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The Dismounted Warrior Network (DWN) is an integrated collection of virtual individual combatant (VIC) simulators designed for dismounted infantry (DI) operations. This report briefly overviews the DWN program and summarizes engineering and user experiments designed to exercise a proof of concept DWN system. These experiments explored the utility of a DWN system as a research and analysis tool for investigating how best to represent DI in virtual simulation. Based on their results as well as current research and development requirements, a follow-on, improved DWN system is being designed to extend the concept to operations in restricted terrain virtual environments.

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EXECUTIVE SUMMARY

The Dismounted Warrior Network (DWN) is an integrated collection of virtual individual combatant (VIC) simulators designed for dismounted infantry (DI) operations. This report briefly overviews the DWN program and summarizes engineering and user experiments designed to exercise a proof of concept DWN system. These experiments explored the utility of a DWN system as a research and analysis tool for investigating how best to represent DI in virtual simulation. Based on their results as well as current research and development requirements, a follow-on, improved DWN system is being designed to extend the concept to operations in restricted terrain virtual environments.

RESEARCH OBJECTIVE AND TASKS

STRICOM and the U. S. Army Infantry Center (USAIC) jointly support the DWN Program, while Lockheed Martin Information Systems (LMIS) is the program's prime contractor through the Advanced Distributed Simulation Technology (ADST) II program. The project objective is to provide a reliable, low-cost, easy-to-use capability to insert DI into synthetic virtual environments. This capability will support analysis efforts for Advanced Concepts and Requirements (ACR), Research, Development, and Acquisition (RDA), and Training Exercises and Military Operations (TEMO). Historically, the insertion of DI into virtual simulations has been limited. This has in turn hampered the ability of analysts to use virtual simulations to address DI related ACR, RDA, and TEMO issues in lieu of expensive hardware prototypes or time consuming and costly field exercises. The DWN Program was conceived and implemented to remedy this deficiency.

To date development of the DWN concept has involved a three-part approach. First, a simulation task analysis was completed to document DI virtual simulation requirements for the ACR, RDA, and TEMO domains and create a baseline for future DI virtual simulation efforts. These analysis results are available in two forms from the DWN Internet site[1]: as technical reports and via query of a searchable relational database. They will also be available through STRICOM's Data Repository (DR STRICOM) by the end of calendar year 1997.

The second task involved creating a DI SemiAutomated Forces (SAF) capability so opposing and friendly forces could be played in the same virtual environment as the DWN virtual combatants. This and the task analysis phase were completed in parallel. Selected behaviors from the Marine Corps' Individual Combatant (IC) SAF (modified to reflect current Army doctrine) and the Army's Close Combat Tactical Trainer (CCTT) SAF were combined to create the DI SAF. It was in effect optimized for open terrain operations since the IC and CCTT SAFs were developed for this environment. A technical report describing this effort is available from the DWN Internet site.

The third task focused on creating and exercising a proof of concept DWN from existing and under-development VIC simulations. Five VIC simulations (VICs A, B, C, Soldier Station, and

[1]http://www.rciorl.com/htms/warrior.htm

F) were selected by a joint government-contractor Integrated Product Team (IPT). Selection was based on three criteria: a desire to have a diverse mixture of VIC characteristics to examine; a cost/benefit assessment of system characteristics; and expected system availability. Following VIC selection, performance and interoperability issues were identified and resolved through the IPT process. Finally, the selected VIC simulations, a DI SAF station, an Exercise Support Station, and an After Action Review Station were tied into a distributed interactive simulation (DIS) Ethernet Network using DIS 2.0.4 protocols. This phase of the DWN effort ended with completion of the engineering and user experiments discussed below.

VIC DESCRIPTIONS

The VIC A simulation used a full-body tracking system to maintain knowledge about the soldier's position and movements in the real and virtual worlds. A "human joystick" approach was used for moving within the virtual world. A Biomechanics animation model represented the soldier in this world. He visually interacted with the virtual world via a head-mounted display (HMD) that had a resolution of 420 x 230 pixels and a 45° x 33° field of view (FOV). The display was fed by a standard image generation system. A video system tracked the aim point location of the soldier's weapon, a demilitarized M16 modified for VIC Alpha.

The VIC B simulation, in contrast, only tracked upper body movement in maintaining knowledge of the soldier's position in the virtual and real worlds. An omni-directional treadmill mediated virtual world movements. The DI-Guy human animation software, together with the BAYONET visualization system, represented the soldier in the virtual world. In turn, the soldier visually interacted with this world via a 360° display formed from four rear projection systems. These were also fed by a standard image generation system. Each display had a resolution of 640 x 480 pixels and a 90° x 77° FOV. The soldier was armed with a Land Warrior like rifle and had a Land Warrior like Integrated Helmet Assembly Subsystem (IHAS) which received video for aiming the rifle.

The VIC C and VIC Soldier Station simulations were similar. Both used a standard desktop CRT display with a joystick control. VIC C was integrated into DWN for the engineering experiments, while VIC Soldier Station was integrated for the user experiments. In both cases, the soldier viewed the virtual world through the CRT display (which had a resolution of 1280 x 1024 pixels with a 60°x 48° FOV) and used a joystick to control his movement through this world. Also, for both experiments, the soldier viewed the virtual world from an eye point perspective and manipulated a virtual M16A1 rifle using a joystick to sight on targets. The principal difference between the two systems was that the VIC Soldier Station was augmented with JANUS constructive simulation to support its operation, while VIC C used only the BAYONET visualization software to represent the soldier in the virtual environment.

Finally, the VIC F simulation was a Navy developed target engagement system. It used a magnetically based head motion tracking system to maintain knowledge about the soldier's position in the real and virtual worlds. The soldier used a foot pedal system to control his virtual world movement, while the DI-Guy animation software represented him in this world. He interacted visually via a large, high-resolution rear projection display fed by a standard image generation system. This system had a resolution of 1280 x 1024 pixels with a 75° x 56° FOV. The soldier was armed with an M16 rifle instrumented with an acoustic aim point tracking system.

ENGINEERING EXPERIMENTS

The engineering experiments were conducted over a three-week period at LMIS in Orlando, Florida. Their purpose was to discover the extent to which the VIC simulations supported the ability of trained soldiers to perform basic infantry tasks (e.g., see, move, and shoot). Two types of data were collected: quantitative measures of soldier performance and opinions about the ease of system use. The subjects were eight active duty male soldiers from Fort Benning, Georgia. Two were sergeants (E-5), two were PFCs (E-3), and two were PV2s (E-2). A repeated measurement design guided the data collection process. The soldiers completed three basic types of tasks within each VIC simulation. They were randomly paired into four two-man groups for the data collection. Data collection within a VIC simulation usually lasted for three days. Practice and fatigue effects were spread across the various VIC conditions and subject trials using a counterbalancing process.

Soldier Tasks

The first task assessed the ability to locomote within the virtual environment. The soldier walked a specified course through a visual database. He moved across open terrain and then entered and passed through several buildings. He was instructed to walk the course as quickly as possible while avoiding collisions with objects including building structures (e.g., walls and doorways). The time needed for and the number of collisions made during course completion were the measures of performance (MOPs) for this task.

The second task assessed visual performance. This was accomplished in three ways. First, the soldier had opportunities to recognize and identify stationary and moving human (e.g., BLUFOR and OPFOR) and vehicular sized targets (e.g., M1A2, T-72, BMP, and Bradley FVs) located at various ranges out to 500 meters. This task was performed from a fixed location within a 90° sector centered along a specific line of sight. Time to acquire, percent targets correctly recognized, percent targets correctly identified, and percent correct assessments of target motion were the primary MOPs. Second, the soldier searched a large open terrain sector of 270° to locate both stationary and moving targets spread over the area of this sector. For each located target, the soldier reported the target range and azimuth and whether it was moving or stationary. Target location time and the percent number of correct locations were the primary MOPs for this task. Finally, the soldier was presented with either of two kinds of targets: a DI animation model whose body components tended to move or sway when the animation walked or ran and a static billboard-like model that remained rigid when it moved across a virtual landscape. For each presentation, the soldier had to state the type of target it was. The MOP for this task was whether the target was correctly categorized as either the DI model or the static billboard-like target.

The final task assessed the soldier's use of the VIC weapon. The soldier engaged a bull's eye target located at different ranges along different azimuths. In some cases the target was stationary; in others it moved. The primary MOPs for this task were the time required to engage a target and the accuracy of each hit (measured as the distance of the hit from the target center).

Findings

Movement. When the soldiers performed the movement task within VIC F, they had the fastest course completion times (Mn = 188.3 sec, SD = 79.4 sec). This was at a cost: they had the most collisions (335) with building structures. When the soldiers performed the movement task within VIC B (which involved use of the omni-directional treadmill), they had the slowest course completion times (Mn = 560.5 sec, SD = 148.3 sec). However, when the movement task was completed within either VIC B or VIC A, the soldiers had the fewest collisions with structures (i.e., 135 with VIC B and 132 with VIC A).

Target Recognition. There were no significant differences among the VICs for the average amount of time required for target recognition. The average varied from 4.98 to 7.18 seconds across the VICs; standard deviations varied from 5.17 to 7.10 seconds. However, recognition ability as measured by the average percentage of targets correctly recognized tended to parallel the visual display parameters that characterized individual VICs. The soldiers performed best and equally well within VIC C and VIC F (i.e., 92% and 91%, respectively). Each of these had the highest resolution visual system (1280 x 1024 pixels). In contrast, for the VICs with the two low resolution systems (VIC B and VIC A), average recognition decreased to 80% for VIC A and 79% for VIC B. What is more interesting is that absolute recognition performance was much better than that predicted by the Johnson criteria model. This was not unexpected since it is well known that the visual systems for computer graphics based trainers must often be degraded to achieve user performance levels comparable to real world levels. Finally, significant differences existed among the VICs for percent number of correct motion assessments. These differences were primarily due to the relatively poor performance within VIC A (78%) versus VIC B, VIC C, and VIC F (i.e., 99%, 98%, and 92%, respectively). This result was not unexpected since visual interactions within VIC A were mediated by an HMD and users of HMDs often have trouble separating apparent target motion from head movement induced motion.

Target Search. Both average target location time and the percent number of correctly located targets were significantly influenced by the VIC simulation within which the search task was performed. VIC C and VIC F performance was comparable for average search time (Mn = 7.91 sec (SD = 4.74) and Mn = 8.66 sec (SD = 4.45 sec), respectively) and percent correct targets located (100% and 98%, respectively). In contrast, average location time was much greater for both VIC A (Mn = 9.27 sec (SD = 6.12 sec) and VIC B (11.64 sec (SD = 6.52 sec), while the percent number of correct locations was much lower for both of these simulations (80% and 67%, respectively). Again, these results are consistent with the visual resolution levels for the simulations. Finally, like the target recognition task, significant differences existed among the VICs for the percent number of correct motion assessments made during the search task. These again were primarily due to the relatively poor performance of the soldiers within VIC A (67%) versus VIC B, VIC C, and VIC F (i.e., 96%, 96%, and 80%, respectively). This result further reinforces the expectation that HMD use may lead to difficulties in separating target motion from head motion.

DI Animation Discrimination. Overall, average discrimination performance was significantly better for the animated (90%) than the static targets (68%). Significant differences existed among the soldiers' discrimination performance for the four VICs. Once more these differences paralleled the differences in the simulations' visual systems. Performance was best within VIC C and VIC F (i.e., 100% and 97%, respectively, for animated targets and 90% and 73%, respectively, for static targets) compared to VIC A and VIC B (i.e., 73% and 90%, respectively, for the animated targets and 68% and 43%, respectively, for the static targets). Further, while discrimination performance decreased as a function of range over the ranges examined (e.g., 50 meters, 100 meters, and 200 meters), it never reached the 50% level required to establish a reliable difference threshold. At such a threshold, it would be possible to reduce the level target detail and, thus, the display-processing burden. The ranges selected for examination in this part of the engineering experiments were picked to be at the 50% difference threshold for VIC C and VIC F (the simulations with the highest visual resolutions). These results represent one more instance in which observed performance exceeded that predicted from the Johnson criteria model.

<u>Time To Engage</u>. Soldiers firing within VIC B and VIC F took significantly less time to engage targets (Mn = 10.2 sec (SD = 4.6 sec) and Mn = 11.0 sec (SD = 5.8 sec)) than did soldiers firing within VIC C (Mn = 14.5 (SD = 5.9 sec) and VIC A (Mn = 16.9 sec (SD = 8.9 sec)). The likely reason for this result was that the aiming process was very similar to the real world process for the VIC B and VIC F simulations. In contrast, the VIC C simulation required the soldiers to move cross hairs on a target by using a joystick whose control/display ratio was not optimized for final fine aiming adjustments. Similarly, for the VIC A simulation, where the soldiers aimed a virtual rifle via the HMD, final aiming adjustments were often disrupted because the image of the rifle and its sights would "jump" off the target as the soldiers prepared to fire.

