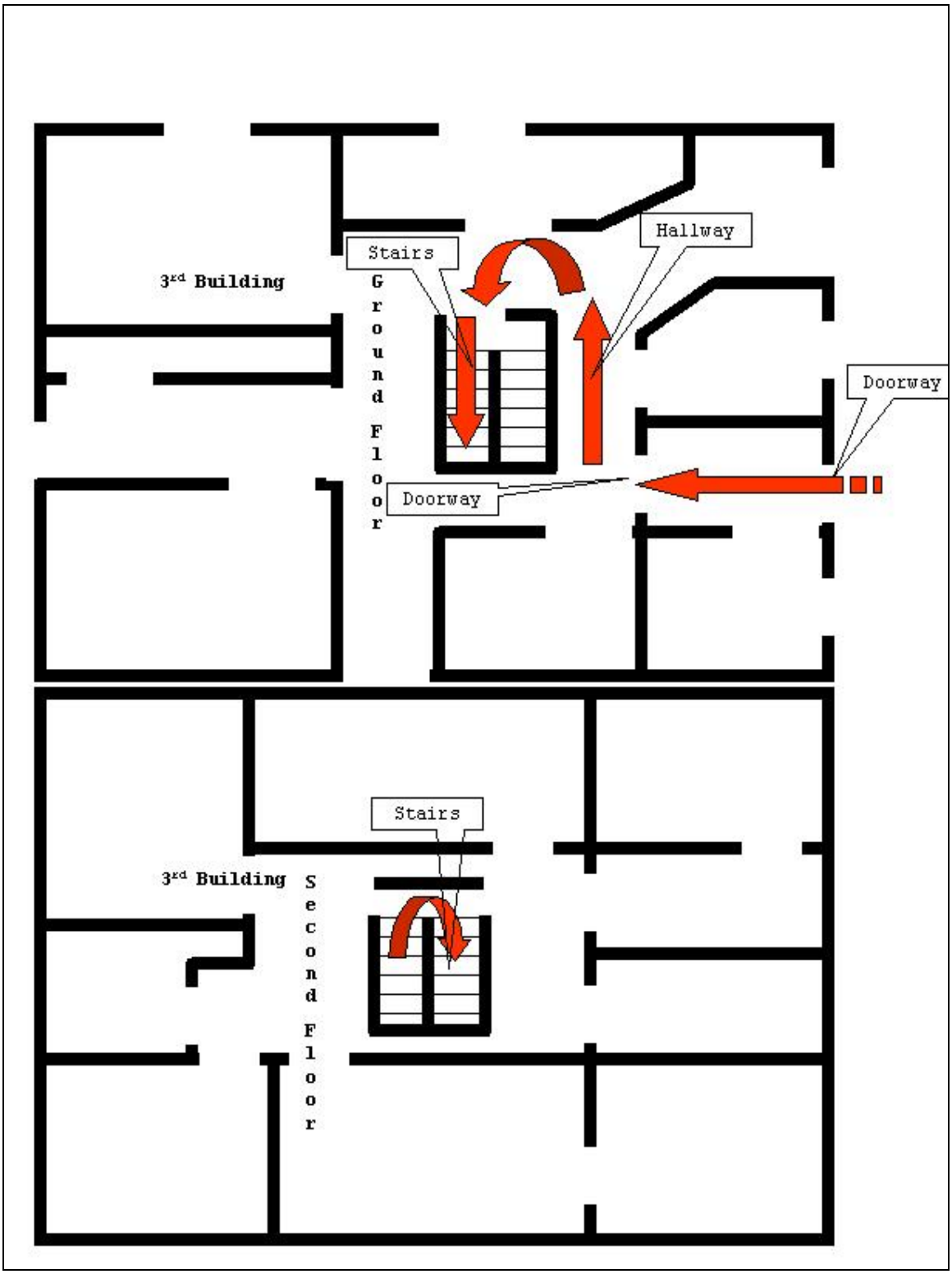
Woodland IMT Course Layout

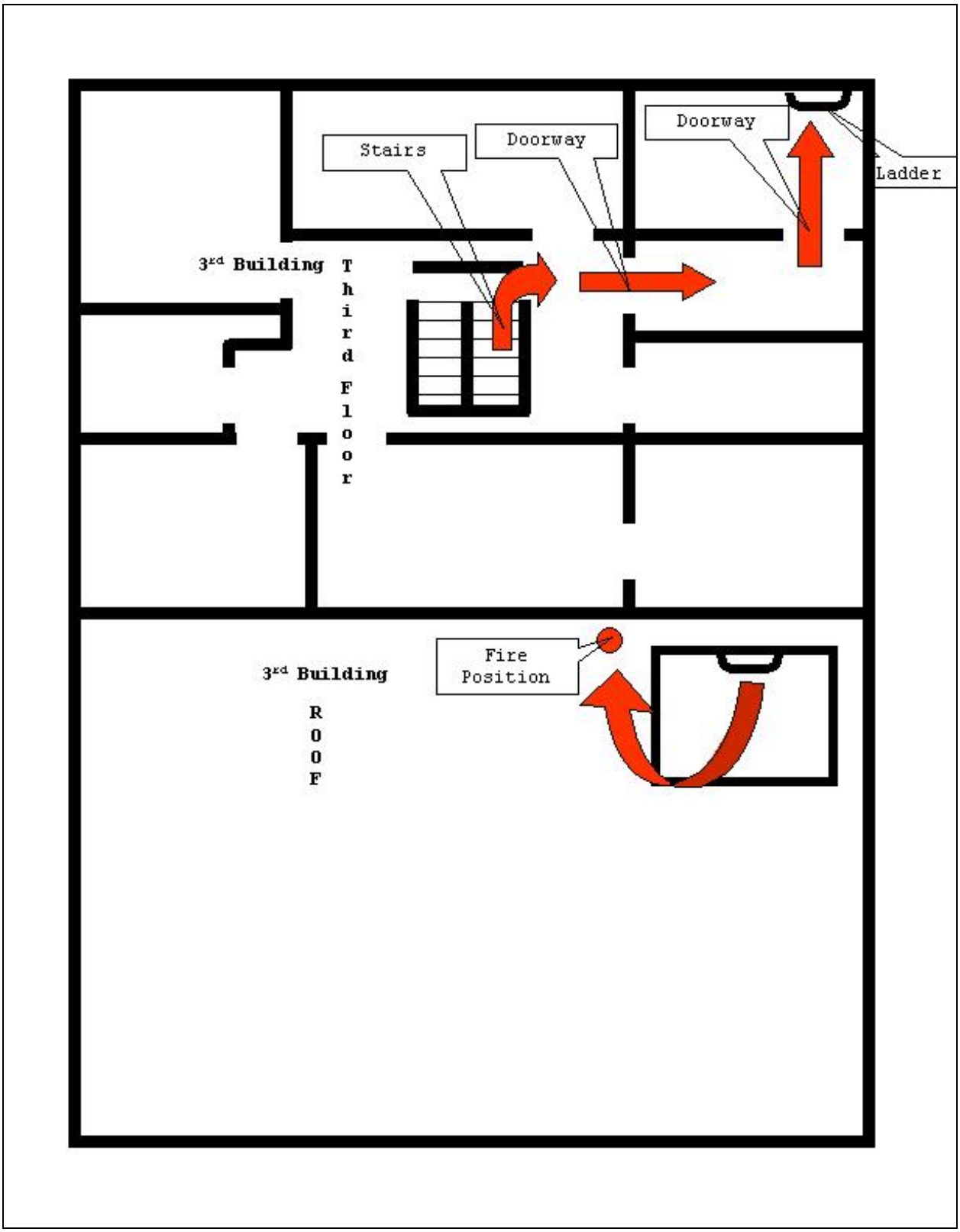


PROPOSED IMT COURSE	
ITEM	OBSTACLE DESCRIPTION
A	PIPE CRAWL
B	ZIG ZAG
C	2 FT JUMP
D	HILL
E	FOX HOLE
F	LOW CRAWL
G	FIRING POSITION
H	HIGH CRAWL
I	FIRING POSITION
J	HIGH WALL
K	FIRING POSITION
	BEAM BREAK SENSOR
	TARGETS