<u>Target Hit Performance</u>. Bull's eye targets were presented at two ranges: 100 and 200 meters. There were no significant differences in the percent number of targets hit at the 100-meter range across the four VICs. At this range, the overall hit rate was 95.5%. However, at the 200-meter range, differences in the percent number of targets hit emerged. Soldiers firing within the VIC F simulation hit significantly fewer of the bull's eye targets (64%) compared to the other VICs (97.3%). Significant differences also occurred for aiming error. Again, these were between VIC F and the other simulations. The average distance between target center and target impact point was larger for VIC F both at the 100 meter (Mn = 1.67 meters (SD = 0.91 meters)) and 200 meter (Mn = 2.20 meters (SD = 1.14 meters)) ranges compared to the other VICs at the 100 meter (Mn = 0.70 meters (SD =0.60) and 200 meter (Mn = 1.19 meters (SD = 0.87)) ranges.

Notice also, that the standard deviation of the aiming error for VIC F was 30 to 50 percent larger than the standard deviation of aiming error for the other simulations combined. This may account for much of the difference between the VIC F hit performance versus the other simulations. If a firer cannot consistently aim at and hit a given mark from one target to the next, then large absolute errors may be expected, especially if the firer tries to compensate for his immediate past performance. This would lead to many firings that would completely miss the target. It also appears that this problem may be related to problems that were found to exist in the VIC F acoustic tracking system. For both the engineering and user experiments, the VIC F tracking system often provided inaccurate data about weapon position relative to the target. Such inaccuracies fed into a ballistic model (like the one used by VIC F to model bullet flyout) would be expected to lead to firing inconsistencies from one target to the next like those experienced by the VIC F firers.

<u>Questionnaire Responses</u>. Across all VICs, the soldiers considered none of the tasks that they performed to be harder than the midpoint of the rating scale (i.e., "Neither Easy nor Difficult").

Further, ratings of "ease of use" tended to follow the performance results. Ratings for ease of locomotion, for example, were consistent with the time for course completion MOP. The more rapidly the soldiers were able to complete the movement course, the easier they rated the VIC within which the course was completed. VIC F (with its foot pedal for movement control) was rated the least difficult to use and the most realistic. In contrast, VIC B (with its omni-directional treadmill) was rated as the most difficult to use and least natural. There were few significant differences among the ratings for the visual performance tasks. Generally, when a visual task was performed within a VIC simulation that had a high resolution visual system, it was rated as easier to use. As such, VIC C and VIC F were considered the easiest environments in which to perform visual tasks. Finally, based on 288 administrations of a standard simulator sickness questionnaire during the engineering experiments, simulator sickness was not found to be a problem.

USER EXPERIMENTS

Following the Orlando engineering experiments, the DWN system was moved to and installed in the Land Warrior Test Bed (LWTB) at Fort Benning, Georgia. Here a second set of experiments was completed over a period of three weeks to examine the ability of the VIC simulators to support execution of DI small unit tasks and missions within virtual environments. Infantry subject matter experts planned these experiments. They were geared to explore how well the DWN technology enabled task performance rather than to define specific or relative performance levels. Most of the data collected during these experiments comprised qualitative judgments about how the system performed. The subjects for the user experiments were also eight active duty male soldiers from Fort Benning, Georgia. Two were sergeants, three were SPCs, two were PFCs, and one was a PVT. Several of these subjects had also participated in the Orlando, Florida, engineering experiments.

Experimental Concept

The experimental concept was to have a group of trained soldiers operate within the DWN system (to include DI SAF) and complete a series of squad-level mission scenario segments (i.e., vignettes). Both open terrain and military operations in urban terrain (MOUT) missions were completed. The open terrain activities involved either a squad assault on an enemy position or the defense from an enemy assault. The MOUT activity involved a sniper clearing operation in which a VIC fireteam attacked and then entered a building. The DI SAF part of the fireteam provided cover during this operation since DI SAF could not operate in building at the time of this experiment. One four-man fireteam of VIC players and one team of DI SAF comprised the BLUFOR squad. The squad leader position was played through a manned BAYONET workstation. The VIC Soldier Station was integrated into the DWN for these experiments to replace the VIC C system used for the engineering experiments. A primary OPFOR station created the enemy forces for both the open terrain and MOUT operations. A secondary OPFOR station provided an enemy sniper for MOUT operations.

The soldiers practiced for four days prior to data collection, learning to operate with each other through the VIC interfaces and with the DI SAF. Each soldier practiced performing in at least one of three squad roles: leader, squad automatic weapon (SAW) gunner, and rifleman. Data collection exercises were completed over a period of two weeks. Each exercise lasted for about

30 minutes. Each soldier completed up to four exercises per day. A mission briefing preceded each exercise to define the requirements for the exercise. Then, the soldiers manned their designated VIC simulation and the exercise was initiated. During completion, data collectors observed the soldiers and recorded their observations on a set of standard forms. Also, protocol data units (PDUs) were recorded so that the exercise events could be later replayed via Simulyzer software. The exercise continued until its objective was achieved or until at least three of the four VIC soldiers had been "killed". An after action review (AAR) followed exercise completion. During this time, the soldiers completed a series of questionnaires that provided the primary MOPs for these experiments. These questionnaires were designed to measure the perceived effectiveness of each VIC simulation and identify problems and difficulties involved in moving and maintaining orientation within a VIC simulation; observing visually; and using a designated weapon.

Findings

Overall. The overall pattern of the soldiers' responses was that VIC B was ranked best for the tasks involving movement, orientation, visual recognition, and weapon usage. This was for both the open terrain and MOUT environments. For the open terrain environment, VIC Soldier Station and VIC F were the next most preferred systems with VIC A ranked last. For the MOUT environment, VIC F was the next most preferred after VIC B, while VIC Soldier Station and VIC A were the two least preferred systems. It was not clear what factors guided the soldiers in making their judgments. However, the soldiers had more favorable responses for systems that allowed them to perform tasks in ways consistent with their real world performance or that led to the fewest differences from tactical procedures.

There were several other factors that may have influenced the soldiers' judgments. With just four days of training, the soldiers were judged not to be fully expert in using all of the functionality of the VIC simulations. Also, even though some of the soldiers had previously participated in the engineering experiments, the user experiment was the first time that these soldiers had worked together as a team. Given their time in service, their combat skills were somewhat limited. Thus, in using the various VICs during the user experiment, soldier performance (and perceptions about this performance) was likely impacted by the simultaneous requirement to learn more about the VIC systems, develop skill in working with their team mates, and deal with particular limitations in their own individual soldiers skills.

The technology itself may also have been an influence. In many instances, the databases for the virtual environments were judged to limit the soldiers' performance. For example, the friendly SAF fireteam acted independently of the VIC players and often added a confusion factor to scenarios when they engaged the enemy SAF. Enemy SAF was often able to engage and kill VIC players at unrealistic ranges and exposure times. The infrastructure technology of some of VIC simulations was often unreliable. All of these influences could be expected to impact the soldiers' judgments about the adequacy of the VIC simulations and their ability to use them in squad level combat activities.

VIC B. The soldiers ranked the VIC B simulation "best" for system flexibility, ease of task performance, ability to perform in a tactically sound manner, and ability to perform in a realistic manner. Also, the soldiers who performed as team leaders during the experiments ranked VIC B as second best for controlling fires and movement. The soldiers liked VIC B's treadmill solution to the problem of "how to move" because they actually moved, i.e., they had to use their legs to move, turn, and maneuver. However, they felt the treadmill mediated movement was too slow and unstable; walking in a straight line was too difficult; and moving as a team and keeping up with the other VIC soldiers was difficult.

VIC F. This was one of the most preferred simulation systems. The soldiers reported that they felt like they were actually moving within the visual scene. Further, the ability to approach an obstacle via foot pedal control and then walk up and look around an obstacle (e.g., around corners) added to the system's realism. They also noted that the size of objects shown on the projected display was very realistic. However, while swift and effortless, some aspects of the movement process were viewed as unrealistic. This seemed to derive from difficulties encountered in controlling speed; crawling by using the foot pedal to control this movement; and moving within buildings.

VIC C. The process of aiming and shooting within this VIC's virtual world were viewed as very accurate. Viewing and scanning were easily accomplished by using the system's joystick. However, the soldiers as a group reported that this approach was not very realistic. Their preference was to stand and hold their weapon while shooting.

VIC A. The soldiers consistently ranked this simulation the lowest. Areas where this VIC experienced difficulties involved the ability to move tactically in open terrain, estimate distances to other personnel, aim the rifle, and move through a building and know which rooms were cleared. However, some soldiers liked the realistic sensations provided by this system's HMD. There was a limitation noted for the HMD. It was difficult to maintain situational awareness because of the limited FOV (45 degrees at any given time) and the poor depth perception and peripheral vision characteristic of the HMD.

SUMMARY

Experimentation with the DWN proof of concept system (i.e., the five VIC simulators) demonstrated that it was possible to have soldiers perform standard infantry like tasks (e.g., move over terrain or in buildings, detect targets, and aim and fire a rifle) in a virtual environment. A major challenge in completing this work was the fact that none of the VICs were designed to be networked together and then be used in a series of research oriented experiments. What is remarkable about the engineering and user experiments is that despite this limitation, the proof of principle network was shown to be a viable way to provide relatively low cost, reliable insights into the performance of humans within virtual environments.

However, limitations in this performance were identified that often reflected the particular technology hosting a given simulation. For example, VIC B's omni-directional treadmill was judged favorably in mediating the experience of walking or running. However, users did not uniformly view this experience as natural. It also could not support postures such as kneeling or crawling. Similarly, the simulations with high-resolution visual systems supported better target acquisition performance. However, this performance tended to be better than that of the real world for similar real world conditions. This is clearly a problem that needs to be resolved. Also, none of the weapon tracking technologies provided satisfactory levels of performance for both aiming and target hit performance. In some instances, aiming performance was well supported but hit accuracy was not (e.g., by VIC F). In other instances, just the opposite was the case (e.g., VIC A and VIC C).

Given the continued interest of the USAIC and STRICOM as well as the MOUT Advanced Concept Technology Demonstration (ACTD), the DWN proof of concept system will be enhanced in a number of ways to capitalize on the DWN engineering and user experiments. These include the following:

- Remedy deficiencies identified in the VIC simulations
- Add two next generation VIC simulations: one with a higher resolution and larger FOV HMD visual system and one with a curved, wide FOV multi-projector visual system
- Enhance the DI SAF with the ability to know about and enter buildings
- Improve the MOUT database by updating it to reflect its real world counterpart at the Fort Benning McKenna MOUT site; adding improved texture maps to increase the spatial cues available to VIC users; and eliminating interior building details not required so that system update rates are maximized
- Provide the ability to create holes in building to support breaching doors and windows
- Add a digital communications component to the VIC simulations with an IHAS capability

1. Introduction

This report documents the work performed under the Dismounted Warrior Network (DWN) Delivery Order (DO), #0020. The DWN DO was awarded by the Army's Simulation, Training and Instrumentation Command (STRICOM) on June 13, 1996 and the technical effort was completed with the submission of this report on September 15, 1997. As prime contractor, Lockheed Martin Information Systems (LMIS) had overall project responsibility, but the project would not have succeeded without the dedicated efforts of many organizations from industry and the government. The contributions of the following organizations are gratefully acknowledged:

Industry Partners:
Boston Dynamics Inc. (BDI)
Hughes Aircraft Corp. (HAC)
Army Research Lab (ARL)
Institute for Defense Analysis (IDA)
Reality By Design (RBD)
Resource Consultants Inc. (RCI)
Science Applications Internat'l Corp (SAIC)
Veda Inc.
Virtual Space Devices (VSD)

Government Partners:
Army Research Institute (ARI)
Naval Postgraduate School (NPS)
NAWCTSD
Soldier Systems Command (SSCOM)
TRAC-WSMR

1.1 Background

The Land Warrior Test Bed (LWTB) at Fort Benning, Georgia is chartered to support the simulation requirements for the US Army Infantry Center's (USAIC) Dismounted Battlespace Battle Lab (DBBL) and infantry materiel developers. Prior to the advent of the DWN project there have been limited simulation capabilities to insert the Dismounted Infantry (DI) into the synthetic environment to support Advanced Concepts and Requirements (ACR) generation and Research, Development and Acquisition (RDA). In addition, the Infantry's simulation requirements to support Training Exercises and Military Operations (TEMO) were ill defined. The USAIC and STRICOM have created the DWN program to help address these shortfalls.

The need for DWN was first articulated by STRICOM in the Individual Combatant Simulation Technology Transfer Plan in November of 1995 [ref 1]. In this document some of the key technical challenges were identified, including: interoperability, graphics and database complexity, integration into networked simulations, computer generated forces, man-machine interfaces, individual representation, and instrumentation. It also reviewed existing simulation programs for relevancy to DI simulation technologies and requirements. It concluded with recommendations for continued "...research, study and consolidation of projects..." and for the initiation of the DWN project in order to "...begin to focus on the requirements for simulation of the individual combatant within the synthetic environment."