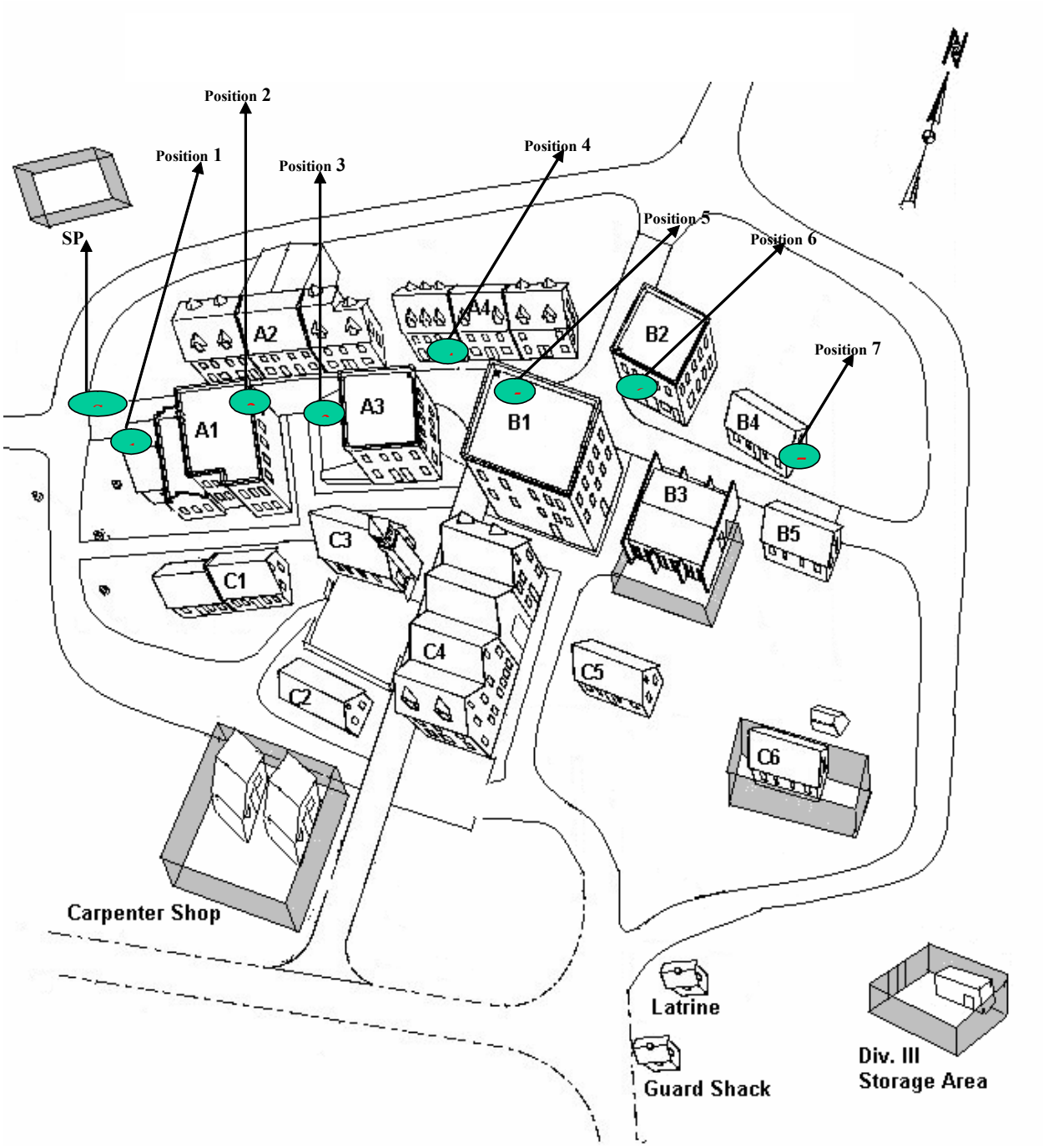
MOUT IMT Course Layout



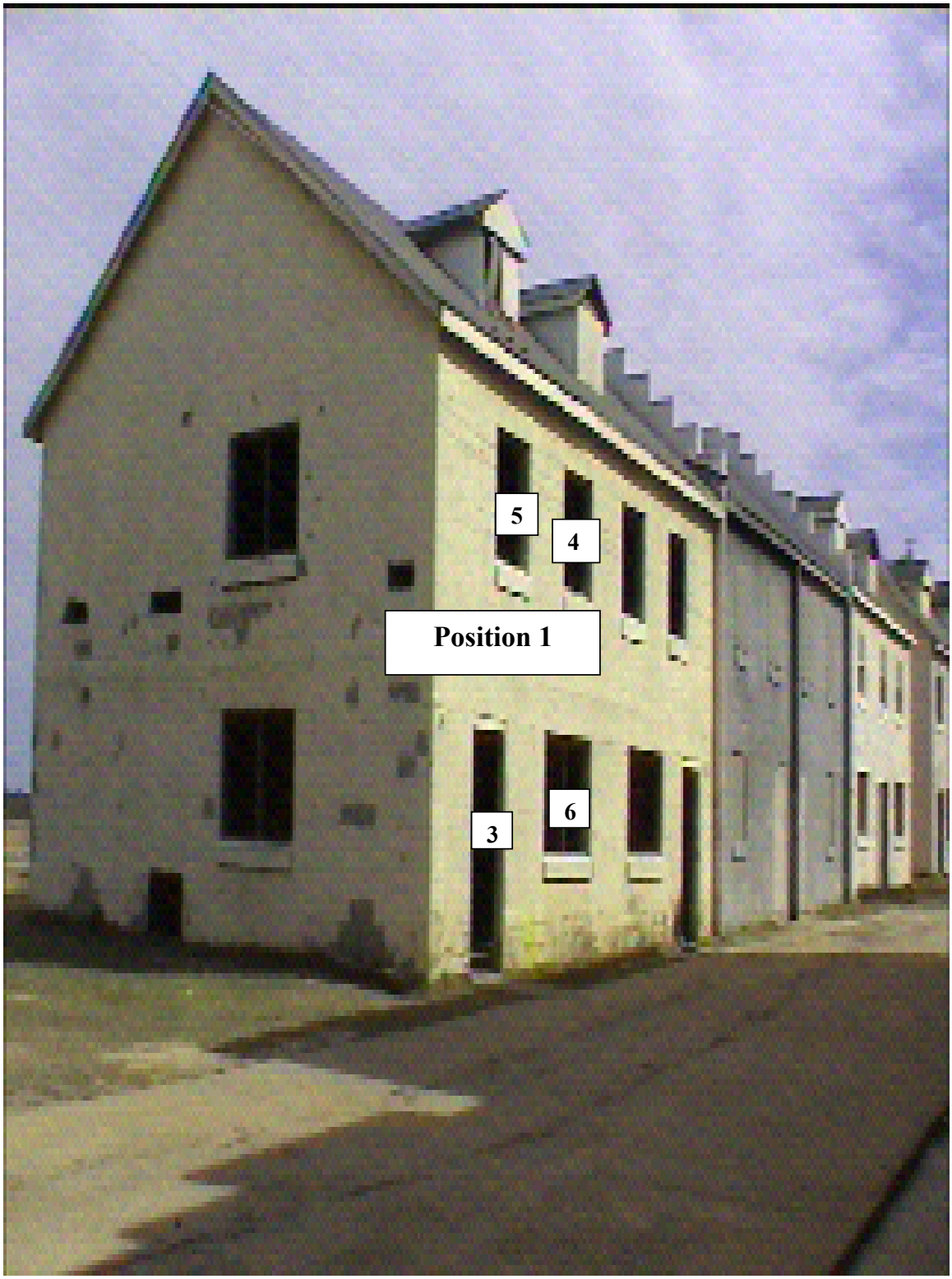

3rd Building
Ground Floor
Stairs
Hallway
Doorway
Doorway
3rd Building
Second Floor
Stairs

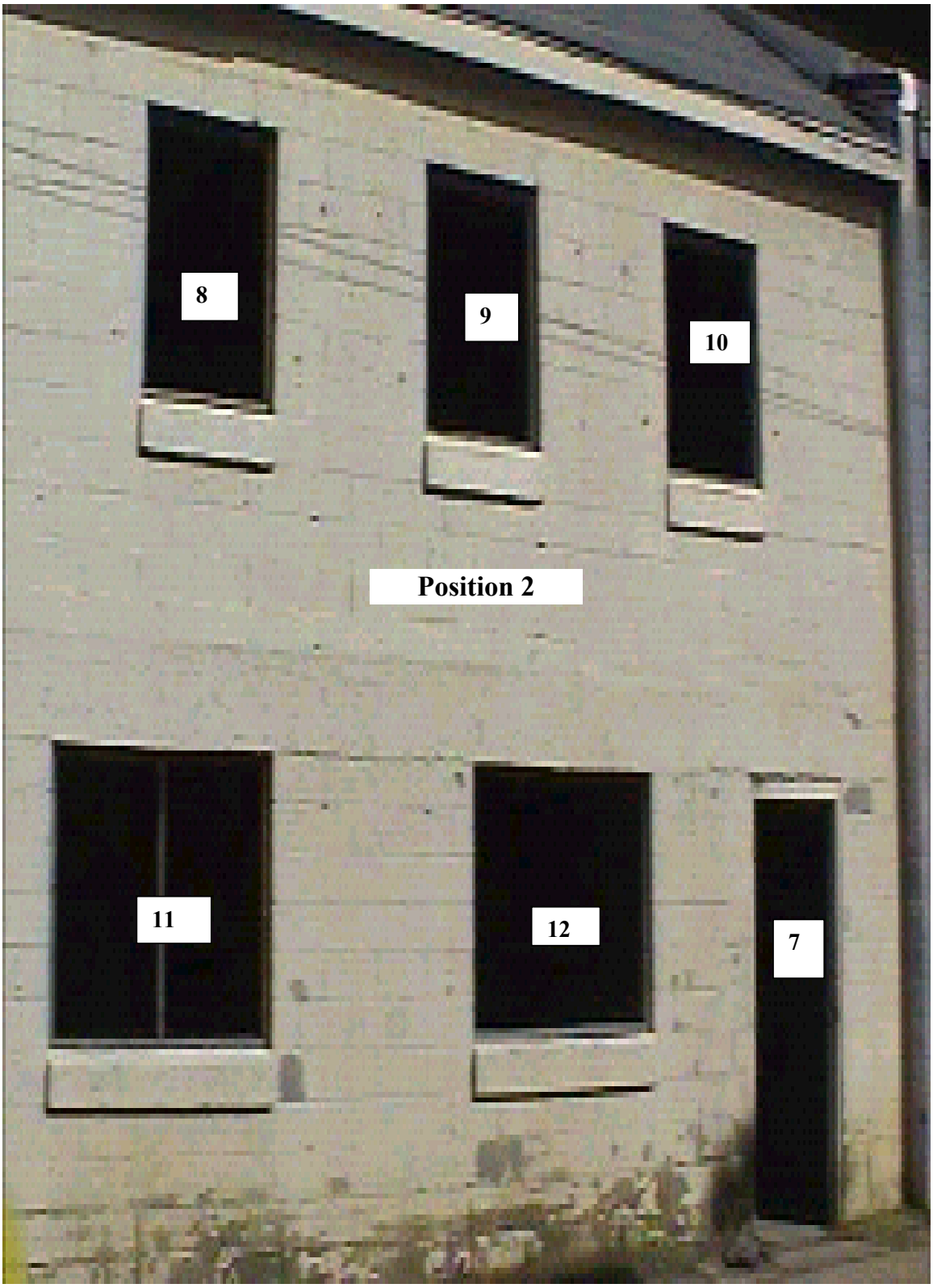

Stairs
Doorway
Doorway
Ladder
3rd Building
Third Floor
3rd Building
ROOF
Fire Position

MOUT Target Detection Lane Course Layout

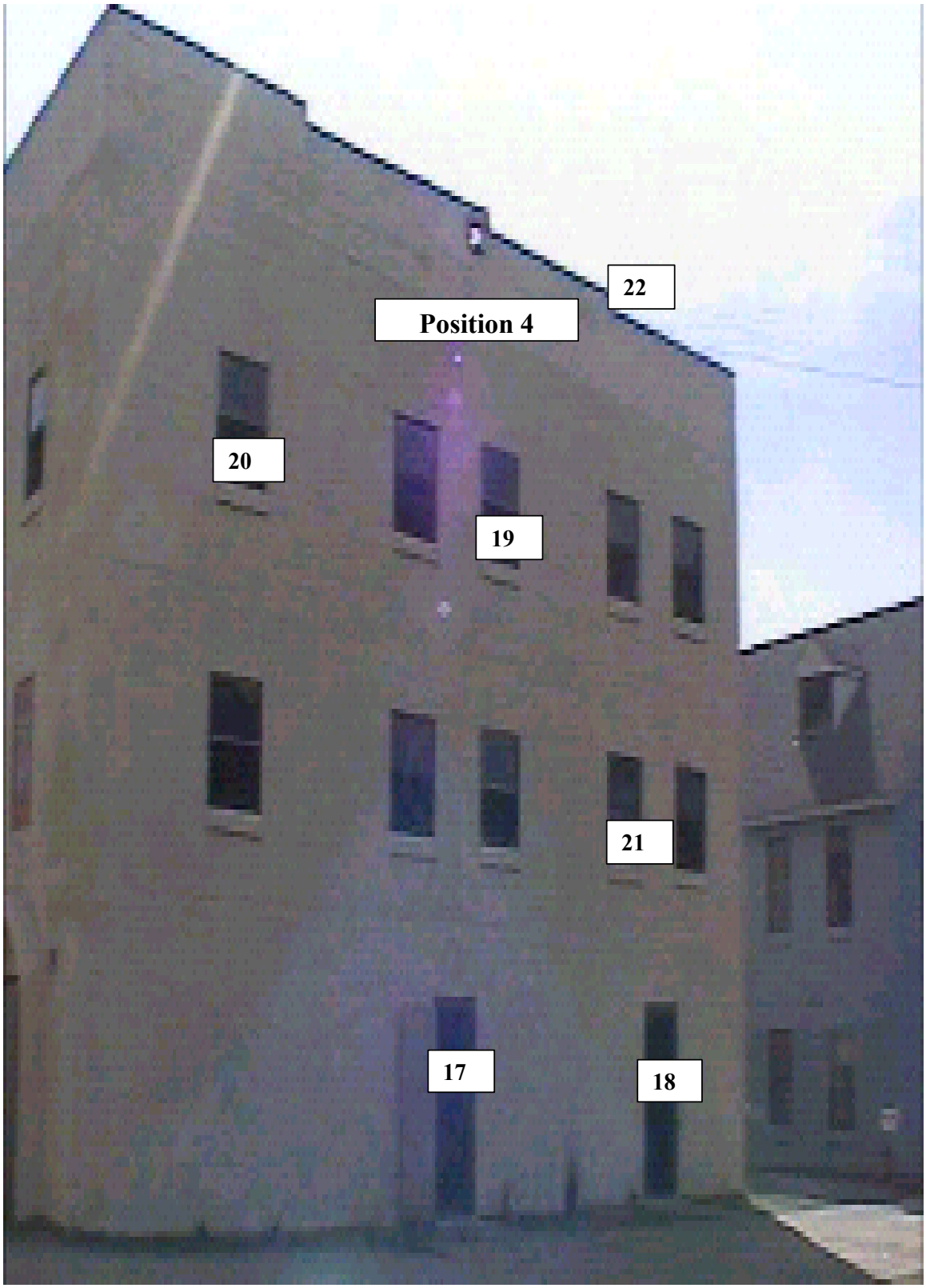


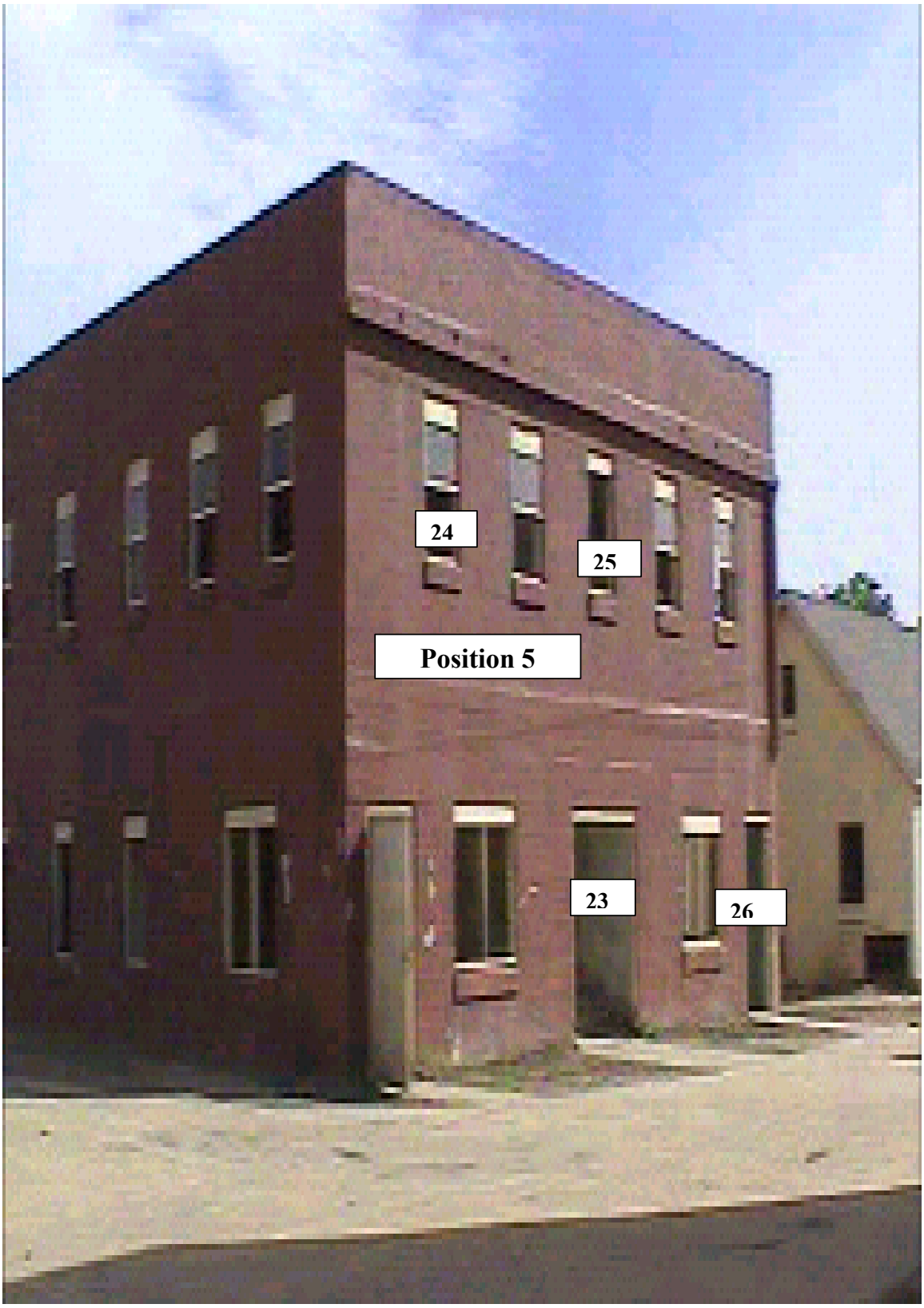
Starting Point
1
2

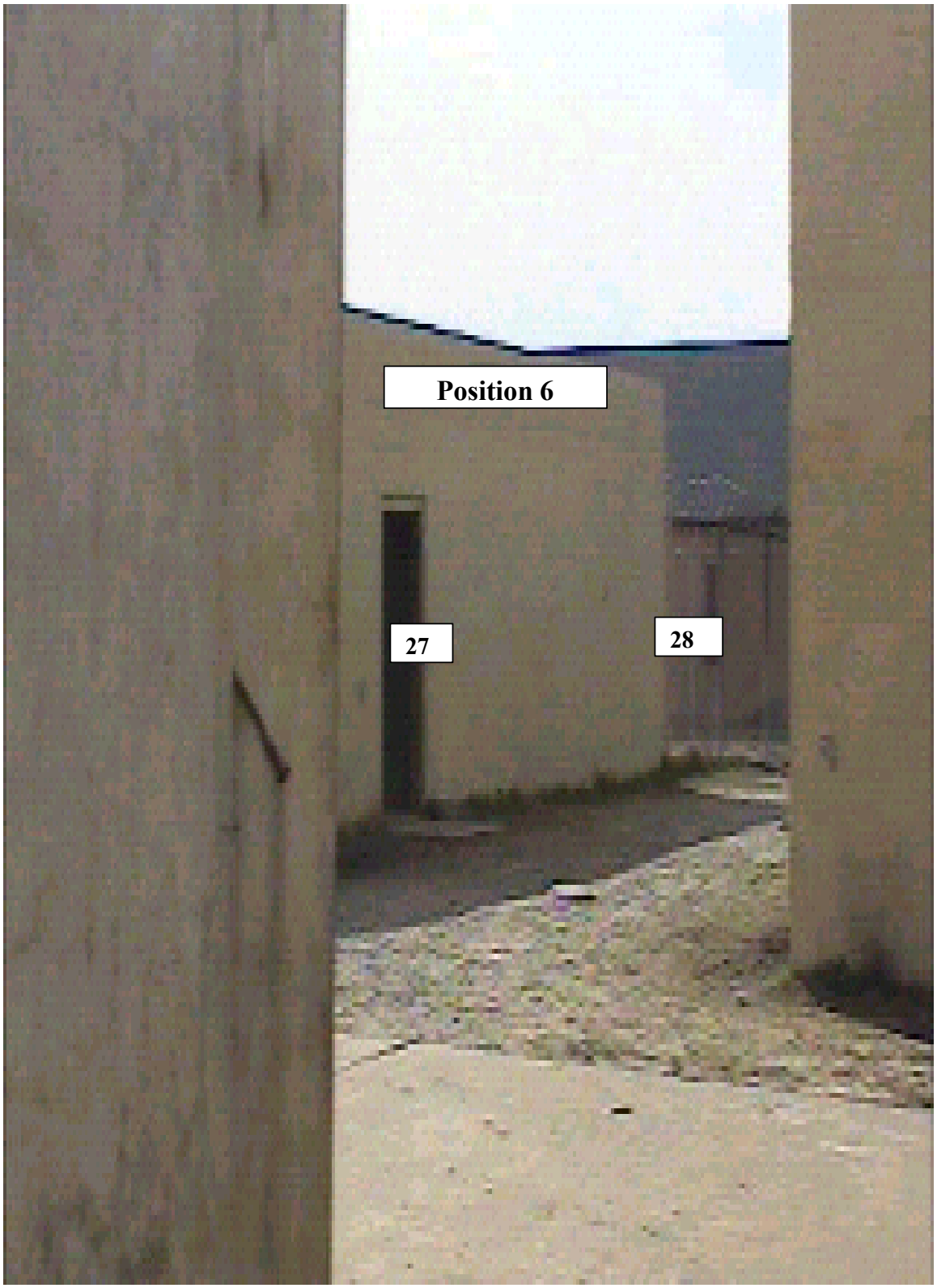

5
4
Position 1
6
3


8
9
10
Position 2
11
12
7

13
14
Position 3
16
15

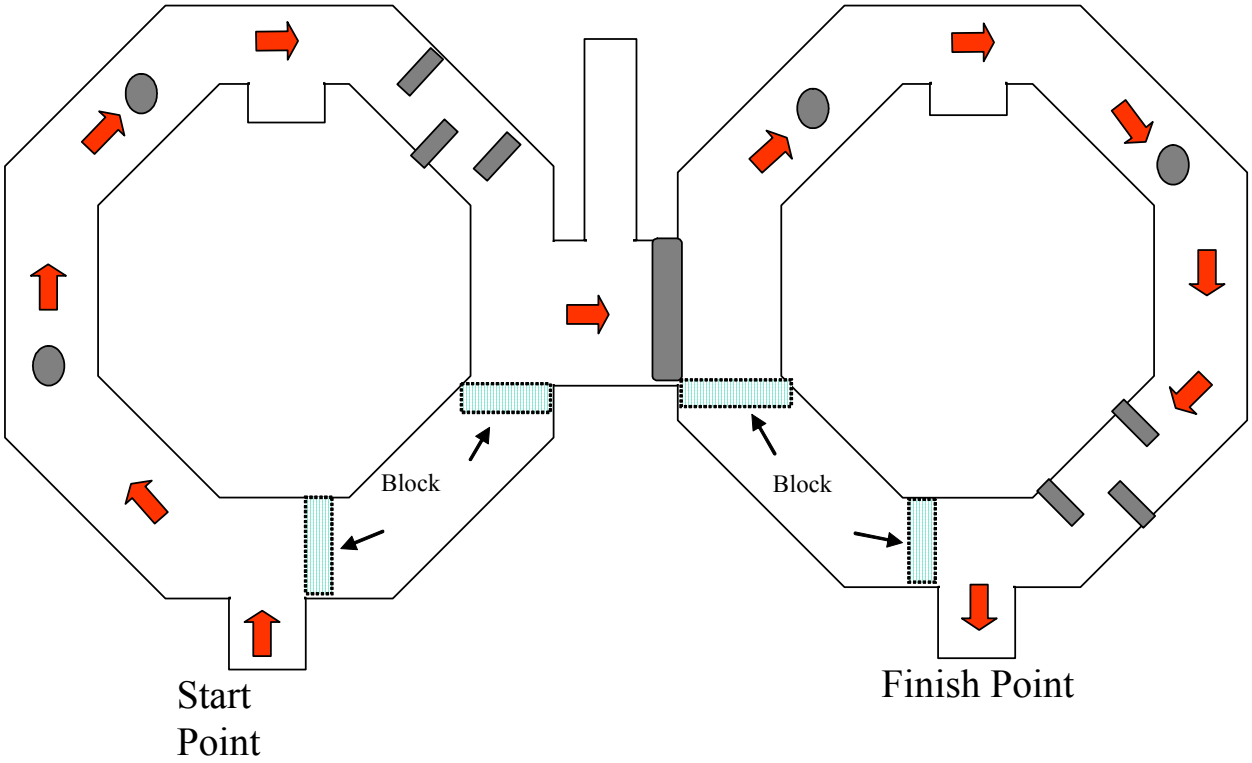

22
Position 4
20
19
21
17
18


24
25
Position 5
23
26


Position 6
27
28

Position 7
30
29

Tunnel Clearing Course Layout



Appendix B. ENVG HFE Questionnaire Results

Soldier Demographics
Sample size = 26

RANK	MOS	DUTY POSITION	TIME IN SERVICE
E-1 – 2	11B – 21	Battalion RTO - 1 OpFor - 1	37 months (mean)
E-3 – 6	63B - 1	Grenadier - 1 Rifleman - 5	
E-4 – 12	31U - 1	M203 – 1 S-4 Clerk - 1	
E-5 - 6	92Y - 1	Machine Gunner – 3 Team Leader - 5	
	91W - 2	Mechanic – 1 Treatment NCO - 1	
		Medic – 1 NR - 5	

1. Do you smoke? 12 Yes 14 No

2. Do you wear prescription lenses? 7 Yes 19 No

   a. If yes, which do you most often wear? 6 glasses 1 contacts

   b. Which do you wear while firing a weapon? 5 glasses 2 contacts

3. With which hand do you most often write? 24 right 2 left

4. With which hand do you most often fire a weapon? 24 right 2 left

5. What is your height? 71 inches (range is 66-76)

6. What is your weight? 177 pounds (range is 145-225)

7. What was your last M4 qualification rating?

   17 expert 7 sharpshooter 0 marksman 1 unqualified 1 NR

8. Have you ever bore sighted an aiming light before?

   10 Yes 16 No

9. Have you received previous training on firing with aiming lights?

   16 Yes 7 No 3 NR

POST TRAINING
Sample size = 26

1. Please rate the training you received on the following NVD topics.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

	MEAN RESPONSE		
	A	B	C
a. Focusing using visual acuity resolution chart	5.78	5.41	5.91
b. Adjusting helmet mounts	5.68	5.50	5.96
c. Fundamentals of night movement techniques	5.50	5.32	5.64
d. Fundamentals of aided vision	5.47	5.35	5.76
e. Fundamentals of unaided vision	5.00	5.00	5.58

Comments **No. of Responses**

Device C

Lots of adjustments that allow for fine tuning of the device. 1

2. Please rate the following training topics you received on the NVD systems.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

	MEAN RESPONSE		
	A	B	C
a. Operating procedures	5.84	5.82	6.04
b. Donning and doffing procedures	5.74	5.77	6.00
c. Level of detail presented	5.63	5.82	6.23
d. Adequacy of training aids	5.68	5.77	6.08
e. Adequacy of training materials	5.79	5.82	6.04
f. Length of training	5.79	5.68	5.96
g. Overall rating of training you received	5.40	5.45	6.00

Device C

Reminds me of PVS-14. 1

OPEN FIELD TARGET DETECTION COURSE

SAMPLE SIZE = 26

1. Please rate your ability to perform the following tasks with smoke with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	B	C
a. Scan sector	4.20	4.52	5.93
b. Detect targets from standing (0-150m)	3.55	4.08	5.92
c. Detect targets from standing (151-300m)	2.52	2.54	5.63
d. Detect targets from standing (301-500m)	2.30	2.14	4.96
e. Detect targets from kneeling (0-150m)	3.56	3.60	5.67
f. Detect targets from kneeling (151-300m)	2.52	2.44	5.40
g. Detect targets from kneeling (301-500m)	2.25	2.19	4.68
h. Detect targets from sitting (0-150m)	3.42	3.89	5.60
i. Detect targets from sitting (151-300m)	2.58	2.38	6.96
j. Detect targets from sitting (301-500m)	2.25	2.12	4.64
k. Detect targets from prone (0-150m)	3.41	3.60	5.58
l. Detect targets from prone (151-300m)	2.46	2.33	5.28
m. Detect targets from prone (301-500m)	2.30	2.17	4.56
n. Detect single targets	3.10	3.15	5.68
o. Detect multiple targets	2.97	2.92	5.59
p. Time required to detect targets	3.34	3.38	5.44

Comments	**No. of Responses**
Device A	
The view was very clear, but without thermal you couldn't see anything on the other side of the smoke.	2
Smoke too dense.	5
Pretty hard to detect any targets.	2
Device B	
This has been the easiest device that I have used this evening.	1
Outstanding imagery.	1
It was easy to detect targets.	2

Comments	**No. of Responses**
Could not see anything through the smoke. I had to wait until there was a break in the smoke to try and detect any targets.	9
All I could see were silhouettes.	1