1.2 Dismounted Warrior Network Project Overview

DWN became a Delivery Order under STRICOM's ADST II contract in June 1996. It was awarded with multiple phases in order to permit tasks to begin as funds became available. These DWN phases are briefly described below.

1.2.1 Simulation Task Analysis (Phase 1)

The Simulation Task Analysis phase of the DO was started in June 1996 and concluded in July 1997. This effort produced a series of reports documenting DI simulation requirements for the ACR, RDA and TEMO domains. The process used to develop these requirements was modeled after the approach used to develop validated simulation requirements for the Close Combat Tactical Trainer (CCTT) program. A series of Information Interchange Meetings (IIMs) were conducted to solicit input from the user community. The following organizations participated in the IIMs: STRICOM, NPS, USAIC, ARI, ARL, USMC, NAWCTSD, TRAC-WSMR, SSCOM, SAIC, RCI and LMIS. The plan is for these reports to be delivered to TRADOC in the near future with the goal of becoming the requirements baseline for future DI simulation efforts in the Army. The reports have been posted on the DWN web site (http://www.rciorl.com/htms/warrior.htm). The six CDRLs produced by this effort are identified in paragraph 1.3.2.

1.2.2 Database for Simulation Task Analysis (Phase 2)

Phase 2 was initiated in September 1996 and completed with the Task Analysis in July 1997. A relational database containing the results of the Simulation Task Analysis was developed; it is available on-line at the web site mentioned above. The database also includes soft copies of the reports and the source documents (the source documents are not available on-line). CDROMs are planned in the near future with a copy of the entire DWN database. See Figure 2.2-1.

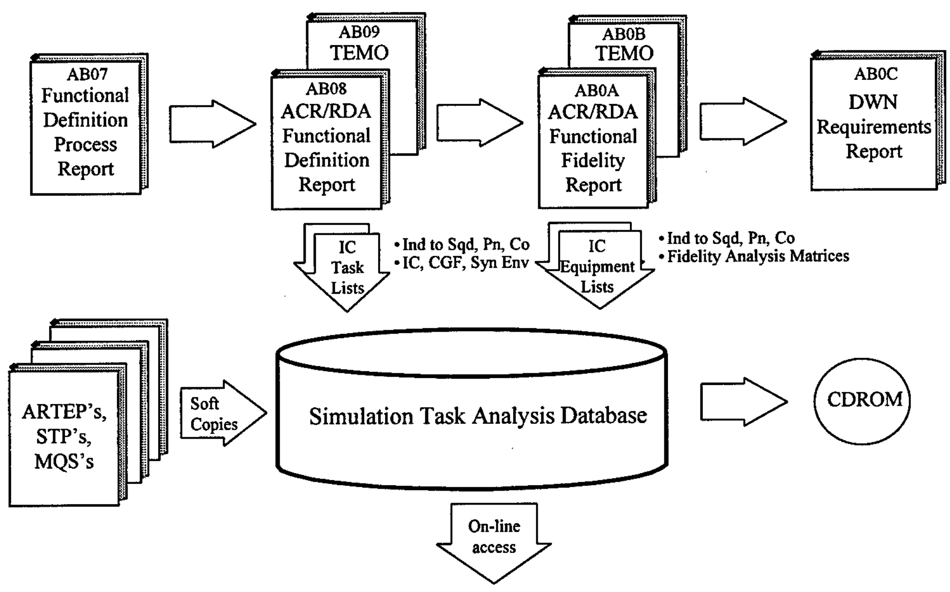


Figure 1.2.2-1: Simulation Task Analysis Products

1.2.3 DI SAF Development (Phase 3)

In September 1996, work started on the DI SAF (semi-automated forces) simulation software phase. This effort began with the incorporation of behaviors from the IC SAF developed for the Marine Corps on the Leathernet project. These Marine behaviors were modified to reflect Army doctrine, and behaviors from CCTT SAF were added as well. The DI SAF will be incorporated into a new ModSAF baseline in the Spring of 1998. Figure 2.3-1 illustrates the overall DI SAF development process.

This initial DI SAF capability has been optimized for open terrain applications because of its IC SAF origins; future work will be aimed at MOUT applications. The DWN DI SAF team recently completed integration of the DI SAF with version 2.2.4 of ModSAF in order to utilize the Multiple Elevation Structures (MES) work done by the Computer Generated Forces Terrain Database (CGFTB) project [ref 2]. The MES capabilities combined with new military operations in urban terrain (MOUT) behaviors will permit the future DI SAF to operate cooperatively with Virtual Individual Combatants (VICs) in and around buildings in the McKenna MOUT database. The current version of DI SAF is referred to as DI SAF 2.0.

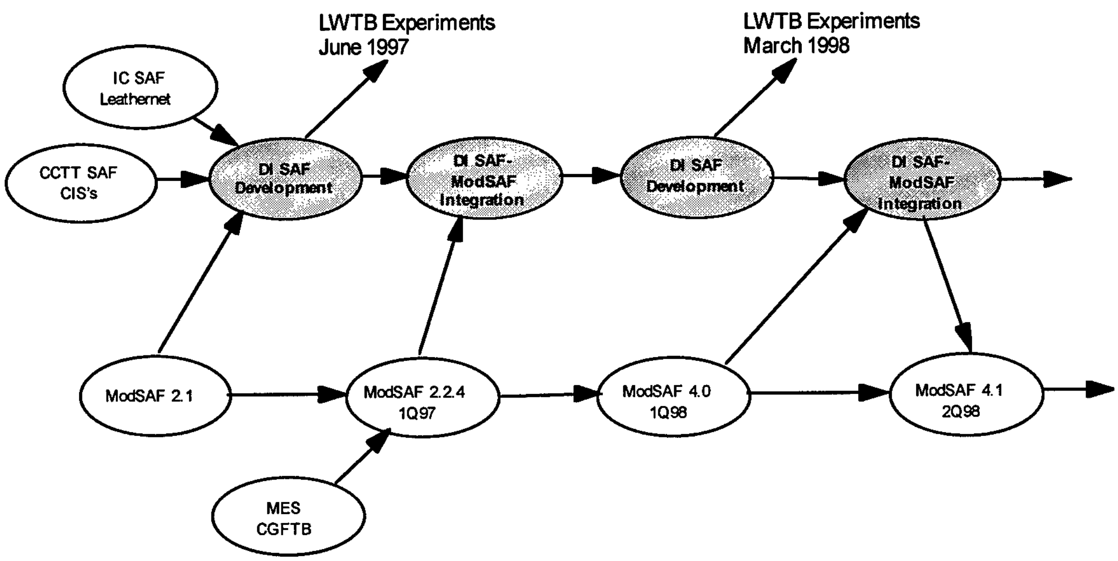


Figure 1.2.3-1: DI SAF leverages DoD investments in ModSAF

1.2.4 Engineering Experiments (Phase 4)

In November of 1996 the engineering experiment phase of the DO was initiated. This phase of the project integrated a number of existing VIC systems with DI SAF into the first instantiation of the DWN network. The VICs included:

- VIC Alpha - a fully immersive Dismounted Soldier System developed by Veda under a STRICOM applied research effort, which utilizes video cameras to capture soldier motion;
- VIC Bravo - a combination of the Omni-Directional Treadmill (ODT) developed by Virtual Space Devices under a STRICOM applied research effort and BAYONET graphics and network software (a derivative of the Naval Postgraduate School's NPSNET) rear-projected onto a 360 degree display surface, and with a Land Warrior-like monocular eyepiece for weapon sighting;
- VIC Charlie - a joystick-controlled soldier simulator using a desktop CRT display and BAYONET software; and

- VIC Foxtrot - a marksmanship trainer developed by NAWCTSD for the Marine Corps, consisting of an virtual simulation with rear projection and instrumented rifle.

The engineering experiments were conducted in the ADST II Operational Support Facility (OSF) in Orlando, Florida for the three weeks beginning 21 April 1997 and concluding 9 May 1997. The experiments successfully compared and contrasted the ability of key features of the different VIC technologies to support DI task performance in a virtual environment. Quantitative and qualitative experiment data was analyzed with the help of ARI and the results are presented in Section 4.0 of this report.

1.2.5 User Exercises (Phase 5)

In February of 1997 the user exercise phase of the DO was initiated. User exercises were conducted at the LWTB at Fort Benning two weeks after the completion of the engineering experiments. The same systems were used except that Soldier Station from TRAC-WSMR was used for VIC Charlie instead of the BAYONET station described above. In contrast to the technology and individual task orientation of the engineering experiments, the user exercises evaluated the ability of the various simulation systems to support execution of DI small unit tasks and missions in a synthetic environment. Soldiers from Fort Benning were rotated through the four VIC systems within a variety of mission scenarios. After Action Reviews were conducted after each experiment to assess soldier-VIC performance and collect soldier feedback on VIC strengths and weaknesses from a user's perspective. Qualitative experiment data was captured by ARI and the results are presented in Section 5.0 of this report.

1.2.6 Land Warrior Simulation Extension for AEIII (Phase 6)

The Land Warrior Simulation Extension (LWSE) was a project within DWN that was initiated in July 1996 and completed in October 1996 concurrent with the AUSA Army Experiment III. This project investigated the potential for advanced Land Warrior technologies to improve the effectiveness of the Individual Combatant on the twenty-first century battlefield. Land Warrior technologies were integrated with the Omni Directional Treadmill (ODT), NPSNET software and three rear projection screens providing 270 degree FOV at the LWTB at Fort Benning. Visitors at the AUSA site in Washington, DC were able to observe soldiers participating in tactical engagements on the LWSE systems via a long haul linkage and video wall displays.

1.3 Deliverables

The deliverables consisted of hardware, software and CDRLs.

1.3.1 Hardware and Software

The hardware and software deliverables and their disposition are tabulated in Table 1.3-1. Many of the deliverables in this table consist of components developed under other government contracts.

Table 1.3.1-1: Hardware and Software Deliverables

Deliverable Item	VIC Bravo BAYONET + ODT	VIC Charlie BAYONET	VIC Charlie - USEX Soldier Station	BLUFOR DI-SAF	Exercise Support Simulyzer & Excel	Radios (Admin & tactical nets)
Provider	RBD, LM and VSD	RBD and LM	TRAC WSMR	SAIC and LM	LM	LM
Disposition of Item	System stays at LWTB; SGI development platform stays at RBD on loan from LWTB	The Maximum Impact remains on loan at LWTB from CDF DO; flybox returned to lender	Maximum Impact, Indigo2, 21" touchscreen CRT, flybox, and speakers plus Soldier Station software remains at LWTB	Max Impact and Indy returned to Orlando OSF for further DI-SAF development; flybox returned to lender	Indy and 1 PC return to Orlando OSF; Indy borrowed from OSF; PC from STP-21 DO; 2nd PC remains at LWTB	Wireless microphones remain at LWTB; TSI virtual radios (7) from STP-21 DO also remain at LWTB
Ownership	ADST II	ADST II	ADST II	ADST II	ADST II	ADST II

1.3.2 CDRLs

Nine CDRLs were developed for the DWN Delivery Order. They are tabulated in Table 1.3-2. The CDRLs are posted to the DWN web site.

Table 1.3.2-1: DWN CDRLs

CDRL #	Description	CM Number	Date
AB02	DI SAF Analysis Report	ADST-II-CDRL-010R-9700009A	03/18/97
AB03	DI SAF Final Report	ADST-II-CDRL-DWN-9700391	09/15/97
AB06	DWN FEA Final Report	ADST-II-CDRL-DWN-9700392	09/15/97
AB07	Functional Definition Process	ADST-II-CDRL-010R-9600266A	10/04/96
AB08	ACR/RDA Functional Definition	ADST-II-CDRL-DWN-9700050A	04/21/97
AB09	TEMO Functional Definition	ADST-II-CDRL-DWN-9700044A	04/21/97
AB0A	ACR/RDA Functional Fidelity	ADST-II-CDRL-DWN-9700146A	07/11/97
AB0B	TEMO Functional Fidelity	ADST-II-CDRL-DWN-9700161A	06/30/97
AB0C	Requirements Document	ADST-II-CDRL-DWN-9700210A	07/15/97

1.4 Applicable Documents

1.4.1 Government

a) Statement Of Work For Dismounted Warrior Network (DWN) DO, AMSTI-96-W007, Revision 4.0, dated 9 December 1996.

b) Statement Of Work For Land Warrior Simulation Extensions to the Dismounted Warrior Network DO, ADST-II-A008-R039, Revision B, dated 17 June 1996.