Device C

Thermal fusion works great.	2
Great visual imaging.	2
Targets from 0 to 300 m were easily identified.	1
Controls were quick and easy to adjust.	1
This is the best detection tool used in these exercises.	4
Easy to use, excellent clarity, and felt good on my head.	2
The targets were easily detected through the smoke. The targets appeared to have no concealment whatsoever.	3
You couldn't really tell the distance but the thermal worked well through the smoke and I think the farthest targets were about 400 m.	1
I thought that this ENVG was hard to use because you couldn't really see that far when you use either the image intensification (I2) or the thermal sight.	1
I was unable to detect any targets.	1
Unable to definitively identify specific range. Only able to estimate ranges.	1
It was very difficult seeing through this type of device.	1
Slight breaks in smoke facilitated acquisition of targets.	1
Could not detect any targets beyond 300 m.	2
I2 was unable to see through smoke, and lights assisting with range were unidentifiable.	1
Once out of focus, it was hard to readjust the focus of targets.	1
NVD keep cutting in and out.	1
Due to smoke could only detect thermal reading. Difficult to tell position or distance.	1

2. How much difficulty did you experience with the device <u>with smoke</u>?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	**B**	**C**
2.30	2.29	6.93

Comments	**No. of Responses**
Device A	
Couldn't see anything on the other side of the smoke.	7
Device B	
I2 alone doesn't work well with smoke.	1
Couldn't see through smoke.	3
Device C	
Saw all targets immediately through smoke.	2
I didn't see smoke at all.	1
The infrared worked flawlessly.	1
Very easy to focus.	1
Could not detect any targets beyond 300 m.	1

3. What is your overall rating of the device you used with smoke?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	**B**	**C**
2.26	2.50	5.75

4. Please rate your ability to perform the following tasks without smoke with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	B	C
a. Scan sector	4.60	4.90	5.63
b. Detect targets from standing (0-150m)	4.93	5.07	5.89
c. Detect targets from standing (151-300m)	4.21	4.41	5.57
d. Detect targets from standing (301-500m)	3.77	3.81	5.04
e. Detect targets from kneeling (0-150m)	4.85	5.07	5.81
f. Detect targets from kneeling (151-300m)	4.15	4.41	5.50
g. Detect targets from kneeling (301-500m)	3.63	3.77	5.00
h. Detect targets from sitting (0-150m)	4.78	5.00	5.79
i. Detect targets from sitting (151-300m)	3.96	4.33	5.41
j. Detect targets from sitting (301-500m)	3.69	3.77	4.88
k. Detect targets from prone (0-150m)	4.80	5.00	5.87
l. Detect targets from prone (151-300m)	4.33	4.59	5.53
m. Detect targets from prone (301-500m)	4.04	4.21	5.22
n. Detect single targets	4.96	5.14	5.71
o. Detect multiple targets	4.88	4.78	5.59
p. Time required to detect targets	4.92	4.96	5.50

Comments	**No. of Responses**
Device A	
These ENVGs are fairly simple to work and you can get a pretty clear picture fairly fast.	1
The only thing that these ENVGs could use is the thermal objective; otherwise, they are pretty good.	1
Could only see targets up to about 100 m.	1
I lost vision after 300 m and everything went blurry.	1
Hard to focus.	
I spent an inordinately large amount of time trying to adjust the device to see either near or far targets. The degree of humidity was a factor that played very heavily in confirming or identifying the targets. I wear glasses and, as such, I feel that the "fogging" of my eyewear was a contributing factor in my difficulty acquiring targets.	1
Device B	
These were really easy to use and focus.	2
Targets seemed relatively clear and fairly easy to detect considering only I2 was available.	1
They were really clear up to about 250 m.	1
They would be nice if they had heat sensing objective.	1

I did not experience the difficulty in acquiring or confirming targets.	1
I spent a nominal amount of time readjusting the I2 and the lenses fit over the eyepieces of my glasses easily.	1
I did have some difficulty with acquisition and confirmation of targets past 150 m.	2
Hard to detect targets past 200 m.	1
Very difficult.	1

Device C

Excellent visibility.	1
Extremely easy to detect targets using thermal device.	1
This device was very easy to use.	2
Scanning ability was made easier by the orange coloration. This made targets not only easy to identify but made their body positions just as easy.	1
The range on the thermal aspect is nothing short of fantastic. The distance and degree of clarity are resounding. I had no need to readjust the focus to scan near or far targets in the thermal mode and this improved the amount of time I had to scan my lane for targets. The only time wasting adjustment that needed to be made from thermal to IR was to determine range. The chem lights were not seen in the ambient temperature.	1
Much more user friendly than the previous NVDs used.	1
There weren't too many adjustments to make to them to get a pretty good picture and the thermal objective worked pretty good for about 150 m. These could be enhanced by making the power switch onto the ENVG itself instead of the battery pack.	1
Scanning anything after 200 m was very difficult. The lens became blurred and impaired several times during the adjusting phase.	1
I was not able to tell if they were standing or sitting but targets were identifiable.	1
I2 was not working.	1

5. How much difficulty did you experience with the device without smoke?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	**B**	**C**
4.72	4.93	5.93

Comments	**No. of Responses**
Device A	
I felt a large degree of difficulty. This may be in part because this is the first of the NVD systems I have used thus far, or my expectations demand a higher level of performance (i.e., ease of use, and application of said device).	1
Had difficulty maintaining focus with this device. Constantly had to move eye or blink to regain focus.	1
Could only see targets up to about 100m.	1
Device B	
Distance was the factor.	1
Device C	
I experienced no difficulty operating the device.	1
I must say it worked very well even though it was placed over my non-dominant eye.	1
Very pleased with this of equipment.	1
Seemed to be easy to identify targets.	1
The device seems to be taking a picture of the object you are focusing on, and when you try to focus on another object, the images bleed over each other. This makes it difficult to identify what you are looking at.	1

6. What is your overall rating of the device you used without smoke?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	**B**	**C**
4.79	4.81	6.04

Comments	**No. of Responses**

Device A

Good device for land navigation, but minimally accurate for detecting targets.	1
Not much experience, and the moonlight interfered.	1
I could not see anything over 50 m.	1
It does the job of a NVD up to about 100 m.	1

Device B

Good for night vision and short distance up to 100 m.	1
Not effective for long range in detecting targets.	2

Device C

Best of the three I've tested so far.	1
I like this device very well.	1
This device seems to be taking a picture when you focus on an object, making it difficult to focus or see other objects. The images bleed over each other.	

7. Please rate the following characteristics of the device you used.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

CHARACTERISTICS	MEAN RESPONSE					
	WITH SMOKE			WITHOUT SMOKE		
	A	B	C	A	B	C
a. Field of view	4.59	5.04	5.50	4.72	4.83	5.39
b. Sight picture clarity	4.79	4.79	5.61	5.07	5.00	5.76
c. Sight picture brightness	5.00	5.11	5.68	4.96	4.93	5.79
d. Ability to perceive depth	4.76	4.75	5.59	5.04	5.21	5.79
e. Head mount balance	5.07	4.75	5.71	4.93	4.79	5.54
f. Wearing comfort	4.83	4.75	5.64	5.33	4.83	5.85
g. Device weight	5.00	4.78	5.50	5.07	4.90	5.64
h. Device shape	4.56	4.94	5.71	5.21	4.82	5.62
i. Design of controls	4.56	5.35	5.89	5.00	4.88	5.89
j. Ease of focus adjustment	4.89	5.47	5.84	5.19	5.38	6.06
k. Ease of eyepiece adjustment	4.47	5.25	6.00	4.88	5.44	6.06
l. Overall ease of use	4.47	5.42	5.93	4.79	4.93	5.76

Comments	**No. of Responses**
Device A	
Fairly easy to use, but the eyepiece constantly collapsed and restricted my field of vision.	1
It is what it is – an okay piece of equipment.	1
The device has adjustments that are too small and require a lot of manipulation. I had difficulty trying to adjust the eyepiece and setting it to a comfortable position to rest on my spectacles. The buttons do not provide for ease of use and the position in which they are located are difficult to adjust (IR and focus).	1
The equipment is too heavy. The focus is bad, but in some instances you can still see what is out there.	1
Difficult to fit to eye properly. Unable to adapt to left eye dominant.	1
Device B	
Very user friendly.	3
The device required little readjustment, and what was required was quick to happen. This afforded me a greater length of time to acquire the targets and greatly reduce my level of frustration.	1
This is a good piece of equipment for night vision without smoke to find your way around.	1
Hard to detect targets though.	1
Bulky and heavy in the front.	3
No depth perception.	1
Severe tunnel vision.	1
Both eyes lose adjustment to darkness when device is removed.	1
Couldn't see too far 200 m+.	1
Device C	
Awesome equipment.	1
Excellent balance.	1
Controls very intuitive.	1
Very user friendly.	1
This device was extremely easy to use and adjust quickly.	1
This is a well rounded device.	1
The device required very little adjustment and the single knob to move from the infrared to the thermal spectrum, to include the fusion, made the task seem relatively easy.	3
Need to make adjustment knobs tighter - they're a little touchy right now.	1
Very poorly made.	1
One of the only things that I don't care about this piece of equipment is the IR flash. The fact that you have to turn it on and depress the button again to turn it off is time consuming. I feel if I need to flash someone, I need it to be a little easier.	1
It can always be lighter.	1
Needs better low battery indicator.	1
White-hot/black-hot feature extremely helpful.	1

The device used needs a lot more work and experimentation in order for it to be useful, especially in combat. 1
Battery pack needs to be built into the device instead of on the back of the helmet. 1
The string that is attached to the device needs to be moved because it hangs right on your nose - it is more annoying than uncomfortable. 1

8. Where within your FOV did you detect the most targets?

	WITH SMOKE			WITHOUT SMOKE		
	A	B	C	A	B	C
Left sector	8	5	1	5	4	1
Center sector	2	6	5	3	4	3
Right sector	2	1	2	0	1	0
Equal ability over entire FOV	16	14	18	18	19	15
NR	2	3	0	2	2	2

Comments **No. of Responses**

Device A

Could see the entire view equally well. 1
It was hard to see long distance. 1
Didn't see any target. 6
Close targets seemed relatively easy to identify whereas farther targets were moderately difficult to difficult to detect. 1

Device B

Could see the entire view. 1
Could see equally well out to 200m. 1
Couldn't see targets. 1
Smoke screened the targets. 2
For a second, the smoke cleared and I thought I might have seen someone in the 150-m mark but I could not be sure of it. 1

Device C

Picked up all the targets instantly. 1
Sight picture was good across the board. 1
Didn't see any target. 3
I actually had to turn my head far right to detect the targets at approx 150 m on the right. 1
Could not detect any other targets beyond the 300-m mark. 2

9. How adequate or inadequate was your situational awareness during this exercise (i.e., aware of what was going on around you)?

1	2	3	4	5	6	7
extremely inadequate	very inadequate	inadequate	neutral	adequate	very adequate	extremely adequate

MEAN RESPONSE					
WITH SMOKE			WITHOUT SMOKE		
A	B	C	A	B	C
4.66	4.69	5.71	5.25	5.19	5.86

Comments **No. of Responses**

Device A

Just kept scanning, looking for something. 1
Was not a distracting device. 1

Device B

Calibration was hard to control the view. 1
You don't spend a lot of time searching because the capabilities aren't there. 1
So the target doesn't just pop out at you like it does with a thermal device.
Couldn't see so I could concentrate on what was going on around me at all times. 1
Severe tunnel vision. 1

Device C

Overlay gave excellent depth perception. 1
Had non-aided eye to maintain adjustment to darkness. 1
The lighting or brightness needs to be worked on. 1

10. Please rate the level of the following problems that you may have experienced with the device you used.

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

PROBLEMS	MEAN RESPONSE					
	WITH SMOKE			WITHOUT SMOKE		
	A	B	C	A	B	C
a. Eye strain	4.94	4.95	5.40	4.76	5.14	5.32
b. Tunnel vision	4.88	4.68	5.40	4.85	4.86	5.47
c. Headaches	5.43	5.06	5.92	5.71	5.53	5.88
d. Motion sickness	5.92	5.86	6.09	6.00	6.06	6.31
e. Screen white out	5.85	5.80	5.73	6.00	5.76	5.88
f. Nausea	5.92	5.85	6.09	6.00	6.00	6.38
g. Disorientation	5.71	5.50	5.85	5.88	5.44	6.00
h. Dizziness	5.92	5.85	6.09	5.93	6.13	6.35
i. Lens fogging	5.38	5.47	6.25	5.72	5.79	6.24

Comments	**No. of Responses**

Device A

I could not tell if my spectacle lenses were fogging or if it was the lens of the NVD eyepiece.	1
Screen didn't fog, but this device is known to do so over time.	1
Did not seem to have any illness from the use of this device.	1

Device B

Experienced no illness during usage.	1
Lost orientation from lack of depth perception.	1
This device has been known to fog up over timely wear, but it did not today.	1

Device C

I did not feel any illness from the use of this device.	1
I felt some tunnel vision, but a soldier should be scanning ALL the time anyway.	1
Simplify connections.	1
Lag during movement between thermal and I2 takes getting used to.	1