1.4.2 Non-Government

a) Proposal for the Front End Analysis Experiments to Support Warrior Network, ADST-O-96-0069, 7 March 1996, revised 17 May 1996.

b) Proposal For Land Warrior Simulation Extension to the Dismounted Warrior Network Delivery Order, ADST-II-TAPP-039R-9600218, 9 July 1996.

c) Cost Growth Change Proposal for the Dismounted Warrior Network Delivery Order, ADST-II-TAPP-010R-9600432, 25 November 1996.

d) Technical Growth Proposal for Dismounted Warrior Network, ADST-II-TAPP-DWN-9700211, 28 April 1997.

e) ADST II Report: Requirements Analysis for Dismounted Warrior Enhancements for Restricted Terrain, ADST-II-MISC-DWN-9700240, 14 July 1997.

f) Dismounted Warrior Network (DWN) Enhancements for the MOUT ACTD Revision B, ADST-II-MISC-DWN-9700292B, July 30, 1997.

g) 3D Visualization for the McKenna MOUT Site Revision A, ADST-II-MISC-DWN-9700293A, July 14, 1997.

h) White Paper: A Vision for the Land Warrior Testbed Simulation Center, ADST-II-WTPR-DWN-9700376, August 15, 1997.

1.5 Document Contents

This document is the Final Report for the DWN Delivery Order. As such, it encompasses all of the work performed on the DO. However, the treatment on the DI SAF development effort is cursory because it is covered in detail in CDRLs AB02 and ABO3. Similarly, the Simulation Task Analysis write-up is very brief because it is covered in detail in CDRLs ABO7, ABO8, ABO9, ABOA, ABOB, and ABOC.

The remainder of this document is organized as follows:

2.0 System Description
3.0 DWN System Integration
4.0 Engineering Experiments
5.0 User Exercises
6.0 Implication of Experiment Results
7.0 Future Plans
8.0 References
Appendix A: Engineering Experiment Plan
Appendix B: Engineering Experiment Questionnaire Forms
Appendix C: Engineering Experiment Questionnaire Data
Appendix D: User Exercise Plan
Appendix E: User Exercise Questionnaire/Data Collection Forms
Appendix F: User Exercise Questionnaire Data
Appendix G: Acronyms

2. System Description

The top level system block diagram for the DWN is shown in Figure 2-1. This is the configuration of the system when the DWN user exercises were performed at Fort Benning in May - June 1997.

As shown, the system consists of four Virtual Individual Combatant (VIC) stations, a BLUFOR DI SAF station, Exercise Support equipment, and an After Action Review (AAR) capability. All systems are connected via an ethernet network and communicate with each other via Distributed

Interactive Simulation (DIS) 2.0.4 Protocol Data Units (PDUs). A separate virtual radio network on its own DIS ethernet LAN supports the system operators (admin net), and a wireless radio network is provided for communications between the soldiers operating the VICs (tactical net).

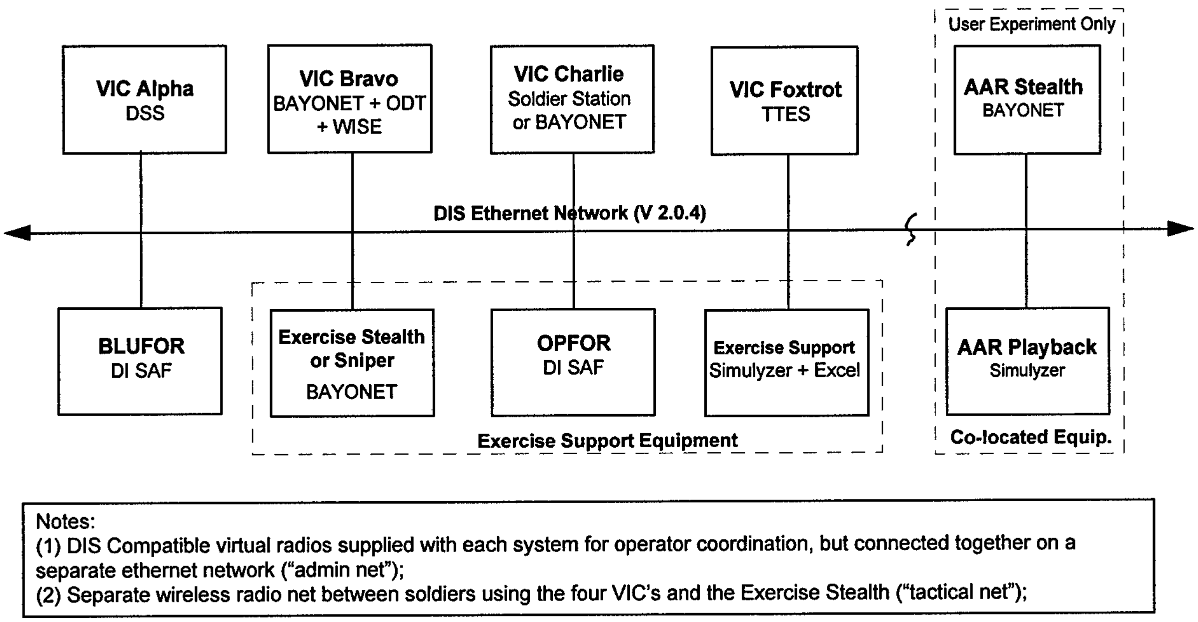


Figure 2-1: DWN System Block Diagram

<u>VIC Alpha:</u> consists of the Dismounted Soldier System (DSS), which is characterized as follows:

- Developed by Veda under a STRICOM applied research effort
- Video based full body motion tracking
- Free movement in a restricted space ("human joystick")
- Biomechanics based human animation model
- Wireless Head Mounted Display (Biocular - same image displayed to both eyes)
- Weapon Simulation (supplied by NAWCTSD)
- SGI Onyx2 Reality Station Image Generator
- Omni-directional Sound (Soundstorm by RBD)

<u>VIC Bravo</u>: comprised of BAYONET software, the Omni-Directional Treadmill (ODT), and a Land Warrior-like rifle and Integrated Helmet Assembly Subsystem (IHAS). These subsystems are in turn made up of the following:

- BAYONET
  - Based on NPSNET visualization software from Naval Postgraduate School; modified by RBD for DWN
  - Magnetic based upper body motion tracking
  - 360 degree display via 4 rear screen projectors
  - SGI RE2 image generator (SGI Infinite Reality for the user exercises)
  - Human animation support (DI Guy by BDI)

- ODT
  - Developed by Virtual Space Devices Under STRICOM applied research effort
  - Full 360 degree mobility via slip ring
  - Force feedback response to terrain slope changes
- Land Warrior Rifle + IHAS
  - From AUSA AE3, plus simulated IHAS device
  - Does NOT include LW C4I message traffic

VIC Charlie: comprised of TRAC-WSMR's Soldier Station:
- NPSNET plus JackML (Univ. of Pennsylvania) for human animation
- Joystick movement control via flybox
- Desktop CRT display with touchscreen (or mouse)
- Weapons aiming via joystick
- SGI Maximum Impact Image Generator
- Movement, detection, engagement, and damage assessment based on Janus algorithms and databases
- Directional Sound

Soldier Station was used for the user exercises only. For the engineering experiments, BAYONET was used, which is similar to the Soldier Station visualization component.

VIC Foxtrot: consists of NAWCTSD's Team Tactical Engagement Simulator (TTES):
- Developed for the USMC by NAWCTSD
- Magnetic based head motion tracking
- Movement control via foot pedal and magnetically tracked head motion
- Large rear projection screen, high resolution projector
- Instrumented M-16; aiming via acoustic sensors
- SGI Infinite Reality (RE3) Image Generator
- Directional sound

DI SAF Station: consists of DI SAF software running on an SGI Indy workstation. This station is characterized as follows:
- Under development by SAIC for DWN
- Based on IC SAF developed for the Marine Corps
  - Behaviors converted to Army doctrine: IC Halt, IC Occupy Position, IC March, IC Move, IC Road March (Fireteam), React to Fire, Infantry Attack
  - Some CCTT DI behaviors incorporated: Conduct Fire and Movement, React to Ambush, Break Contact, Mount/Dismount, Fireteam Assault, Suppressive Fire
  - Initial version emphasizes open terrain operations
- SGI Indy Workstation
  - DI SAF Execution + Plan View Display
  - Animation Support provided by BAYONET software with JackML on SGI Maximum Impact
- Formal ModSAF Release

- DI SAF to be incorporated into the Army's official ModSAF baseline

Exercise Support Station: supporting the VIC network for the DWN experiments was a Stealth, a DI SAF station, and an Exercise Support Station, as described below:

- Stealth
  - SGI Maximum Impact with BAYONET software
  - Permits exercise conductor/facilitator to oversee activities
  - A similarly configured station was also used as a Sniper (OPFOR)
- DI SAF, modified to use OPFOR weapons, used as the OPFOR in scenarios
  - Plan view display for monitoring and controlling action
  - Runs on an SGI Indy Workstation
- Exercise Support Station
  - Simulyzer on SGI Indy used for data logging and real-time monitoring
  - Selected fields of specified PDUs are captured and time stamped
  - PC with Excel support post processing of experiment results

After Action Review Support Equipment: During the user exercises, BAYONET hosted on a Maximum Impact served as a stealth display for After Action Review (AAR). Simulyzer played back PDUs recorded during the previous exercise and transmitted the PDUs to the AAR Stealth.

3. DWN System Integration

Award of the engineering experiments (Phase 4) also initiated the system integration effort. The selection of the four participating VICs was accomplished contractually by funding proposed WBS (work breakdown structure) line items for development, integration, and experiment support efforts for only these VICs. These four VICs were identified through an IPT (Integrated Product Team) process with the government. Their selection was based on system availability and cost/benefit assessments of system characteristics and costs associated with bringing them into the DWN effort.

The proposed method for integrating the DWN system and exchanging information within the entire extended DWN team (including representatives from the USMC, SSCOM, ARL, ARI, NAWCTSD, TRAC-WSMR, USAIC, Sandia National Labs, as well as STRICOM, LMIS, and the subcontractors) was through Technical Interchange Meetings (TIMs). Two TIMs were conducted during which all DWN team members participated. Prior to the formal TIMs, working group meetings were held with only the members of the team that were providing the VICs or other direct support. The results of these meetings are discussed in the following section.

3.1 TIMs

The formal TIMs were held at LMIS on 22 January 1997 and 27 February 1997, with the informal working group meetings held the day before each TIM. The first TIM reviewed the DWN program effort including a presentation of the phased approach. The overall system design concept was discussed, and a member of each of the VIC development teams presented an overview and capabilities assessment of their system. Demonstrations of the DI SAF and VIC

Alpha (DSS) were conducted. The meeting concluded with preliminary plans for the engineering experiments and notional concepts for the (unfunded) user exercises.

The second TIM updated the overall project status and provided an overview of the simulation task analysis effort. Representatives of each VIC updated the status of their development and integration efforts. TRAC-WSMR announced that Soldier Station would not be participating in the engineering experiments and that they were still debating whether or not to be involved with the user exercises; soon thereafter TRAC-WSMR announced that they would participate in the user exercises.

The focus of TIM #2 was to obtain agreement on the engineering experiment plan, which was distributed at the meeting, and to present the preliminary plans for the user exercises, which had been initiated earlier in the month. Following the presentations and discussions, the team was kept current with developments and changes via email distribution of planning documents.

During the pre-TIM integration meetings, system performance and interoperability issues were identified and agreements reached for their resolution. These included the following:

- DIS 2.0.4 PDUs and fields to be sent/received
  - Collision PDUs required; output at no more than 1 Hz when in prolonged contact with an object such as a wall
- 29 Palms and McKenna MOUT database distribution and integration issues
  - McKenna database was thinned and distributed to all participants via an FTP site
  - VIC Alpha upgraded its SGI computer to maintain acceptable update rates
  - 15 Hz minimum update rate was set as the goal for all visual systems

- Modeling Issues
  - Target models were distributed so all VICs had the same models (except DI models)
  - DI model data requirements (local and network) were resolved for each system (DI-Guy, JackML, and a Biomechanics developed model were used)
- Database correlation issues were discussed (Flight and ModSAF formats, Soldier Station grid-based terrain model)
  - TRAC-WSMR announced plans to improve the resolution of the Soldier Station gridded database, but it was agreed that intervisibility mismatches between Soldier Station and the other VICs with polygonal terrain representations could still occur
- Bandwidth/load issues
  - It was agreed that the number of DI animations to be displayed at one time would be limited to 17
  - Digital radio traffic was assigned to a separate DIS network
- Communications
  - Due to the untethered nature of VIC Alpha, wireless microphones were used to support communication between the VICs and the Squad Leader
- Mobility Issues
  - VIC Bravo was originally built with 270 degree visibility, which limited mobility; a fourth (rear) screen was added to give VIC Bravo 360 degree mobility

- VIC Charlie (i.e., the Soldier Station version) is unable to enter multi-story buildings because of current limitations in its underlying Janus terrain representation of multi-story buildings; therefore scenarios were developed to accommodate this characteristic - in particular, outside movement tasks were defined

Discussion of these and other issues resulted in system capability agreements that were captured in a matrix, presented here as Table 3.1-1

In addition to the two TIMs, task analysis coordination meetings were conducted between LMIS and SAIC, and sometimes supported by ARI. These meetings were held in conjunction with the TIMs and/or Information Interchange Meetings (IIM - these were task analysis meetings held to support the simulation task analysis effort) and attempted to ensure that any issues raised during the task analysis that could benefit from experimental analysis were identified and fed into the experiment planning process. The user exercises benefited from this information exchange.