11. Which of the following ENVG characteristics did you use during this exercise?

a. **I^2:**

Device A

Very easy to use and see.	1
The NVDs made it very easy to see in the dark.	1
Good strong picture.	1
Could not see through smoke.	1
Thought it would work better.	1
Yes, it is a AN/PVS- 14.	3
Only one available.	20
At distances beyond 150m it became very hard to discern targets.	2

Device B

It works well for its capabilities.	1
The double eyepieces make it very easy to spot targets and make it to where you don't have to squint or close one eye.	1
Better focus.	1
Thermal was hard to see.	1
All I needed for this task.	20
Needs work.	1
The I2 was fine until the smoke.	1

Night vision only.	1
Only good for about 100mm or so; can't focus on anything further.	1

Device C

Very good for movement and gave an excellent field of view.	2
Used to detect ranges of targets.	3
Yes, to see distance.	1
Close range targets.	1
Slightly weak at long distance.	1
Used for situational awareness.	1
Could not see through smoke with I2.	1
The I2 is only used full when moving because it gives you a larger field of view.	1
Would not stay on.	1
Was not working.	1
Used I2; no problems but only could see so far.	1

b. **Thermal**:

Device C

Easiest method to recognize targets.	15
Shows targets very well, at long distances especially.	3
When the thermals were turned all the way up, the ability to see was outstanding; almost as good for movement as all I2.	1
When you turn off the I2 your vision is almost as good with the thermals as without.	1
The thermals were used because the IR's only intensified the smoke. The thermal allowed you to cut through the smoke.	4
Used thermal to pick up targets at 300+, and it was very useful.	1
To see people.	1
The IR was only needed to determine range.	1
Worked better for seeing on left side at long distance.	1
Some targets were too far; the I2 was not working well.	1
Needs more work.	1
This would be a good device if more research was put into it. This would include adjusting the brightness and making the controls more user friendly, as well as working on the imagery and scan lag.	1

c. **Fusion**:

Device C

I could see clear, and with more detail.	1
Together they are superior; the I2 and thermal together is very good.	7
On this course it made it extremely easy to identify targets.	1
Used for walking around.	2

Gives better depth perception.	1
IR used on very dim setting.	1
Not necessary without smoke.	1
Makes it easier to detect targets when you can see their heat signature.	1

12. Which of the following ENVG characteristics did you use most often?

	WITH SMOKE			WITHOUT SMOKE		
	A	**B**	**C**	**A**	**B**	**C**
I^2	23	20	0	23	24	3
Fusion	0	0	9	0	0	13
Thermal	0	0	11	0	0	8
NR	3	6	3	3	2	2

Comments	**No. of Responses**
Device A	
Only had I2.	3
Device B	
It's all the capabilities that it has.	2
Device C	
I really like the fusion theory. It makes the device work rather well I believe.	2
Gives more detail and three-dimensional look.	1

WOODLAND TARGET DETECTION COURSE

SAMPLE SIZE = 18

1. Please rate your ability to perform the following tasks with smoke with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	B	C
a. Scan sector	4.90	4.65	5.95
b. Detect standing targets (0-15m)	4.75	4.53	6.16
c. Detect standing targets (16-30m)	4.55	4.35	6.16
d. Detect standing targets (31-50m)	4.30	4.12	6.16
e. Detect standing targets (beyond 50m)	4.05	4.00	5.89
f. Detect kneeling targets (0-15m)	4.63	4.46	6.06
g. Detect kneeling targets (16-30m)	4.50	4.23	6.00
h. Detect kneeling targets (31-50m)	4.25	4.00	6.06
i. Detect kneeling targets (beyond 50m)	3.94	3.92	5.94
j. Detect sitting targets (0-15m)	4.47	4.31	6.00
k. Detect sitting targets (16-30m)	4.33	4.08	6.00
l. Detect sitting targets (31-50m)	4.07	3.92	6.00
m. Detect sitting targets (beyond 50m)	3.93	3.92	5.88
n. Detect prone targets (0-15m)	4.00	4.08	6.23
o. Detect prone targets (16-30m)	3.87	3.92	6.23
p. Detect prone targets (31-50m)	3.80	3.83	6.23
q. Detect prone targets (beyond 50m)	3.73	3.83	6.15
r. Detect single targets	4.60	4.41	6.26
s. Detect multiple targets	4.53	4.19	6.16
t. Detect target(s) in open	4.80	4.41	6.26
u. Detect target(s) by trees	4.68	4.18	6.26
v. Detect target(s) in brush	4.37	4.12	6.21
w. Time required to detect targets	4.47	4.41	5.95

Comments	**No. of Responses**
Device A	
Equipment worked well with the given environment.	1
My lens for the device fogged up as soon as I started moving into the brush. I could not see.	1
It was difficult to see targets; at times everything seemed fuzzy.	1
Took a little long with a thermal target to my left.	1
Device B	
This device affords a lot of time to scan the area and to do so with relative ease. I felt that I could identify most targets in a reasonable amount of time.	1
I could detect targets only when I was close.	1
Smoke wasn't really thick, but there.	1
Can't see through the smoke.	1
Device C	
Good stuff.	1
Thermal helped out a lot.	1
There were no problems with this ENVG, it worked perfectly for this objective.	1
This device uses fusion the best, maximizes the capabilities.	1
Overall, a pretty good system. It took a little getting used to because of the depth perception issue, but it took minimal amount of time to alleviate the situation.	1
The paper targets were hard to detect at long range but all other targets were very easy to detect with the high thermal feature of the device used.	1
Thermal targets stood out like a sore thumb from 100 m or more; it took a bit longer to see the non-thermal silhouettes, 50 m or less.	1

2. How much difficulty did you experience with the device with smoke?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	**B**	**C**
4.82	4.61	6.18

Comments	**No. of Responses**
Device A	
Didn't really see any smoke.	1
You really can't see much through the smoke but when it clears you can see fine.	1
It took more time, because always having to shift the lens of the device to see close and far.	1
Found it pretty easy to navigate except when I couldn't tell whether a fallen tree was on the ground or just above it – depth perception a little off.	1
Used unaided eye for navigation and aided eye for target detection. Could navigate with unaided eye, even through smoke.	1
Device B	
Got tripped up quite a bit due to the little amount of depth perception I had.	1
Can't see through the smoke.	1
Fell once.	1
Device C	
Thermals are awesome.	1
With the exception of paper targets.	1
The I2 and the thermal work really well in combination on this objective.	1

3. What is your overall rating of the device you used with smoke?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	**B**	**C**
4.50	4.41	6.17

4. Please rate your ability to perform the following tasks without smoke with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	B	C
a. Scan sector	5.22	5.06	6.11
b. Detect standing targets (0-15m)	5.31	5.24	6.25
c. Detect standing targets (16-30m)	5.00	5.06	6.25
d. Detect standing targets (31-50m)	4.69	4.82	6.13
e. Detect standing targets (beyond 50m)	4.31	4.59	6.06
f. Detect kneeling targets (0-15m)	5.14	5.21	6.14
g. Detect kneeling targets (16-30m)	4.86	5.00	6.07
h. Detect kneeling targets (31-50m)	4.57	4.64	6.07
i. Detect kneeling targets (beyond 50m)	4.36	4.46	6.07
j. Detect sitting targets (0-15m)	4.77	5.00	6.21
k. Detect sitting targets (16-30m)	4.54	4.85	6.07
l. Detect sitting targets (31-50m)	4.31	4.54	6.07
m. Detect sitting targets (beyond 50m)	4.23	4.46	6.00
n. Detect prone targets (0-15m)	4.60	4.93	6.20
o. Detect prone targets (16-30m)	4.36	4.79	6.07
p. Detect prone targets (31-50m)	4.47	4.64	6.13
q. Detect prone targets (beyond 50m)	4.33	4.71	6.13
r. Detect single targets	5.22	5.17	6.11
s. Detect multiple targets	5.17	5.11	6.12
t. Detect target(s) in open	5.17	5.00	5.33
u. Detect target(s) by trees	4.94	4.61	5.28
v. Detect target(s) in brush	4.61	4.39	5.28
w. Time required to detect targets	4.78	4.50	5.17

Comments **No. of Responses**

Device C

The device worked well with what I walked through. 1

5. How much difficulty did you experience with the device without smoke?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	B	C
5.15	5.21	5.95

Comments **No. of Responses**

Device C

Love it. 1

6. What is your overall rating of the device you used without smoke?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	**B**	**C**
4.85	5.05	5.79

7. Please rate the following characteristics of the device you used.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

CHARACTERISTICS	MEAN RESPONSE		
	A	**B**	**C**
a. Field of view	5.25	5.16	5.74
b. Sight picture clarity	5.10	5.26	5.84
c. Sight picture brightness	5.30	5.00	5.74
d. Ability to perceive depth	4.95	4.68	5.47
e. Head mount balance	4.95	4.89	5.95
f. Wearing comfort	5.00	4.73	5.93
g. Device weight	5.07	4.71	5.93
h. Device shape	5.27	4.71	6.00
i. Design of controls	5.33	5.43	6.00
j. Ease of focus adjustment	5.29	5.46	6.08
k. Ease of eyepiece adjustment	5.29	5.46	6.00
l. Overall ease of use	5.29	5.42	5.92

Comments **No. of Responses**

Device C

The sight picture on these ENVGs is very clear and crisp; it made it easy to detect targets and navigate this objective. 1

I had a fish eye lens type of view. 1

8. Where within your FOV did you detect the most targets?

	A	B	C
Left sector	0	0	0
Center sector	1	3	3
Right sector	0	0	2
Equal ability over entire FOV	3	0	0

Comments **No. of Responses**

Device A

It was equal. 1

9. How adequate or inadequate was your situational awareness during this exercise (i.e., aware of what was going on around you)?

1	2	3	4	5	6	7
extremely inadequate	very inadequate	inadequate	neutral	adequate	very adequate	extremely adequate

MEAN RESPONSE		
A	B	C
5.75	5.00	5.40

Device A

Used to using PVS-14. 1
Not distracted by thermal. 1

10. Please rate the level of the following problems that you may have experienced with the device you used.

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

PROBLEMS	MEAN RESPONSE		
	A	B	C
a. Eye strain	5.50	5.50	5.67
b. Tunnel vision	5.00	2.00	6.00
c. Headaches	5.67	4.00	5.67
d. Motion sickness	5.67	4.00	5.67
e. Screen white out	5.67	6.00	6.00
f. Nausea	5.67	5.00	6.00
g. Disorientation	5.67	4.00	6.00
h. Dizziness	5.67	4.00	5.67
i. Lens fogging	5.33	7.00	6.33

WOODLAND IMT COURSE

SAMPLE SIZE = 26

1. Please rate your ability to perform the following tasks with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	B	C
a. Crawl through pipe	5.31	4.48	5.40
b. Negotiate zigzag course	5.42	4.08	5.32
c. Jump over obstacle	5.23	4.04	5.16
d. Run up mound	5.35	4.72	5.40
e. Run down mound	5.08	4.44	5.28
f. Low crawl	5.04	4.36	5.24
g. Moving at quick, steady pace	5.23	4.44	5.40
h. Perform combat rolls	5.44	4.92	5.52
i. Assume prone firing position	5.38	4.96	5.70
j. High crawl	5.44	4.79	5.52
k. Assume kneeling firing position	5.64	4.88	5.72
l. Scale high wall	5.56	4.48	5.56
m. Assume prone firing position	5.52	4.96	5.72
n. Detect target(s)	5.04	4.60	5.44
o. Lase target(s)	5.16	4.76	5.40

Comments	**No. of Responses**
Device A	
Good clarity.	1
I found the device extremely easy to use while navigating the various obstacles - you don't have to line up the thermal with the I2. It's not as confusing while performing movements. My comfort with this device may also be due to familiarity.	1
This system worked wonderfully tonight due to the incredibly high level of natural illumination. Hopefully other tests run on nights with less illumination would have similar good results.	1
I did not have any complaints about this device.	1
Better than B's because of monocular design.	1
Lens fogged up, hard to see while moving at a steady pace.	2
My glasses were so fogged up, I could not see the course. Had it not been for my prior dry run, I feel I would have never passed the course in a realistic amount of time. The image through the device was fuzzy at best.	1
When I jump over one obstacle, the PVS-14 turns off because when I land it came off my face. So I performed immediate action which had worked well.	1
Detection is the hardest thing.	1
While running, the device doesn't stay too close to your face.	1

Device B

Depth perception is very poor; I had to use my hands a lot to know what was ahead.	2
The head mount was loose – they didn't stay on my face, so I couldn't really see out of the NODs without holding them in place.	2
Wiggles (engineer term) a lot on head.	1
The weight of the device and front heavy balance made the device jump up and down, making it hard to run at a steady pace and through zigzags.	1
Because both eyes are relying on I2, all you can see is the field of view that is intensified - this made it hard during high and low-crawls.	1
Every time I got into a firing position, I had to readjust the sight on the device. It was very difficult to see where my PEQ-2 was lasing. It was difficult to see targets.	1
This device got in the way of my weapon when I combat rolled.	1
I find that running the course with the device on was hard because I could not use my naked eye to see where I was so I had to go slower and be more careful.	2

Device C

Too easy.	1
Couldn't see well while low crawling.	1
The overlay get misaligned with movement; increases target acquisition time.	1
Would have been better, but the thermal did not pick up people well for this iteration. I had to switch to black hot and run the obstacle course with a heavy red screen that partially blocked my view. Possibly a malfunction or low power.	1
NODs fell off mount halfway through.	1
When running, orange screen kept popping on and off.	1
When you're running through the course, the device isn't going to stay on your face enough for you to really see where you are going. I find myself using my naked eye more than the device.	1

2. Please rate the following characteristics of the device you used.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

CHARACTERISTICS	MEAN RESPONSE		
	A	B	C
a. Field of view	5.17	4.60	5.50
b. Sight picture clarity	5.36	4.60	5.36
c. Sight picture brightness	5.12	4.32	5.46
d. Ability to perceive depth	4.80	4.16	5.16
e. Head mount balance	4.88	4.16	5.48
f. Wearing comfort	4.76	4.08	5.40
g. Device weight	5.04	4.12	5.16
h. Device shape	5.20	4.40	5.40
i. Design of controls	5.60	5.28	5.56

j. Ease of focus adjustment	5.60	5.00	5.50
k. Ease of eyepiece adjustment	5.29	4.88	5.52
l. Overall ease of use	5.48	4.79	5.52

Device A

The device did not move very much when negotiating the course. This is a very good thing. 1
A little front heavy. 1
Overall was good, besides lens fogging. 1
Had a hard time acquiring last target. 1

Device B

Bulky and front heavy. 1
Field of view not very good due to both eyes covered by an eyepiece; same reason why depth perception stunk. 1
Only problems I had was my ability to detect depth which slowed me down on the downhill run and when I came up on walls. 1

Device C

Easy. 1

3. How adequate or inadequate was your situational awareness during this exercise (i.e., aware of what was going on around you)?

1	2	3	4	5	6	7
extremely inadequate	very inadequate	inadequate	neutral	adequate	very adequate	extremely adequate

MEAN RESPONSE		
A	**B**	**C**
5.16	4.47	5.81

Device A

It was fairly accurate although I was mostly focused on the course. 1

Device B

Felt a lot of tunnel vision. 1
It was hard to determine what was going on around me when I was so focused on the course. 1

Device C

Fully aware. 1

The device stayed on my face at all times during obstacle negotiation. 1
All I could see was my next obstacle and so I focused on that and not so much on what was going on around me. 1

4. Please rate the level of the following problems that you may have experienced with the device you used.

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

PROBLEMS	MEAN RESPONSE		
	A	B	C
a. Eye strain	5.22	5.06	5.47
b. Tunnel vision	5.12	4.69	5.50
c. Headaches	5.43	5.36	5.62
d. Motion sickness	5.57	5.79	5.38
e. Screen white out	5.64	5.29	5.54
f. Nausea	5.29	4.83	5.47
g. Disorientation	5.78	4.70	5.40
h. Dizziness	5.67	5.44	5.72
i. Lens fogging	4.84	4.79	5.75

Device A

Minimal illness
My NVDs did shut off one time, but it was a simple matter of turning the on/off switch to off then back to on to fix the problem. 1
Shut off 4 times. 1
The PVS-14 fogs up a bit when it is closer to your face. 1

Device B

The tunnel vision was really bad moving through tight areas, bumped into walls here and there. 2
This device shorted off while doing the low crawl obstacle but was quickly and easily fixed by turning the switch to off then on again. 1
Fogged so bad couldn't see anything, shut off twice, disorienting due to both eyes being covered. 1

5. How much difficulty did you experience with the device?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	**B**	**C**
5.38	4.09	5.56

Device A

Very familiar with device.	1
It shut off on me once during the course.	1
Lens fogging.	1

Device B

Could not focus on targets while in the prone.	1
Because of the loose head mount I had some difficulty, but the NOD worked fine besides the tunnel vision.	1
Tunnel vision.	1

Device C

The NOD was good.	1
The image becomes misaligned with your eye as you move.	1

6. What is your overall rating of the device you used?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	**B**	**C**
5.57	4.25	5.38

Device A

Hard to see targets.	1

Device B

You can see well with them, but there is a lot of tunnel vision involved.	1
The dual eyepiece design on the NVDs is no good.	1

Device C

I like them.	1

7. Which of the following ENVG characteristics did you use during this exercise?

a. I^2:

Device A

The single eyepiece allowed you to be able to close one eye if you had trouble gauging. distances	1
This device is only capable of I2.	11
Best NODs out there without the thermal.	1

Device B

No thermal capabilities.	1
The dual eyepieces works well.	1
This device is only equipped with I2.	9
Good IR vision but bad depth perception.	1

Device C

Good combination of IR to thermal.	1
That's all that I needed.	1
Night targets acquisition.	1
The I2 is very cloudy looking and hard to see clearly with.	1
I2 was used for the whole course except for detecting and "lasing" targets.	1
For movement.	1
There was no need for thermal imaging on the course.	1

b. Thermal:

Device C

Human targets.	1
The thermal kept turning off and on.	1
Had on standby.	1

c. Fusion:

Device C

Awesome.	1
The combination of both made for optimum performance.	2

I used both features during this iteration.	1
Fusion was the best for the obstacles and the targets, you could see both clearly.	2
Fusion was used to detect and "lase" targets.	1
Both see targets and where I was going.	1
Better for this task.	1
I used I2 to negotiate the obstacle course and the thermal to detect targets.	1
Constantly.	1

8. Which of the following ENVG characteristics did you use most often?

	A	**B**	**C**
I^2	21	23	6
Fusion	1	1	16
Thermal	0	0	0
NR	4	1	3

MOUT IMT COURSE

SAMPLE SIZE = 20

1. Please rate your ability to perform the following tasks with smoke with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	B	C
a. Movement through mouse holes	4.95	4.95	5.42
b. Movement within rooms	5.05	5.21	5.58
c. Movement through doorways	5.10	5.15	5.58
d. Movement through windows	5.00	4.90	5.32
e. Movement from building to building	4.60	4.40	5.35
f. Movement down hallway	5.05	5.10	5.58
g. Movement up stairs	4.90	4.90	5.37
h. Climbing a ladder	4.90	4.90	5.32
i. Movement at quick, steady pace	5.05	5.05	5.47

Comments	**No. of Responses**
Device A	
No problems negotiating obstacles.	1
I could not see anything in the smoke.	3
The head mount was loose so moving at a quick pace up the stairs was a little rough, and the tunnel vision made it tough going up stairs also.	1
NODs came off during movement through mouse holes. Took a few seconds to reattach.	1
Device B	
The device did not interfere with my ability to climb the ladder.	2
Getting through the hatch at the top was hard.	1
Going through window, system turns off when you land, takes a couple of seconds to get back up.	1
The only difficulty I had was walking up the ladder. I did not readjust to see very near objects and negotiated it by feel instead.	1
The PASGT was too big for my head making it difficult to see out the NOD.	1
Can't see.	1
Smoke blocked view completely.	1
Device C	
Too easy.	1

Device itself is great, performs very well.	1
Problems with the helmet mount, needs to be sturdier.	1
The device did not stay in place while moving, and the shifting caused me to move through the course at a slower pace.	1
Anything that required a close focus was hard (window and ladder).	1
The red light inside the device (for the IR light) is too bright.	1

2. How much difficulty did you experience with the device <u>with smoke</u>?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	**B**	**C**
4.25	3.89	4.95

<u>Device A</u>

Couldn't see through smoke.	3

<u>Device C</u>

Had fusion on and couldn't see through smoke.	1

3. What is your overall rating of the device you used <u>with smoke</u>?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	**B**	**C**
4.07	4.27	5.20

<u>Device A</u>

When there was a clearing in the smoke you could see.	2

4. Please rate your ability to perform the following tasks <u>without smoke</u> with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	B	C
a. Movement through mouse holes	5.79	5.50	5.75
b. Movement within rooms	5.74	5.60	5.75
c. Movement through doorways	5.68	5.60	5.70
d. Movement through windows	5.68	5.45	5.70
e. Movement from building to building	5.79	5.50	5.50
f. Movement down hallway	5.74	5.60	5.75
g. Movement up stairs	5.79	5.44	5.84
h. Climbing a ladder	5.68	5.39	5.68
i. Movement at quick, steady pace	5.79	5.33	5.63

Device A

No problems with this device. 1
Good for MOUT environment. 1

Device B

Good performance. 1
Mount was loose, held device in hand. 1

Device C

Very good device, no problems. 1
The only problem I had was when I had to climb the ladder. I had a problem with depth perception and focus when the rungs were so close. 1

5. How much difficulty did you experience with the device without smoke?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	B	C
5.74	5.63	5.75

6. What is your overall rating of the device you used without smoke?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	B	C
5.79	5.42	5.84

7. Please rate your ability to perform the following characteristics with the device you used.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

CHARACTERISTICS	MEAN RESPONSE					
	WITH SMOKE			WITHOUT SMOKE		
	A	B	C	A	B	C
a. Field of view	5.20	4.95	5.68	5.74	5.35	5.80
b. Sight picture clarity	5.30	5.16	5.58	5.72	5.40	5.90
c. Sight picture brightness	5.45	5.37	5.58	5.84	5.55	5.90
d. Ability to perceive depth	5.40	5.16	5.53	5.63	5.25	5.55
e. Head mount balance	5.25	5.37	5.47	5.53	4.95	5.75
f. Wearing comfort	5.16	5.26	5.63	5.79	5.20	5.90
g. Device weight	5.40	5.26	5.61	5.78	5.20	5.95
h. Device shape	5.47	5.21	5.56	5.74	5.35	5.74
i. Design of controls	5.44	5.19	5.60	5.53	5.50	5.82
j. Ease of focus adjustment	5.44	5.18	5.60	5.88	5.32	5.56
k. Ease of eyepiece adjustment	5.19	5.27	5.50	5.82	5.44	5.88
l. Overall ease of use	5.19	5.20	5.57	5.81	5.61	5.88

Device A

Had a problem turning IR on and off with only one hand. 1

Device B

Hard to see close distance if you come up on something quick. 1

Device C

The device bounced around a lot. 1
Lens has a fish-bowl effect. 1
Lens is magnified and causes depth perception problems at close ranges. 1
Close objects like ladders were harder to detect. 1

8. How adequate or inadequate was your situational awareness during this exercise (i.e., aware of what was going on around you)?

1	2	3	4	5	6	7
extremely inadequate	very inadequate	inadequate	neutral	adequate	very adequate	extremely adequate

MEAN RESPONSE					
WITH SMOKE			WITHOUT SMOKE		
A	B	C	A	B	C
5.44	5.33	5.75	5.88	5.53	5.94

Device A

Can't see through the smoke. 1

9. Please rate the level of the following problems that you may have experienced with the device you used.

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

PROBLEMS	MEAN RESPONSE					
	WITH SMOKE			WITHOUT SMOKE		
	A	B	C	A	B	C
a. Eye strain	5.69	5.69	5.92	6.15	6.00	6.15
b. Tunnel vision	4.89	4.80	5.91	5.63	5.20	6.00
c. Headaches	5.50	5.00	6.13	5.60	5.29	6.14
d. Motion sickness	5.50	5.20	6.13	5.80	5.71	6.14
e. Screen white out	5.33	5.40	5.78	5.80	5.86	6.14
f. Nausea	5.33	5.40	6.13	5.80	5.86	6.14
g. Disorientation	5.57	5.40	6.22	5.80	6.00	6.00
h. Dizziness	5.33	5.40	6.22	5.80	5.86	6.00
i. Lens fogging	5.00	5.00	6.30	5.00	5.17	6.17

Device A

The tunnel vision was a problem going up steps. 1

Device C

Moving fast caused the NOD to flash with multi-colored screens on the HUD. 1
There is about a 1/NA in wiggle in the device which makes it harder to see directly through the device to get the clearest image. 1

10. Which of the following ENVG characteristics did you use during this exercise?

a. I^2

Device A

The I2 worked very well. 2
Worked the best. 2
This was the only option for these NODs. 11
Could see doorways, windows, and stairs. 1
No thermal capabilities. 4
PVS-14/IR was used. 2
Very good set of NODs. 1
Very good without smoke. 1
Used with IR flood light. 2

Device B

Better to see doorways, window, and stairs.	1
Worked the best.	1
No thermal capabilities.	1
That is my only option.	7
The I2 works very well.	2
This device only has I2.	3
Very good NODs because you look through with both eyes.	1
Very good without smoke.	1
Only night vision was available with this device.	2
Used with IR flood.	2