Table 3.1-1. DWN Capabilities Matrix

DWN Capability	**VIC Alpha** (DSS)	**VIC Bravo** (BAYONET + ODT + IHAS)	**VIC Charlie** (Soldier Station)	**OPFOR, BLUFOR** (DI-SAF)	**Sniper/Stealth** (BAYONET)
DIS 2.0.4 PDUs: Collision Rate 1 PDU/sec	yes	yes	yes	yes	yes
Remote Entity Postures Supported	Stand, Walk, Run, Kneel, Prone, Crawl	Stand, Walk, Run, Kneel, Prone, Crawl	Stand, Walk, Run, Kneel, Prone, Crawl	Stand, Walk, Run, Kneel, Prone, Crawl	Stand, Walk, Run, Kneel, Prone, Crawl
Impacts/Detonations	DI die, probabilistic determination, xyz impact loc.	DI die, probabilistic determination, xyz impact loc.	DI die, DI wound, probabilistic determination, xyz impact loc.	DI die, probabilistic determination	DI die, probabilistic determination, xyz impact loc.
Number of Entities Supported	at least 9 articulated IC's plus at least 8 vehicles	at least 9 articulated IC's plus at least 8 vehicles	at least 9 articulated IC's plus at least 8 vehicles	at least 9 articulated IC's plus at least 8 vehicles	at least 9 articulated IC's plus at least 8 vehicles
Visual System Capacity	2 ch Onyx 2, 2 R10000 CPUs; 128 MB memory	4 channel RE2, 4 CPUs, 256 MB memory (IR for User Exp)	1 ch Maximum Impact, 1 R10000 CPU, 128 MB memory	N/A	1 ch Maximum Impact, 1 R10000 CPU, 128 MB memory
Databases: 29 Palms, AUSA MOUT (via LM FTP site)	yes	yes	yes	yes	yes
Moving Models: M1A2, M2A3, AH-64, HMMWV, T72, BMP, HIND, DI Enemy (Available via LM FTP site)	yes	yes	yes	yes	yes
Database Correlation Issues	none	none	Janus gridded database vs flight visual database	terrain correlation errors noticed in 29 Palms database	none
Local Animation Capabilities/Limitations	Biomechanics DI Model; 14 body angles	DI Guy	JackML; 14 body angles supported	N/A	JackML; 14 body angles supported
Local Entity Gestures	yes (unconstrained)	no	yes (42 different gestures)	no	JackML can do 27+ arm and hand signals
3D Display Characteristics: color, resolution, field of view	Wireless HMD 420 by 230	Walk in Synthetic Environment (WISE)	CRT 1280 by 1024	none	CRT 1280 by 1024

DWN Capability	**VIC Alpha** (DSS)	**VIC Bravo** (BAYONET + ODT + IHAS)	**VIC Charlie** (Soldier Station)	**OPFOR, BLUFOR** (DI-SAF)	**Sniper/Stealth** (BAYONET)
(FOV), field of regard (FOR)	NTSC Color 45 deg FOV 360 deg FOR	640 by 480 Color 360 deg FOV 360 deg FOR	Color 10 - 60 deg FOV 360 deg FOR		Color 45 deg FOV 360 deg FOR
Aural Cues - Mono/Stereo, Omni-directional	omni-directional, speakers (Soundstorm3d)	omni-directional, speakers (Soundstorm)	stereo, 2 speakers	none	stereo, 2 speakers
Weapon Type(s), Aiming Capability, Lasing Capability (NOTE: M-16 and SAW weapons used for DWN experiments)	M16, AT8, SAW planned, lasing (range), LOS vector	M16, SAW, lasing (range, heading, elevation), LOS vector	M16, SAW, AT8, others, LOS checks, ballistics model	M16, LOS checks, ballistics model	M16, SAW, lasing (range, heading, elevation), LOS vector
Physical and Graphical Weapon Representations Available	M16	M16	M16, SAW, AT8, others	N/A	M16
Mobility Capabilities and Limitations (Inside buildings? Up stairways?)	Collide with walls, objects, walk thru doors, climb stairs	Collide with walls, objects, walk thru doors, climb stairs	Collide with walls, objects, respond to surface type (cannot go inside multi-story buildings)	Collide with walls, objects	Collide with walls, objects, walk thru doors, climb stairs
SAF Behaviors Supported (see note below)	N/A	N/A	N/A	squad level & below (entities will be represented individually)	N/A
Night Vision Capabilities (thermal, NVG, LLLTV, etc.)	none	none	basic thermal, basic NVG	none	none
Weather Effects Supported (haze, wind, etc.)	Time of Day, Fog	Time of Day, Fog	Time of Day, Wind	Time of Day	Time of Day, Fog
Battlefield Effects (explosions, fire, smoke, etc.)	Explosions, fire, smoke, missile exhaust	Explosions, fire, smoke, missile exhaust, dust trails	Explosions, smoke	Explosions, fire, smoke (stealth representation)	Explosions, fire, smoke, missile exhaust, dust trails
Dynamic Terrain (craters, mines, holes, etc.)	Crater overlay; holes in walls	Crater overlay	Crater overlay	no	Crater overlay
Indirect Fire Casualty Effects	yes	yes	yes	yes	yes
Local Entity Controls	Resurrect, Invincible modes	Resurrect, Invincible modes	Resurrect, Invincible modes	Invincible mode	Resurrect, Invincible modes

DI SAF Behaviors:
Converted behaviors: IC Halt, IC Occupy Position, IC March, IC Move, IC Road March (Fireteam), React to Fire and Infantry Attack.

DWN Capability	**VIC Alpha** (DSS)	**VIC Bravo** (BAYONET + ODT + IHAS)	**VIC Charlie** (Soldier Station)	**OPFOR, BLUFOR** (DI-SAF)	**Sniper/Stealth** (BAYONET)

New behaviors: Conduct Fire and Movement, React to Ambush, Break Contact, Mount/Dismount , Fireteam Assault, Suppressive Fire

3.2 Facility Requirements

During the DWN planning process, it was assumed that the integration and engineering experiment effort would be conducted in the ADST II Operational Support Facility (OSF) at LMIS in Orlando. As time progressed and space requirements for ADST II in general and DWN in particular became clearer, it was determined that the OSF high bay would not be able to support DWN efforts. Discussions on alternate sites, including the LWTB at Ft. Benning, eventually focused on an area in Building E-6 at the LMIS Orlando facility. A space contiguous with VIC Alpha's location in E-6 was available, so plans to modify this area were incorporated into the DWN integration planning process. The eventual layout for the integration and engineering experiments is shown in Figure 3.2-1.

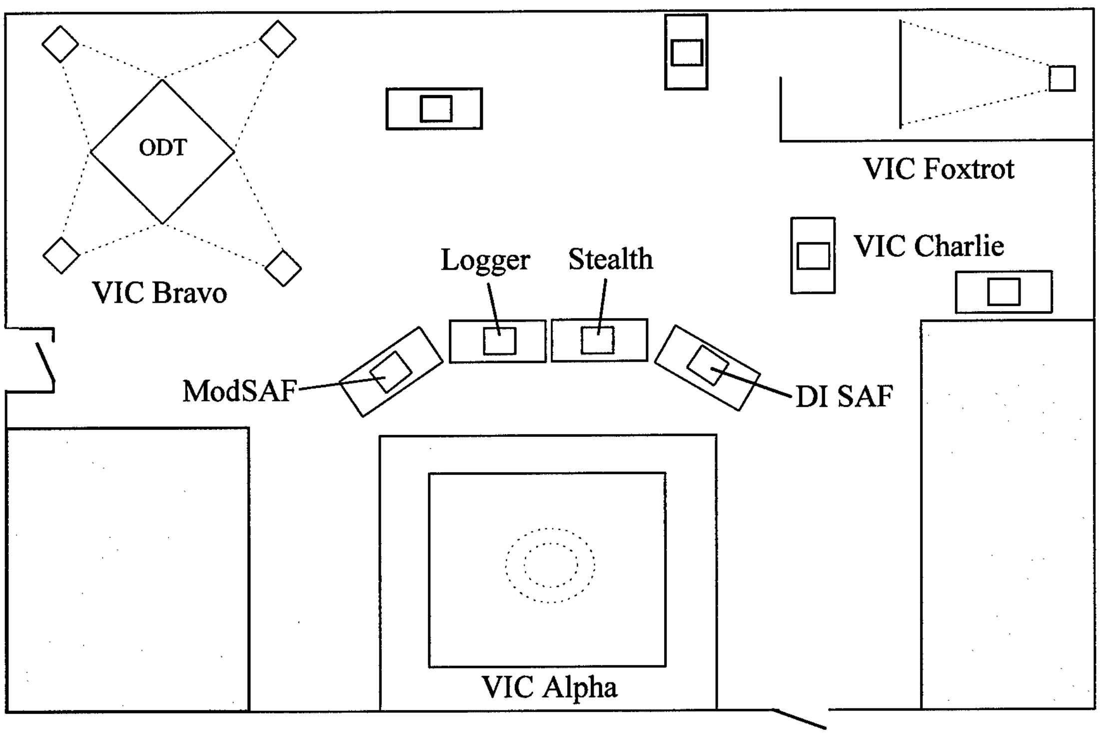


Figure 3.2-1. DWN Integration Facility Layout

3.3 DWN Integration

VIC hardware began showing up at the integration facility during the last week of March 1997. Integration was scheduled for the three-week period from 31 March through 18 April 1997. Organizations providing personnel to support integration included LMIS, LMSG (Lockheed Martin Services Group), Veda, RBD, VSD, NAWCTSD, and TRAC-WSMR (even though Soldier Station was not supporting the engineering experiments, they participated in integration in preparation for the user exercises). Specific system performance and interoperability challenges that were encountered during DWN integration included the following:

- <u>Communications:</u> The digital radios acquired (some purchased, some were existing ADST II assets) for use on the administrative network suffered from intermittent transmission problems and excessive time delays and were not used. A public address (PA) system was used by the exercise director to communicate to the contractor VIC operators and the soldiers using the systems. The wireless intercom system purchased for use by the soldiers operating the VICs suffered from interference problems within the facility. Adequate volume for some systems could not be achieved. Reliability of the components was low.

- DIS standard interpretation/implementation issues: Different VICs had different interpretations of the DIS standards for items such as entity state output rates and whether bullets should be modeled as entities. The level to which information was enumerated was different among the VICs, as was the way each handled missing information. This was resolved by defining and agreeing to a common set of enumerations. VIC Alpha needed coordinate information, such as starting locations, in geocentric coordinates, the rest could use database x, y values. VIC Foxtrot needed elevation specified in the starting locations since they did not ground clamp. Again, the needed data was provided. Foxtrot's not using ground clamping eventually proved to be a problem. When walking up slopes in the 29 Palms database, Foxtrot's figures appeared to sink into the hill over time during dead reckoning, then pop out when the entity state PDU was issued. This effect was minimized by increasing the frequency with which the other simulators issued entity state PDUs (1 Hz).
- Databases and models: Ensuring that everyone had the same model and its correct representation was not a problem *per se* but rather a bookkeeping and verification exercise. Once VIC Alpha received its upgraded computer, all systems could run the McKenna database with (approximately) the required update rates.
- IHAS video: IHAS integration into VIC Bravo was not straightforward. The display purchased was designed to sync off a PC video card. Trying to drive it off a SGI machine did not work, despite both SGI and PC video signals meeting the same spec. An adjustable video amplifier was used to "tweak" the signal so that the SGI would drive the IHAS.
- Light isolation: Projection systems required isolation from external light to obtain adequate contrast. A curtain was installed between VIC Alpha's lights (used for the cameras and reflective markers) and VIC Bravo; VIC Foxtrot isolated itself with black plastic sheeting.
- Noise isolation: VIC Foxtrot required noise isolation for its acoustic sensors. This impacted experiment design; e.g., it wasn't feasible to run VIC Bravo locomotion trials while VIC Foxtrot was running aiming experiments so the session scheduling took this into account. Also, there were issues with VIC Bravo running its sound system while VIC Foxtrot was shooting. Noise around VIC Foxtrot was kept to a minimum.
- Locomotion rates: Each VIC had its own locomotion parameters - maximum rates, acceleration functions, etc. It quickly became apparent that VIC Foxtrot was much faster than the other VICs. Therefore, all locomotion maximum rates were set at 3.5 meters/second. However, acceleration rates were not uniform, so VIC Foxtrot, for example, accelerated to maximum speed in essentially zero time, while other systems had some acceleration component.
- Damage assessment: Each VIC had its own damage assessment algorithm. VIC Foxtrot, using a probabilistic kill model, seemed impossible to kill. Others would be wounded but could function normally or at degraded levels. The decision was made to equalize all VICs such that a hit would always cause a kill. This was carried on into the user exercises with the

exception of Soldier Station, who was not participating in the engineering exercises when the decision was made and was inadvertently not informed before the user exercises.