Device C

Gave best overall picture.	1
Didn't need to use thermal.	3
Best thing to use for exercise.	1
IR was used.	2
The I2 is kind of foggy looking and hard to see through.	2
I knew there was no smoke or targets so I did not opt to use thermal.	1
All that was needed.	1
IR is all you need without smoke.	1
I did not need to use the thermal sight on this course.	1
Yes, with flood light inside. IR only outside.	1

b. Thermal

Device C

The thermals work fine.	1
Good for smoke.	1
I used this one.	1

c. Fusion

Device C

Fusion worked great for the smoke and the navigation of the course.	1
I used fusion.	1
Worked better.	1
No problems.	1
Easy to see with both.	2
IR with thermal to be able to see obstacles.	1
They work well together.	1
Great to see through the smoke with the thermals.	1

Works great with both to see through the smoke and see images (if that were the task). 1
Used with IR flood light. 1

11. Which of the following ENVG characteristics did you use most often?

	WITH SMOKE			WITHOUT SMOKE		
	A	**B**	**C**	**A**	**B**	**C**
I^2	16	16	6	17	17	12
Fusion	1	1	11	1	1	6
Thermal	0	0	0	0	0	0
NR	3	3	3	2	2	2

Device A

Only capability it has. 2

Device B

Only capability. 2

Device C

Works great with both to see through the smoke and see images (if that were the task). 1
I knew there was no smoke or targets so I did not opt to use thermal. 1

MOUT TARGET DETECTION COURSE

SAMPLE SIZE = 26

1. Please rate your ability to perform the following tasks with smoke with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	B	C
a. Movement through mouse holes	5.24	4.74	5.68
b. Movement within rooms	5.16	4.87	5.88
c. Movement through doorways	5.12	4.96	5.96
d. Movement through windows	5.16	4.80	6.00
e. Movement from building to building	4.96	4.64	5.84
f. Movement down hallway	5.00	4.68	5.80
g. Movement at quick, steady pace	5.19	4.64	6.00
h. Detecting targets in windows	4.35	4.13	5.96
i. Detecting targets in doorways	4.38	4.13	6.08
j. Detecting targets in open	5.79	4.13	6.04
k. Detecting single targets	4.65	4.25	6.16
l. Detecting multiple targets	4.48	4.23	6.09

Comments	**No. of Responses**
Device A	
Good view!	1
When the smoke cleared, the targets were extremely easy to detect and movement was quick.	1
Hard to detect targets through smoke, especially in windows.	4
Within smoke areas, movement was slow and difficult and targets were impossible to detect.	1
Device B	
Easy to see targets at short distance.	1
Movement in less smoky areas was easy but not very quick.	1
Harder to detect targets with smoke in any position.	2
I was not able to use the device effectively, due to the moisture and hot air funneled from the mask directly onto my glasses and the lens of the device.	1
This device kept hitting my weapon when I was crawling through the mouse holes.	1
There was no depth perception so I had to walk to avoid holes.	1
Device C	
The device was extremely easy to use.	1

Good device for detection.	2
Movement was very easy.	2
Most effective.	1
Awesome.	1
This device is excellent in smoke with thermal targets and non-thermal targets.	1
By far the best piece of equipment.	1
It was very easy to detect heat signatures but difficult to detect cold targets.	1
The fusion was very helpful and enabled me to clear the course in a rapid amount of time and to do so with a high degree of confidence.	1
It would not maintain an "in line position," so I switched from my dominant to my non-dominant eye. I felt that this more useful because it was just as effective and I could acquire my target through my rifle sight picture.	1
The IR would lose focus every now and then after a slow trot between buildings.	1
The thermals would cut out when I ran.	1

2. How much difficulty did you experience with the device <u>with smoke</u>?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	**B**	**C**
2.73	2.46	5.87

<u>Device A</u>

Did not see anything.	2
Impossible to detect targets through heavy smoke.	2

<u>Device B</u>

Hard to see targets in windows.	1
No visibility with smoke.	3

<u>Device C</u>

Awesome.	1
No difficulty except with the durability of the device.	1
I could not detect or locate paper targets easily.	1
Low difficulty in smoke.	1
Could not detect inanimate target through heavy smoke.	1
Connection was loose. When walking, thermal would ping in and out.	1
Some targets I could see a lot better with the thermal imaging when I had more light behind it.	1

3. What is your overall rating of the device you used with smoke?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	**B**	**C**
3.04	3.00	5.91

Device A

I could see through smoke. 1
Could not see through smoke. 1

Device B

Tough to see unless tracer round being fired at you or you can see a muzzle flash. 1
Can't see through smoke. 1

Device C

Excellent. 1
Great for detecting human presence through heavy smoke. 1
The overall concept and function of this device is great. But, I started to go from one point to the next and the viewer started flashing from the bar code screen to an orange screen to IR off, and then cycle back through over and over. Changed out the batteries and it did not correct the problem. Also when I started to jog from one point to the next, it acted like it lost the connection and glitched, rebooting the IR, which in turn makes it impossible to detect IR for approx 10 seconds. Crucial time. 1
It wasn't the best visibility, but targets were visible. 1
I could make out every window and door, but only when the device was pulled down securely after a movement. 1

4. Please rate your ability to perform the following tasks without smoke with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	**B**	**C**
a. Movement through mouse holes	5.74	5.65	6.13
b. Movement within rooms	5.96	5.85	6.15
c. Movement through doorways	5.96	5.83	6.12
d. Movement through windows	6.05	5.90	6.26
e. Movement from building to building	6.00	5.88	6.19
f. Movement down hallway	5.95	6.08	6.30

g. Movement at quick, steady pace	6.17	5.88	5.96
h. Detecting targets in windows	5.68	5.73	6.00
i. Detecting targets in doorways	5.88	5.88	6.12
j. Detecting targets in open	5.81	6.00	6.26
k. Detecting single targets	5.96	5.92	6.14
l. Detecting multiple targets	5.95	5.88	6.05

Device A

I think it was easy to see the targets, but not really sure if I saw all the targets or not. They don't tell us.	1
Hard to decipher targets in windows and at different depths.	1
I have yet to be able to detect any targets at position 7, with either device A, B, C, or D.	1
The device did not shift when moving to different observation locations. The device did not need to be refocused; however, my depth perception did suffer from the monocular sight.	1
I could not see anything in the smoke.	1
There was only one silhouette that I could not immediately identify in a window.	1

Device B

Easy to maneuver through the buildings.	1
I could see clearly and detect targets without a problem.	2
These were very clear, and crisp. Easy to perform movement.	2
Good piece of equipment, despite being outdated.	1
The only difficulty I had was detecting one target. It took a little more time to make sure the target was actually a target or just light coming in from a window. The device did not require readjustment or having to shift the focus, which aided in time of target acquisition.	1
The equipment kept bumping my rifle during the movement through the mouse holes.	1
NODs shut completely off in mouse hole.	1

Device C

Easy to use.	2
Awesome.	2
They focus easily and the clarity is great.	1
It was efficient overall.	2
Much easier without smoke, I could see no problem.	1
The device is very useful in the thermal mode. Targets were immediately illuminated and negotiating the terrain was very easy.	1
Had some difficulty acquiring targets.	1
Did have trouble keeping the device in line with my eye because it constantly shifted. The eyepiece was hard to maneuver over my eye (laterally) and the sight picture was seen at angle.	1
I missed a few cold targets using this device.	1
Having thermal on reduced the ability to see the target in the window.	1

5. How much difficulty did you experience with the device without smoke?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	**B**	**C**
6.00	5.84	6.21

Comments	**No. of Responses**
Device A	
Provided clearest image of all tested.	1
I could see rather clearly w/out smoke.	1
Some difficulty.	1
Device B	
Very easy to operate and maneuver with.	1
I had better contrast which allowed me to see shape and form and, consequently, targets.	1
No difficulty.	1
Device C	
Too easy.	1
Very clear picture.	1
The only problem I had with the device was having to turn the thermal up and down after I came out of the smoke.	1

6. What is your overall rating of the device you used without smoke?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	**B**	**C**
5.74	5.80	6.21

Device A	
Good overall performance and function, needs more brightness.	1
Couldn't detect thermal images.	1
Device B	
Excellent.	1

Can't see thermal images. 1

Device C

Works like a charm. No problems this time. 1
I still like this device and how it operates. I hated to see the slight malfunctioning of the device during my run. I had to hold it all the way down and apply a little pressure for it to work properly. I don't have time to do that in the battlefield. I don't have enough hands as it is. 1

7. Please rate your ability to perform the following characteristics with the device you used.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

CHARACTERISTICS	MEAN RESPONSE					
	WITH SMOKE			WITHOUT SMOKE		
	A	B	C	A	B	C
a. Field of view	5.46	4.96	5.76	5.64	5.69	5.88
b. Sight picture clarity	5.65	4.76	6.08	5.60	5.88	5.96
c. Sight picture brightness	5.46	4.96	6.12	5.60	5.92	5.92
d. Ability to perceive depth	5.19	4.28	5.64	5.56	5.46	5.72
e. Head mount balance	5.00	4.32	5.76	5.64	5.23	5.80
f. Wearing comfort	4.96	4.36	5.92	5.48	5.23	5.84
g. Device weight	5.04	4.12	5.72	5.40	5.08	5.64
h. Device shape	5.20	4.04	5.92	5.71	5.08	5.72
i. Design of controls	5.32	5.33	5.78	5.74	5.84	5.80
j. Ease of focus adjustment	5.48	5.29	5.87	5.83	5.96	6.04
k. Ease of eyepiece adjustment	5.44	5.21	5.79	5.86	5.80	5.96
l. Overall ease of use	5.63	5.27	5.79	5.91	5.91	5.96

Device A

Device is good, just need to add thermals. 1
Needs brighter sight picture. 1
The alpha's performed well except during the movement into the smoke. 1
Field of view is wide. 1
Extremely front heavy. 3
Uncomfortable to wear. 1
Digs into forehead. 1
A little long. 1
On this iteration, it was required of me to use the IR function and I found that it's not the easiest thing in the world to find the control knob to turn IR on and off. 1

Device B

Over all was good, but if it was smaller would be better. 2

This device was the simplest device to operate, but focusing each eye was a little hard.	1
Can't see anything with the smoke.	1
Front heavy device.	6
Field of view seems larger.	1
Starts digging into the forehead and eventually the back of the head.	3
Prefer monocular - no need to adjust for space between eyes, keeps one eye adjusted to darkness.	4
Biocular greatly decreases depth perception.	1
Tunnel vision a problem.	2

Device C

Great device.	3
This was very easy to use.	4
Provided good view and clarity.	2
Easy to adjust. The ease of use was very comparable to PVS-14.	1
Once again, the controls and ease of use for this device were far and away the best.	1
I was impressed with the power of the device, except when double timing.	1
Thermal detection was very good.	1
A lot more comfortable than PVS-14s - I did not feel uncomfortable at all.	1
Controls too touchy.	1
At closer ranges the overlay is slightly mismatched.	1
The only problem with the device was that there was a better heat signature on the left side of the view and a poor signature on the right side of the view.	1
A little trouble with smoke.	1

8. How adequate or inadequate was your situational awareness during this exercise (i.e., aware of what was going on around you)?

1	2	3	4	5	6	7
extremely inadequate	very inadequate	inadequate	neutral	adequate	very adequate	extremely adequate

MEAN RESPONSE					
WITH SMOKE			WITHOUT SMOKE		
A	B	C	A	B	C
5.48	5.08	5.86	5.86	5.60	6.00

Device A

This device offers excellent peripheral vision and better field of view through the eyepiece than others.	1
Without smoke, everything was easy to see.	1
Picture was very easy to see when the smoke cleared in certain areas.	1
Nothing to really distract you.	1

Awareness depends on illumination - if it is high the other eye can be used. 1

Device B

Good view. 1
Performed well. 1
Hard to see through smoke. 2
You are kind of limited to what is in your NODs. Can't really see anything else. 1

Device C

Good field of view and mobility. 1
This device is great and makes it easier to tell what is going on around you. 1
I had to concentrate on if it was working or not when I needed to be focusing on what was being seen through the device. 1
This device made it slow and difficult to detect the cold silhouettes. 1
Had hard time with smoke and identifying target. 1

9. Please rate the level of the following problems that you may have experienced with the device you used.

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

PROBLEMS	MEAN RESPONSE					
	WITH SMOKE			WITHOUT SMOKE		
	A	B	C	A	B	C
a. Eye strain	5.28	5.47	5.76	5.50	5.85	6.11
b. Tunnel vision	4.92	4.73	5.86	5.27	4.93	6.06
c. Headaches	4.91	4.58	5.83	6.18	5.67	6.15
d. Motion sickness	5.67	6.25	6.42	6.27	6.09	6.53
e. Screen white out	6.18	6.18	5.64	6.11	5.83	6.07
f. Nausea	6.30	6.09	6.33	6.22	6.30	6.46
g. Disorientation	6.18	6.09	5.92	6.30	6.17	6.36
h. Dizziness	6.00	6.10	6.42	6.22	6.30	6.33
i. Lens fogging	5.23	5.50	6.43	5.64	6.25	6.54

Device A

Causes no illness. 3
Starts to fog after extensive wear. 1

Device B

Some fogging of the lens. 1
The weight causes pressure on the front which causes a slight headache. 4
Tunnel vision due to having both eyes covered. 1
Eye strain inevitable if the two eyepieces are not adjusted correctly. 2