- Network loading: Network load appeared not to be a problem. One overload situation was encountered, but it was due to concurrent DI SAF development taking place on the same network; once moved to a separate local network the problems disappeared. Network loading was monitored in real-time using the Simulyzer data logging and analysis software.

Even given this litany of challenges, the net result was a working system that was integrated on schedule with relatively few problems. The system proved to be robust as well, at least in the fact that no system down-time due to network problems was experienced during the experiments.

4. Engineering Experiments

4.1 Introduction

As previously discussed in paragraph 1.2.4, the DWN engineering experiments were initiated as a Phase 4 activity, along with the system integration described above. The experiments were intended to gather specific quantitative data on the performance of the selected VICs in allowing the user (soldier) to move through the virtual environment and to identify, acquire, and engage targets with small arms (rifles). The experiments were conducted at the LMIS Orlando facility over a three-week period (April 21 - May 9) immediately following the integration period. Soldiers from Ft. Benning, Georgia served as subjects. Personnel from RBD, VSD, Veda, and NAWCTSD provided operational support for the VICs. Additional experiment and site support was provided by LMIS and LMSG personnel from Orlando and Ft. Benning. As previously discussed, TRAC-WSMR opted not to be involved in this phase of DWN. Soldier Station was replaced during the engineering experiments by a BAYONET station from RBD. While the man-machine interface for these two stations is very similar, a clear distinction should be made between the VIC Charlie used during the engineering experiments (BAYONET) and the Soldier Station that participated in the user exercises discussed later.

This section of the report summarizes the experiment purpose (4.2), plan (4.3), procedures (4.4), results (4.5) and lessons learned (4.6). Experimental results are presented in detail, along with a discussion of these results and overall lessons learned from the experiments.

4.2 Purpose

DWN was instigated to investigate requirements for both manned and unmanned simulators to support the integration of the individual soldier into the virtual battlefield. These experiments were an adjunct to the task analysis effort (paragraph 1.2.1), which was the primary motivation for the DWN program. The purpose of the DWN experiments was primarily a virtual simulation technology demonstration/proof of concept demonstration that is relatively independent of but applicable to both the ACR/RDA and TEMO domains.

In a perfect world, the technology issues associated with providing the soldier the means to move, shoot, and communicate in the virtual world would have been identified, then some number of simulators would have been built in such a manner as to allow factorial comparison of these issues. This would have been a time consuming and expensive effort, so the decision was made to instead survey existing solutions to these problems and to select from these a subset of simulators to carry forward into the DWN experiments. This subset was chosen to represent a range of solutions to the issues of interest (see, move, shoot), so they were intentionally chosen to be different from each other in at least one way, although all differed in more than one way. This posed experimental design problems but offered the potential for the greatest return on investment. The realities of schedule and funding limited the changes to the systems we could impose on our subcontractors for two systems (Alpha and Bravo), and the limited sphere of influence restricted our ability to accomplish changes in the other two (Charlie and Foxtrot). Even given this, it is unclear what if any additional changes would have been implemented beyond those effected as a result of TIM planning and integration requirements.

The engineering experiments specifically addressed the technology issues of how well each VIC could shoot (in various postures), detect and identify targets, and move through the virtual environment, including navigation through buildings. Thus, part-task type studies were used to specifically target these issues. In contrast, the user exercises (Section 5) were designed to allow the user community (infantry) to exercise the systems in more mission-oriented contexts to see how well they met the user's needs for such simulators, again not specifically for either TEMO or ACR/RDA (although the latter was emphasized). The focus was on small unit operations, rather than individual soldier tasks, and was more of a test to use the VICs, identify strengths and weaknesses from the user perspective and use this data in conjunction with the engineering data to point the way to the next generation VIC and to VIC requirements in general.

4.3 Experiment Plan Overview

This section summarizes the plans generated for the conduct of the engineering experiments. The full experiment plan is attached as Appendix A.

As previously discussed, the four VICs selected for the experiments provided specific technology solutions to the issues related to immersion of the individual into the synthetic environment. Table 4.3-1 shows the technology evaluation options that the VICs provided, and Table 4.3-2 presents specific component capabilities of the four VICs that were available for specific experimental comparisons. The VICs themselves were previously described in Section 2.

Given these system capabilities and the issues of interest defined in Table 4.3-1, the following sets of experimental tasks were proposed for the evaluation. The tasks defined in the experiment plan sections 5.6 and 5.7 were not conducted.

- Locomotion
  - Human joystick
  - Bi-directional treadmill
  - Omni-directional treadmill
  - Joystick
- Motion Capture
  - Video: • whole body tracking • rifle pointing
  - Magnetic sensors: • upper body tracking • rifle pointing
  - Acoustic sensors: • rifle pointing
- Communicate
  - Digital radio
  - Gesture/Voice control of SAF *
- Shoot
  - Weapon performance
  - Physical representation
- Semi-Automated Forces
  - Realistic behavior, individual and collective, open terrain
  - MOUT behaviors*
- DIS Technologies
  - Interoperability Issues
  - Network Issues
- Human Animation
  - Physical based (JACKML)
  - Appearance based (DI-GUY)
  - Biomechanics based (DSS)
- Visual Presentation
  - HMDs - wireless
  - IHAS
  - WISE, CRTs
- Aural Cues
  - Directional sound

*Not currently funded

Table 4.3-1. Technology Evaluation Options

Function	Subsystem			
	VIC Alpha	VIC Bravo	VIC Charlie	VIC Foxtrot
Locomotion	Human Joystick	ODT	Joystick	Foot Pedal + Head LOS
Visual Display	HMD (wireless, low resolution)	WISE	Monitors	Projection Screen (1)
Body Motion Capture	Video-based tracking	Electro-magnetic (E-M)	N/A	E-M
Weapon Tracking	Video	E-M	N/A	Acoustic
Weapon Aiming	In video thru HMD	In video thru IHAS	Crosshairs in video	Rifle sight
Directional Sound	Yes	Yes	Yes/stereo	Yes/stereo
DI SAF*	Yes	Yes	Yes	Yes
Human Animation	DSS-unique	DI-Guy	JackML	DI-Guy
Communication*	Digital Radio	Digital Radio	Digital Radio	Digital Radio

* No difference so no comparison possible

Table 4.3-2. VIC Component Comparison Matrix

4.3.1 Locomotion

The task was to walk a specified course through the McKenna MOUT database (see Figure 4.5.1-1). This course followed a defined roadway around the western perimeter of the site to the north of the buildings, then wound southeasterly through three separate buildings en route to the original starting point. This course was presented at the beginning of each locomotion session and was followed by each VIC. Only two VICs were on the course at any one time to minimize interference. One VIC started at the north part of the course, the other would start at the southern part. Both VICs followed the course in a clockwise direction. Upon completion of this base course, the subjects practiced locomotion on different practice courses until the approximately one-half hour session was over.

4.3.2 Visual System Performance

Four tasks were proposed to investigate the effects of the different visual display systems on soldier task performance - target detection, target identification, target search, and DI animation detection. All visual system tasks were conducted in the flat, open terrain of the 29 Palms database.

4.3.2.1 Target Detection

This task was designed as psychophysical measurements to determine the detection threshold distance for each system. One-half of the targets started at beyond visual range for each system and moved toward the stationary observer; the other half started within sight and moved directly away from the observer. Subjects were to indicate when the target appeared/disappeared from view.

4.3.2.2 Target Identification

In this task, fixed observers were to detect and identify targets that would appear within their initial field-of-view (FOV). These targets included DI (BLUFOR and OPFOR), tanks (M1A2 and T-72), and vehicles (BMP and Bradley Fighting Vehicle). Subjects were also required to estimate the range to target, azimuth location in world coordinates, and speed of motion (if moving). Targets were located at one of six initial target distances from the observer. One half of the targets were moving and the other half were stationary.

4.3.2.3 Target Search

The purpose of this task was to examine how well each VIC could locate a DI target positioned at various ranges within ±135° in azimuth from the observers initial line-of-sight (LOS). Four distances and four azimuth positions were combined to form the initial target locations. Half of the targets were moving, the other half were stationary. Subjects had to report target location in azimuth and range and whether it was moving or not.

4.3.2.4 DI Animation Detection

In these trials, two DI models were used, the VICs' usual DI model (DI Guy, JackML, or Biomechanics), and a specially developed model that was essentially a static 3-D billboard. When moving, the VICs' usual models were animated, that is, the legs and other body components would move or sway as the entity walked or ran through the environment. The static model, when moving, slid along the ground with no limb or other body component movement. The two targets were randomly presented to the subjects starting from three distances, and moving at one of five orientations relative to the observer. The subject had to indicate whether the target was animated or static.

4.3.3 Weapon Aiming/Shooting Accuracy

In support of the weapon aiming accuracy tests, a large (7 meter square) bull's eye target model was developed. It was made large to increase the probability that each VIC could hit it and thereby record accuracy data, i.e., where relative to the target center (bull's eye) that the round fired hit the target. For rounds that missed the target, it could not be determined by what distance the target was missed.

Two shooting tasks were used to assess weapon aiming accuracy. The first was to determine the VIC's capability to shoot accurately in standing, kneeling, and prone positions. The second was to generally assess aiming accuracy from the standing position.

4.3.3.1 Aiming Posture Trials

For these trials, subjects fired at a fixed or moving bull's eye target located 200 meters away. Subjects were to fire three shots at the target from each of three positions: standing, kneeling, and prone. The subject was to return to a ready (non-aiming) posture between each shot.

4.3.3.2 Target Acquisition and Engagement Trials

The task for these trials was to search over a 270° field of regard for the bull's eye target and to engage it when located. All subjects were standing at a fixed location; targets could appear at one of two distances at any of five azimuth locations relative to the subjects' initial line of sight. Targets were either stationary or moving at one of two speeds.

4.3.4 "Free Play" Sessions

Following each block of three day experimental data collection sessions, the soldiers in the four VICs engaged in semi-structured exercises involving tasks that would be required for the follow-on user exercises. This included searching for and engaging each other in the McKenna site, first individually then operating in buddy teams, assaulting a hilltop position in the 29 Palms database defended by DI SAF entities, and cooperatively searching for and engaging a sniper hiding in the McKenna site. The intent was to identify integration issues for the user exercises, and no data was recorded for these exercises.

4.3.5 Data Collection

The primary data collection devices during the engineering experiments were Simulyzer software used to collect DIS PDU data from the network and questionnaires developed and administered by ARI. Entity State, Fire, Detonation, and Collision PDUs were selectively collected during the different sessions. The data collected for each of the experimental tasks is presented in Table 4.3.5-1 below. The PDU data fields recorded are presented in Table 4.3.5-2. The questionnaire forms used are presented in Appendix B, and the results of the questionnaire data are presented in paragraph 4.5.6.

Experimental Task	Data Collected
Locomotion	Entity State, Collision PDUs
Visual Search	Entity State, Fire PDUs, Subject Responses via paper and pencil

Weapon Aiming	Entity State, Fire, Detonation PDUs

Table 4.3.5-1 Data Collected for Experimental Tasks

It should be noted that time, as indicated in the respective PDUs, was not logged. No attempt was made to coordinate time stamping among the VICs. Instead, the time stamp automatically recorded by Simulyzer along with each PDU was used as the system time to record when events (PDUs) occurred.

Table 4.3.5-2 PDU Data Fields Recorded

PDU	Data	Fields
Entity State	PDU HEADER	Exercise ID
		PDU Type
	ENTITY ID	Application (Host) ID
		Entity ID
	ENTITY LINEAR VELOCITY	X Component
		Y Component
		Z Component
	ENTITY LOCATION	X Component
		Y Component
		Z Component
	ENTITY ORIENTATION	Psi
		Theta
		Phi
	ENTITY MARKING	Four character string
Fire	PDU HEADER	Exercise ID
		PDU Type
	FIRING ENTITY ID	Application (Host) ID
		Entity ID
	TARGET ENTITY ID	Application (Host) ID
		Entity ID
Detonation	PDU HEADER	Exercise ID
		PDU Type
	FIRING ENTITY ID	Application (Host) ID
		Entity ID
	TARGET ENTITY ID	Application (Host) ID
		Entity ID
	LOCATION IN ENTITY COORDINATES	x coordinate
		y coordinate
		z coordinate
Collision	PDU HEADER	Exercise ID
		PDU Type
	ISSUING ENTITY ID	Application (Host) ID
		Entity ID
	COLLIDING ENTITY ID	Application (Host) ID
		Entity ID

In addition to determining time of fire for the weapon aiming experiments, the Fire PDU was used to serve as an indication of target acquisition or identification events during the visual system tests. A "virtual eye chart" database model was also developed and presented as an additional visual system performance measure. Also, locomotion sessions were videotaped and anecdotal information was informally collected by the test management personnel.

4.3.6 VIC Characterization

The test plan defines engineering measurements that were to be independently collected before or during the experiments. These measurements include system lag, display and tracking device resolution, repeatability, control device output characteristics, etc. Some measurements were made, but time, measurement tool availability, and other factors mitigated against collecting the intended set of measures. Personnel responsible for each VIC were asked to and provided written system performance characterizations. However, these were not independently verified in most cases. These characterizations are presented in paragraph 4.5.5.

4.3.7 Schedule

The planned schedule presented in Experiment Plan paragraph 6.3 was followed during exercise execution. Most daily sessions went from 0800 to 1500 or 1600 with a 1 to 1-1/2 hour lunch break, depending on how the sessions were progressing.

4.4 Experiment Procedures

The experiments were conducted as described in the experiment plan. A safety inspection of the VICs and the facility was conducted with LMIS, STRICOM, and TECOM safety personnel during the integration period. All identified issues were addressed and a safety release was obtained from TECOM prior to soldier participation in the experiments. The only significant item of concern was the noise generated by the ODT on VIC Bravo. Hearing protection was required to be worn by users, operators, and other personnel coming within 13 feet of the ODT while operating. Disposable hearing protection was made available at the facility entrance nearest the ODT and at other locations.

4.4.1 Soldier Participants

Eight active duty soldiers from Ft. Benning, Georgia were provided to serve as subjects over the full three-week period of the engineering experiments. Four were PFCs, two were PV2s, and two were SGTs. ARI collected personal history information as part of their data collection process.

4.4.2 Training

Prior to the experiments, all soldier participants received a briefing on what each VIC was made up of (in terms of technologies, control and display devices) and how, in general, it operated. Prior to operating the VIC for the first time, the subject was briefed by the VIC operators and given some time to operate unique devices, such as VIC Bravo's ODT. Soldiers assigned to VIC Alpha underwent a calibration process prior to the first experimental session. The subjects were also shown what the visual target models looked like prior to the experiments. The majority of familiarization and training took place during the experimental sessions, as planned.

4.4.3 Instructions

Written instructions were read to all subjects prior to the experiment and before the first session of each type of trial (Target ID, Target Search, Locomotion, Weapon Aiming, etc.). These instructions are included in Appendix A as attachments to the engineering experiment plan.

4.4.4 Trial/Session Conduct

Two soldiers were assigned to each VIC and participated in all trials for all tasks over a three-day period as described in Section 6 of the experiment plan. After the first block of three-day sessions, the soldiers were assigned to new VICs and the trials repeated. This process was replicated a total of four times so that each soldier experienced all trials on each VIC, with subject counterbalancing as indicated in Paragraph 6.2 of the experiment plan.

4.4.4.1 Session Schedules

Within each 3-day block, all subjects experienced 6 sessions per day, with a session defined as a block of trials within the same experimental task. Sessions varied in the number of trials presented, but were designed to last no more than 30 minutes. With two subjects participating on each VIC, a total of 12 sessions were conducted per day. A representative daily schedule is presented in Table 4.4.4.1-1.

Table 4.4.4.1-1 Daily Session Schedule

Time	Session	VIC Alpha	VIC Bravo	VIC Charlie	VIC Foxtrot
0800	1	Locom. Session 1	Locom. Session 1	Visual Session 1	Visual Session 1
0830	2	Visual Session 1	Visual Session 1	Locom. Session 1	Locom. Session 1
0900	3	Locom. Session 1	Locom. Session 1	Visual Session 1	Visual Session 1
0930	4	Visual Session 1	Visual Session 1	Locom. Session 1	Locom. Session 1
1000	5	Aim Session 1	Locom. Session 2	Aim Session 1	Locom. Session 2
1030	6	Locom. Session 2	Aim Session 1	Locom. Session 2	Aim Session 1
1100 - 1300	Debrief, Lunch, Setup for Afternoon Sessions				
1300	7	Aim Session 1	Locom. Session 2	Aim Session 1	Locom. Session 2
1330	8	Locom. Session 2	Aim Session 1	Locom. Session 2	Aim Session 1
1400	9	Visual Session 2	Visual Session 2	Visual Session 2	Visual Session 2
1430	10	Aim Session 2	Aim Session 2	Aim Session 2	Aim Session 2
1500	11	Visual Session 2	Visual Session 2	Visual Session 2	Visual Session 2
1530	12	Aim Session 2	Aim Session 2	Aim Session 2	Aim Session 2
1600	Debrief, Make-ups				

Note: Shaded Sessions are those for Subject 1 of VICs, Open Sessions are those for Subject 2 of VICs

Starting Locations:	VIC Alpha:	1393-1238-657, Oriented facing West
	VIC Bravo:	1530-2422-0000, Oriented facing North
	VIC Charlie:	6536-676-0000, Oriented facing East
	VIC Foxtrot:	3564-1232-0000, Oriented facing South

Two constraints were followed in constructing this schedule:

1. Only two VICs were performing locomotion tasks at one time (to minimize interference)

2. VIC Foxtrot was not performing aiming tasks while VIC Bravo was performing locomotion trials. This was due to a concern that the ODT noise would interfere with the acoustic sensors used by Foxtrot to determine weapon pointing (see Integration paragraph 3.3).

Also shown on the schedule is the location for the VIC for the specified block of trials. For both the visual and aiming trials, four separate locations within the 29 Palms database were selected for task performance, one for each VIC. These locations were selected to be far away from each other and with subjects oriented in different directions. This was to eliminate the possibility target confusion among the VICs, especially with the large bull's eye targets. The VICs were assigned one location for each block of 3-day session, and these locations were rotated so that each VIC performed one block of trials at each location, in case any location introduced performance effects on any task.

This same schedule was followed for the first two days of each block. The third day completed the defined experimental tasks by 1130. The remaining time after lunch was used for any necessary make-up sessions, debrief by ARI, the "Free-Play" sessions, and set-up (soldier calibration) for the next VIC Alpha team.

Each trial of the total number of trials for each task type (e.g., 50 trials for weapon aiming) was randomly allocated across the experimental sessions within each block, with a different randomized order used for each of the four blocks of sessions. Thus, for example, each of the three aiming sessions per block consisted of 17, 17, and 16 randomized trials, respectively. The same subject performed two sessions in a row, then the same two sessions were repeated with the second subject.

4.4.4.2 Individual Trial Conduct

Prior to each trial session, the soldiers were set up in there respective VICs. They were given or reminded of the instructions prior to the first trial. Before every trial, the Simulyzer operator selected which PDUs to record and specified a file name for each PDU file using a predetermined format that indicated the day of the trial, session number, type of task, PDU type, and trial number.

For the locomotion trials, once it was determined that the VICs were at the proper locations and were ready to go, the OK to commence was given by the test director and the Simulyzer operator initiated logging the PDUs for locomotion. Different exercise numbers were used to keep PDU data separate for locomotion and other (i.e., visual or aiming) trials conducted simultaneously. When the course had been completed, the VIC operators informed the Simulyzer operator who terminated data logging for that VIC (by filtering on Host ID). The soldier on the VIC was then to continue locomotion practice on one of the practice courses for the remainder of the session. This PDU data was not logged.

For the other task trials, the exercise director coordinated with the Simulyzer and ModSAF operators to initiate and terminate trials. ModSAF was used to generate all targets for the experiment through previously constructed and verified scenario files. These scenario files contained the target type, initial location, heading, and motion parameters for each trial. Each file contained data for four targets - one for each VIC location (see 4.4.4.1 above). The exercise director and both the ModSAF and Simulyzer operators had a complete listing of the trial sequence for each session. The exercise director had primary responsibility for the proper execution sequence of trials, but the two operators provided extremely useful cross-check validation.

During trial execution the next trial was called out to the two operators and verified by them. The ModSAF operator began loading the associated scenario data file, and the Simulyzer operator readied the log files so they could be quickly initiated. The exercise director used the ModSAF plan view display (PVD) for cues to target loading. This target file loading took a variable amount of time, so the time between trials was also variable. Targets would appear on the PVD as they were broadcast over the network to the VICs and route lines would appear for targets that were to move. When the targets were loaded, the ModSAF operator resumed the scenario (from a frozen state) upon the exercise director's command. This initiated a trial for static targets. For moving targets, after resuming the scenario, the operator waited for the "On Order" menu option to appear. When it did, the operator gave the order to move for each target by selecting each target name under the "On Order" menu. The targets (and corresponding icons) would then accelerate to their terminal velocity.

This incremental appearance of targets, variable inter-trial time intervals, and time differential between moving and stationary targets posed challenges for target presentation and premature presentation to subjects. These were handled as follows:

- Subjects were instructed to look away (generally down) from their visual displays between trials. The concern was that targets would appear for some VIC before others, and in all cases before the trial was ready to begin, especially for moving targets. Subjects were told to begin looking for the target upon the "Go!" command from the exercise director. "Go!" was always preface by "Ready . . . Set" to alert the subjects that the trial was about to begin. Adherence to this instruction was monitored by the VIC operators and by the exercise director.
- The exercise director used the ModSAF PVD to cue his "Ready . . . Set . . . Go!" command. For moving targets, the command was not issued until all targets were observed moving.
- The Simulyzer operator was to hold off initiating data logging until the "Set" portion of the command sequence. This reduced but did not eliminate the variability between the beginning of the trial (relative time zero) and the subjects response time. This variability limits the usefulness of the time to respond measures in an absolute sense, e.g., to compare against real-world times, but does still allow relative inter-VIC response time comparisons to be made.

For aiming trials, the trial was considered over when all subjects had fired their weapons. This could be observed on the ModSAF PVD and confirmed by the Simulyzer operator monitoring Fire PDUs. For visual task trials, subjects indicated when they had located or identified a target by firing their weapons (i.e., issuing a Fire PDU). Also, a 30 second trial duration limit was imposed, since some targets may never have been detected by certain VICs after any amount of time. When a trial had been determined to be over, a "Trial Over" notice was given by the exercise director. This was a cue to the ModSAF and Simulyzer operators to terminate the ongoing trial and prepare for the next, and the cue for the subjects to look away from their displays. Subjects' responses to target identification, range, motion, azimuth angle information was collected manually between trials by the VIC operators. Subjective data was collected by ARI personnel as described in paragraph 4.5.6.

4.5 Results

The PDU data files and visual task subject response data (target identifications, range estimates, etc.) were loaded into Excel workbooks. The Entity State PDU data was pre-processed to covert the geocentric position and rate data into 'flat-earth' metric data, and the subject response data was entered manually into a spreadsheet. The data reduction process was literally that - the volume of data made file manipulation excruciatingly difficult. The data was eventually reduced to time-coded events broken out by subject, trial, and session. These final data files are available as Excel workbooks in soft copy.

For the visual and weapon aiming tasks, the primary measures of performance (MOP) were time to respond and accuracy metrics such as absolute error and variability. For locomotion trials, MOP were time to complete the base course and number of collisions (with building structure). An overall summary of VIC performance on the various tasks is presented in Table 4.5-1.

The results of individual tasks will be discussed in detail in the following sections, but a general statement can be made about each task using this table. For weapon aiming tasks, Bravo and Foxtrot were relatively fast at target acquisition, but Foxtrot was significantly less accurate than any of the other VICs. In the visual tasks, Alpha, with its limited FOV compared to the other VICs, took longer to locate DI targets than any other VIC. VIC Bravo was the least successful in locating DI targets, followed by VIC Alpha, with VICs Charlie and Foxtrot both performing well at this task. This same pattern holds true for target recognition, and animation detection, although not for target identification. Finally, there was significant inter-VIC variability in time to complete the base course, with VIC Foxtrot being the quickest to complete the course. This quickness, however, comes at the expense of having significantly more collisions than any of the other VICs. This result was anticipated from observation of VIC locomotion performance during the experiments.

Test	MOP*	Score	VIC Alpha	VIC Bravo	VIC Charlie	VIC Foxtrot
Locomotion	Time to Complete Course (Seconds)	Mean	321	560	296	188
		S.D.	69.5	148.3	114.9	79.4
	Collisions	Number	132	135	182	335
Target Recognition/ Identification	Time to Locate (Seconds)	Mean	7.2	5.0	6.9	7.0
		S.D.	5.5	5.2	7.0	7.1
	Tgts Recognized	Percent	80%	78%	92%	91%
	Tgts Identified	Percent	80%	65%	76%	71%
DI Target Search	Time to Locate (Seconds)	Mean	11.8	9.3	7.9	8.7
		S.D.	6.5	6.1	4.7	4.6
	Targets Located	Percent	80%	67%	100%	98%
Animation Detection	Identify if Animated or not	Percent Correct	70%	67%	95%	85%
Weapon Aiming	Time to Fire (Seconds)	Mean	16.9	10.2	14.5	11.0
		S.D.	8.9	4.5	5.9	5.7
	Absolute Error (meters)	Mean	1.1	1.1	0.6	1.9
		S.D.	0.9	0.8	0.6	1.0

*Measure of Performance

Table 4.5-1. Overall VIC Task Performance Summary

Each of the following sections will begin with a brief restatement of the experimental task, task conditions (variables), and MOPs. This will be followed by a presentation of significant differences observed among VICs and relevant task conditions, along with any other observations of interest made during the experiments.