Device C

No problems on the eyes.	1
Felt no illnesses.	2
Lens has a convex effect.	1
Every now and then thermal image would seize, you had to look away it would clear up.	1

10. Which of the following ENVG characteristics did you use during this exercise?

a. I^2:

Device A

Good and powerful.	2
This worked well.	3
Only option available.	16
This was the only option and it wasn't good for this objective.	1
No thermal capabilities.	1
PVS-14.	2
My favorite out there, but the thermals do help in some situations.	1
Used IR illumination on a couple scenarios.	1

Device B

Good strong picture.	1
These are the best.	1
This was the only option I could use.	24
Worked fine.	3
No thermal capabilities.	1
PVS-7D.	1
The two lens work great together to give you a good picture.	1
7D's only have IR capabilities.	2
Used for all operations.	1
Cannot see anything through the smoke.	2
This was the only one to use and it wasn't good in the smoke.	1

Device C

Good power, clear picture.	1
Worked well.	3
When moving from point to point.	4
Targets night observation.	2
Used the most because of high illumination.	2
When the thermal function obscured view of the objectives, I switched to almost complete use of the I2.	1
Very good combination of IR and thermal capabilities.	2

Non smoke areas.	1
The I2 looks a bit foggy.	2

b. <u>Thermal</u>:

<u>Device C</u>

Worked extremely well; excellent.	1
Used thermal detection very effectively to target both thermal targets and human targets.	1
For long range scanning and target detection.	4
I started out in all thermal but soon changed to fusion.	1
To locate hot targets (human).	2
When the thermals were on, everything had an orange glow - making it hard to discern targets.	1
The thermals would cut out when I ran and wouldn't pick up heat at any distance.	1
Just to highlight.	1
When fog/smoke, made the use of I2 a hindrance rather than help in viewing the objectives. Switching to the full thermal mode made everything from observation of each objective to movement from position to position a much easier task.	1
Smoky areas.	1
Helps ping live targets.	1

c. <u>Fusion:</u>

<u>Device C</u>

Used all the time.	5
Very clear, like the orange screen as it is easier on the eyes.	1
It was the best way to detect targets when switching from smoke to no smoke.	1
It is the best way to detect targets because if there isn't enough light for the I2, then the thermal picks up the target.	1
Fusion was the best objective for spotting targets and for navigating through the course.	4
Fusion with mostly thermal was the easiest way to go through this route.	1
Works extremely well.	1
Worked the best for this task.	8
Worked best with this device and easier to see targets and non thermal objects.	1
Worked well with the smoke - I was still able to detect targets.	2
Not so much, if at all. It makes the IR or the thermal perform at lower levels. The button to switch from full IR to thermal was very useful item and I feel should remain with the product.	1
The color scheme was pretty good.	1
I love how the fusion works on this device. You can see the best of both worlds with this device.	2
The fusion function was highly effective on this device as both I2 and thermal capabilities worked together instead of partially or completely canceling each other out. The calibration of the two modes on top of each other was consistently correct and both pictures were clear, even when laid on top of each other.	1
Without smoke, fusion proved to be by far the easiest configuration to use this ENVG	1

most effectively.
The overlay was the only way I used this device. It seemed to work together very well. 1
The thermals kept blinking out leaving a large orange patch right in the middle of my vision 1

11. Which of the following ENVG characteristics did you use most often?

	WITH SMOKE			WITHOUT SMOKE		
	A	**B**	**C**	**A**	**B**	**C**
I^2	22	21	1	22	23	0
Fusion	0	0	19	1	1	22
Thermal	0	0	2	0	0	2
NR	4	5	3	2	2	2

Device A

That's all that is available for this piece of equipment. 3
I2. 2

Device B

Only capability this device has. 2

Device C

Thermal option was excellent and worked well. 3
Outstanding piece of equipment. Ease of use, weight, and target ID was fantastic. 1
Scanned for hot spots with NODs. 1
The red thermal image is very easy to see over the green I2. 1

TUNNEL CLEARING COURSE

SAMPLE SIZE = 26

1. Please rate your ability to perform the following tasks with the device you used.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

TASKS	MEAN RESPONSE		
	A	B	C
a. Movement through mouse holes	5.86	5.70	5.63
b. Movement within tunnel	5.91	5.70	5.54
c. Movement through obstacles	5.91	5.65	5.33
d. Movement at quick, steady pace	6.00	5.87	5.58
e. Detecting single targets	5.91	6.00	5.71

Comments	**No. of Responses**
Device A	
No problem.	1
Movement was very easy and clear.	1
It was difficult to distinguish between friendly and enemy targets. It took a few seconds for each target to be identified.	1
Device B	
The IR was excellent. I was able to detect targets immediately and was able to negotiate the course rapidly.	1
It did not shift even when striking the surface of the tunnel and the view never changed. I did not need to readjust to see my targets and this helped greatly in improving my time.	1
Sometimes I could not tell if they were enemy or friendly.	1
The only drawback was the weight of the device.	1
When the tunnel narrowed, you're forced to look down and the front heavy nature of the device worsens the downward angle. I held the NODs up with my left hand to see.	1
Device C	
Really good concept.	1
The fusion technology proved quite useful for target detection. In hindsight, I should have used full thermal to scan a long distance ahead, then switched to IR to maneuver through the tunnel.	1
I detected the targets adequately enough; however, it was usually only at shorter distances.	1
I did have some problems with the device holding in a taut position. After my helmet would collide with the surface of the tunnel, I was constantly readjusting the device.	1
Battery pack came off. Lost all power halfway through the course.	1

I had a problem seeing the ground below me and it was difficult to tell which target was enemy or friendly. I bumped my helmet on the roof and the battery fell off. I was able to retrieve it and reattach it in the dark with little difficulty. 1

2. How much difficulty did you experience with the device?

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

MEAN RESPONSE		
A	**B**	**C**
6.10	5.76	5.73

Device A

Good. 1
NODs kept shutting off. 1

Device B

I had to hold it up a lot to see. Kept falling down. 1

Device C

I love it. 1
You could see well with the fusion and the IR on; you could see the targets plain as day. 1
My only troubles were keeping the device adjusted properly. 1
The only difficulty I had was not with the NODs, but that the PASGT was too big for my head so it slowed down my movement. 1

3. What is your overall rating of the device you used?

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

MEAN RESPONSE		
A	**B**	**C**
5.90	5.83	5.67

Device A

Worked very well under the conditions of the test. 1
The floodlight stayed on. 1
Fogged up. 1

Device B

The device is very easy to use and quite durable. 1
I had to hold it up a lot to see. Kept falling down. 1

4. Please rate the following characteristics of the device you used.

1	2	3	4	5	6	7
extremely bad	very bad	bad	neutral	good	very good	extremely good

CHARACTERISTICS	MEAN RESPONSE		
	A	B	C
a. Field of view	5.77	5.35	5.54
b. Sight picture clarity	5.82	5.26	5.75
c. Sight picture brightness	5.91	5.65	5.83
d. Ability to perceive depth	5.32	4.83	5.17
e. Head mount balance	5.41	4.83	5.58
f. Wearing comfort	5.36	5.35	5.50
g. Device weight	5.41	5.26	5.54
h. Device shape	5.64	5.00	5.52
i. Design of controls	5.73	5.70	5.79
j. Ease of focus adjustment	5.95	5.78	5.83
k. Ease of eyepiece adjustment	5.82	5.71	5.87
l. Overall ease of use	6.05	5.94	5.90

Comments **No. of Responses**

Device A

Could be shorter and lighter. 1
The control for the IR illuminator is a pain to use when you want the IR illuminator to stay on. 1

Device B

IR floodlight is outstanding for tunnels; illuminates very well. 1
I could see very well when the weight wasn't interfering. 1
Front heavy. 1

Device C

Given the task, conditions, and standards for this test setup, the small size and light weight of these ENVGs made them easy to use. They worked very well under low light, space-restricted conditions. 1
I think all the devices are going to be uncomfortable in the tunnel because of the way your head will be canted. 1

5. How adequate or inadequate was your situational awareness during this exercise (i.e., aware of what was going on around you)?

1	2	3	4	5	6	7
extremely inadequate	very inadequate	inadequate	neutral	adequate	very adequate	extremely adequate

MEAN RESPONSE		
A	**B**	**C**
6.11	6.05	5.76

Device A

Hit the device going into a smaller tunnel. 1

Device C

I was able to actually run through the course until the battery pack came off. 1
This was my first run through and I wasn't entirely sure how the situation was supposed to run. The further along the scenario went, the clearer it became. 1

6. Please rate the level of the following problems that you may have experienced with the device you used.

1	2	3	4	5	6	7
extremely high	very high	high	neutral	low	very low	extremely low

PROBLEMS	MEAN RESPONSE		
	A	**B**	**C**
a. Eye strain	6.24	6.22	5.94
b. Tunnel vision	6.27	5.94	6.27
c. Headaches	6.47	6.47	5.92
d. Motion sickness	5.94	6.13	6.23
e. Screen white out	6.00	6.43	5.75
f. Nausea	6.33	6.43	6.00
g. Disorientation	6.10	6.43	6.00
h. Dizziness	6.71	6.43	6.33
i. Lens fogging	5.50	6.00	6.50
j. Other	6.24	6.22	5.94

Comments **No. of Responses**

Device A

Lens fogged. 1

Device B

Could see well, but the tunnel was a problem detecting targets swiftly. 1

I guess you would get tunnel vision in a tunnel.	1

Device C

Neck strain. I should have used the tilt function more to accommodate my primarily down focus.	1
I thought it worthwhile to mention that, since in a tunnel a Soldier's head needs to be moving up and down constantly, checking position and moving around obstacles and what not, the easily accessible, simple to use swivel control on the head mount made it quick and easy to effectively adjust the NODs on my head as they needed to be moved.	1

7. Which of the following ENVG characteristics did you use during this exercise?

a. I^2:

Comments	**No. of Responses**
Device A	
Went through pretty smooth, had no problem with the equipment.	1
Good set of NODs, except for the fact that they kept shutting off.	1
No thermal capabilities.	1
This was the only option.	5
PVS-14.	1
With the IR illuminator, it was almost like I had a flashlight.	1
With flood light.	1
Device B	
The dual eyepieces work great; used I2, had no problem.	1
Worked very well in the tunnel.	1
No thermal capabilities.	1
Only option available.	7
PVS-7D.	1
With IR flood light.	1
Device C	
I used only the I2 with the illuminator.	1
The I2 worked just fine with the IR on.	1
Only feature I used.	1
Very good combination of the IR and thermal.	1

b. Thermal:

Device C

The thermals worked just fine. 1
I used the thermal alone only when a target had already been detected with fusion and I was trying to determine more accurately if they were friend or enemy. 1

c. Fusion:

Device C

Fusion is awesome. 1
Fusion with the IR on was the best way to go so I could navigate the tunnel and detect targets easily. 1
Worked really good; best for task. 1
Able to identify targets with thermals. 2
I used both features. 3
They work well together. 2
I used fusion for almost the entire exercise. 1

8. Which of the following ENVG characteristics did you use most often?

	A	B	C
I^2	19	19	3
Fusion	1	1	17
Thermal	0	0	0
NR	1	3	3

Device A

Only capability. 1

Device B

Only capability. 1

Device C

Fusion is awesome. Works well together. 1

HUMAN FACTORS ENGINEERING TRIALS
COMPATIBILITY

SAMPLE SIZE = Varied from 1 to 7

CLOTHING/EQUIPMENT: NBC = NBC Gloves/Mask
BLEP = BLEP/Leather Gloves
SWD = SWD Goggles/Bare Hands

Please rate your ability to perform the following tasks and characteristics based on the trials you just completed.

1	2	3	4	5	6	7
extremely hard	very hard	hard	neutral	easy	very easy	extremely easy

1. **Donning and Doffing:**

TASKS	MEAN RESPONSE		
	C		
	NBC	BLEP	SWD
a. Donning	5.50	6.40	6.40
b. Doffing	5.50	6.60	6.40

2. **Reach and focus:**

CHARACTERISTICS	MEAN RESPONSE		
	C		
	NBC	BLEP	SWD
a. Assume standing position	5.33	6.40	6.20
b. Focus device	5.33	6.60	6.10
c. Manipulate device controls	5.83	6.60	6.20
d. Manipulate weapon safety	6.40	6.67	6.33
e. Obtain magazine	6.33	7.00	7.00
f. Change magazine	6.33	7.00	7.00
g. Pull charging handle	6.33	7.00	7.00
h. Obtain sight picture	5.80	6.20	5.80
i. Field of view	5.40	6.40	5.80
j. Head mount balance	6.20	6.20	6.20
k. Wearing comfort	5.60	6.20	6.40
l. Device weight	6.00	6.20	6.40
m. Device shape	6.00	6.40	6.40
n. Situational awareness	6.00	6.40	6.40
o. Overall ease of use	6.20	6.40	6.40

Comments	**No. of Responses**
Device C	
I thought this device was compatible with what I needed to get done with it.	1
Good stuff.	1
Hard to attain proper distance between mask and device.	1
Hard to get proper field of view.	1

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