4.5.1 Locomotion

Task: Navigate the base course as quickly as possible while trying not to collide with objects in the environment, especially building doorways, walls, and other structure. Two VICs were on the course at one time, starting at different locations on the course. Figure 4.5.1-1 depicts the base course and starting locations.

Task Conditions: None

MOPs: Time to complete course, number of collisions with objects

Anecdotally, from watching the soldiers perform during the experiments, the expectation was that VIC Alpha would be the fastest, VIC Bravo the slowest, with Alpha and Charlie in between. Again, as previously discussed in the integration section (3.3), all VICs had their maximum rate of movement limited to 3.5 meters/second (m/sec). A spot check of the rate data in the entity state

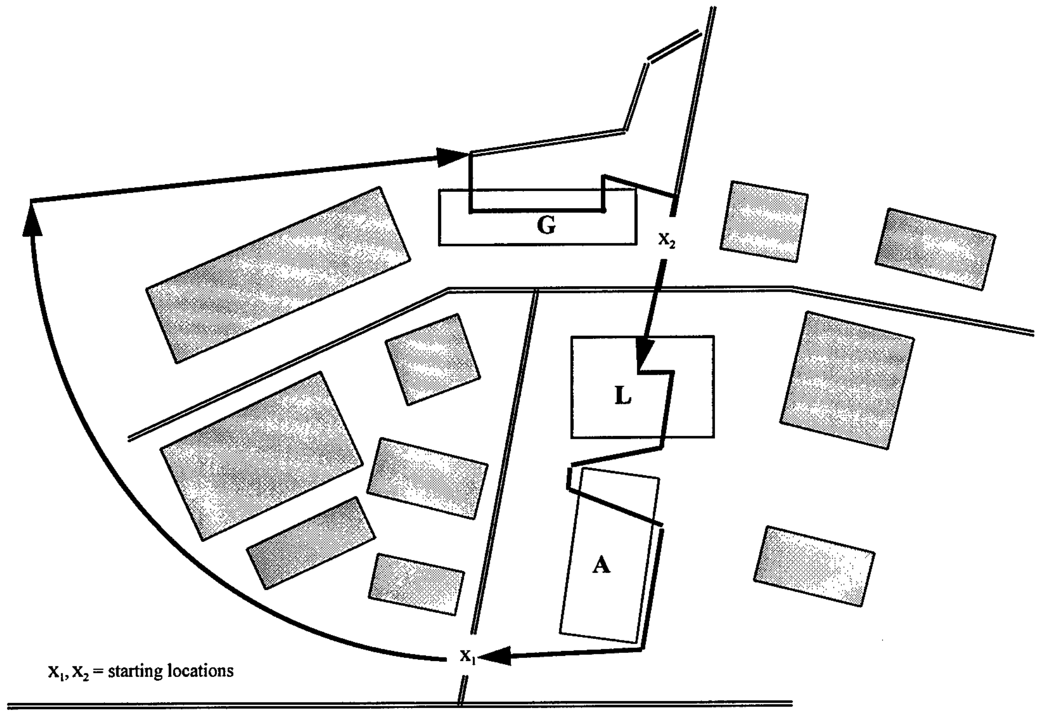


Figure 4.5.1-1. Locomotion Task Base Course

PDUs found only one sample from VIC Foxtrot to be 3.78 m/sec, all other samples for all VICs were at or below the 3.5 m/sec limit.

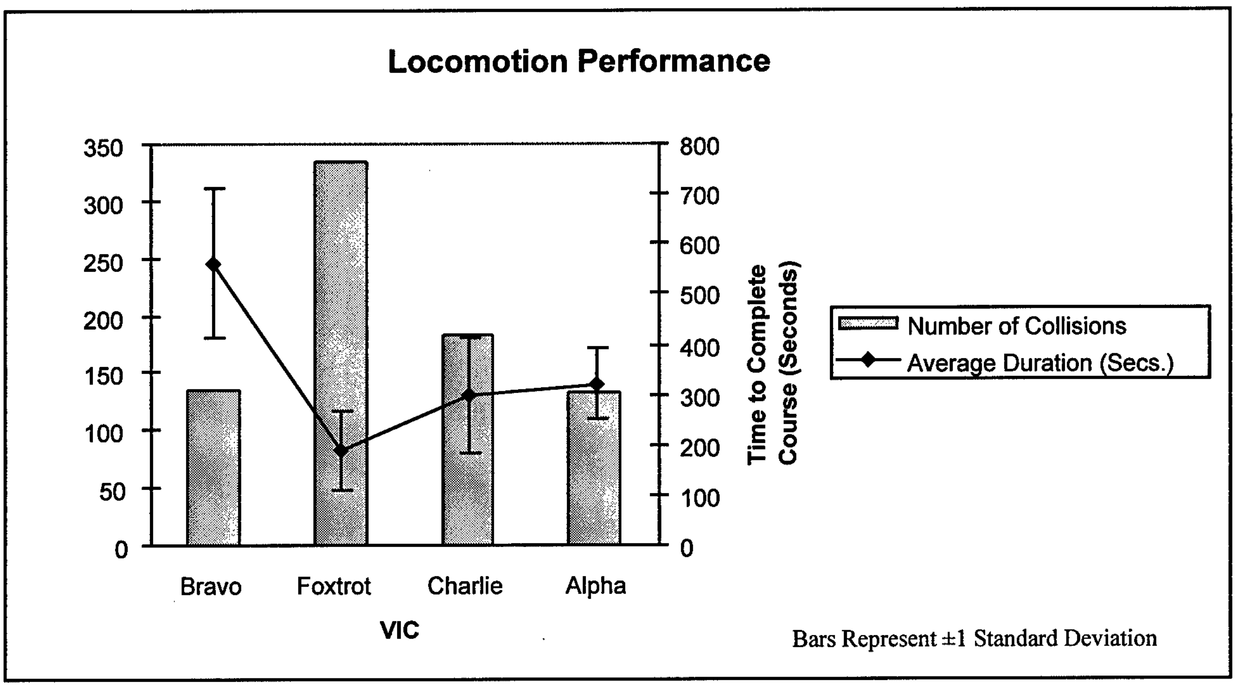


Figure 4.5.1-2. Locomotion Task Results

The results from the data are presented graphically in Figure 4.5.1-2. As can be seen by the line graph, this time performance expectation was realized, with VIC course completion time differences significant at the $p = 0.0001$ level (as determined by a repeated measures ANOVA). Pairwise comparisons of the VICs indicated significant time differences between all VICs except Charlie and Alpha.Figure 4.5.1-2 also shows the total number of collisions for each VIC (bar graph). Again, the differences between VICs is significant ($p = 0.001$), with the primary contribution being Foxtrot's greater number of collisions. Again, this is consistent with observations during the experiments. Foxtrot's foot controller encouraged motion at full speeds, but this high rate of travel was not conducive to close-in maneuvering within buildings. Also, since head LOS determined direction of travel, one could not look around while moving to look for obstacles without moving toward or into them.

It should be noted that during the TIMs, it was agreed that with any collisions including prolonged contact with an object, a wall for example, collision PDUs would be issued at no more than a 1 Hz rate, although it appears from the data that only Alpha implemented this correctly. Thus, for determining separate collisions for inclusion in the above totals, only collisions separated by greater than 1.1 seconds were counted as a unique collision. Obviously, this is a relatively arbitrary threshold, but since it has been applied uniformly across VICs it should not differentially impact one VIC over another.

4.5.2 Visual System

Four visual system tasks were planned for the engineering experiments. Each of these is discussed separately in the following sections.

4.5.2.1 Target Detection

Task: From a fixed location in the 29 Palms database, the subjects were to signal when incoming targets starting from beyond visual range could first be detected or when targets starting within visual range and moving away disappeared from view.

Task Conditions: Target type: DI or M1A2 tank

MOPs: Target range at detection (appearance or loss)

This task was previewed prior to the experiments using VIC Charlie. When executed experimentally, the half hour session passed without successfully completing two trials out of the 40 originally planned. For some systems, such as Alpha, the target going away never seemed to completely disappear. For other systems, it seemed to come and go (see ref 10, page 156 for a possible explanation). After a half hour and considerable comment from subjects and operators alike, the exercise director decided to abandon this task and use other means to assess visual performance limitations in target acquisition.

4.5.2.2 Target Identification

Task: From a fixed viewing location in the 29 Palms database, subjects were to locate, identify, and estimate the distance, direction, and speed of motion of a target presented within their initial field of view.		
Task Conditions:	Target type:	DI (BLUFOR and OPFOR), Tank (M1A2 and T-72), Vehicle (Bradley and BMP)
	Target range:	50, 100, 200, 300, 400, 500 meters (tanks and vehicles) 25, 50, 75, 100, 200, 300 meters (DI)
	Target motion:	Moving or stationary
MOPs: Time to acquire target, recognition/identification accuracy, motion estimation accuracy		

This task was intended to complement the target detection task described above, resulting in measures for target detection, recognition, and identification. The ranges selected for target presentation were chosen to bound the predicted target identification ranges based on VIC visual system resolution and FOV using the Johnson criteria [ref 8] (see paragraph 4.5.4 below). The best predicted identification range (VIC Charlie's) was 239 meters for tank targets and 181 meters for DI targets (in decreasing order of range performance, the prediction results for the other VICs are Foxtrot, Alpha, and Bravo). To define terms, recognition is the correct determination of the class of target, i.e., tank, vehicle, or DI. Identification is the correct determination of which target it was within the class, i.e., an M1A2 or T-72 tank, a Bradley or BMP vehicle, or a BLUFOR or OPFOR DI.

In scoring the subjects' responses, one of three values was assigned to target responses under both a target recognition and a target identification category. A negative one (-1) was assigned to both categories if no response was recorded. There were several question mark or "NO ID" responses recorded on the answer sheets. A zero (0) was assigned to both categories if the subject responded with an incorrect classification, either generally (i.e., responding with "tank" when the target was actually a BMP) or specifically (responding "T-72" when the target was a BMP). If the subject correctly classified the target, again either generally (responding "tank" when the target was an M1A2) or specifically (responding either "M1A2" or "T-72" when the target was an M1A2 tank), a one (1) was entered in the classification category. Finally, a 1 was entered into the identification category only if the target was correctly identified ("M1A2" when the target was an M1A2). Otherwise a zero was entered.

The results of the PDU data analysis are presented in the following paragraphs. No discussion of target recognition/identification response times is presented since no significant differences were found among the VICs (response times were in the 5 to 7 second range). All other results discussed are significant at the specified probability levels.

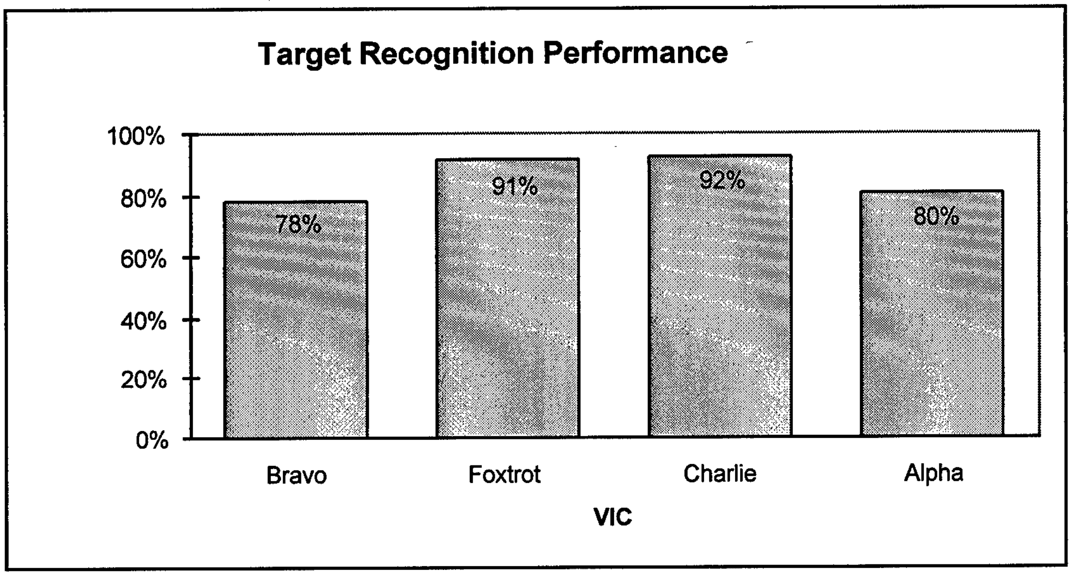


Figure 4.5.2.2-1. Overall VIC Target Recognition Results

Figure 4.5.2.2-1 presents the overall target recognition results ($p = 0.0001$). Both Foxtrot and Charlie performed equally well and significantly better than both Alpha and Bravo. Alpha and Bravo's performance was equivalent. The observed performance of all VICs was ordinally in correspondence with the predicted results, along with the pairing of VICs with roughly comparable performance.

Figure 4.5.2.2-2 presents the overall target identification results, summarized in two ways. The shaded bars in the graph presents correct identification percentages for all targets correctly recognized. For example, VIC Bravo Correctly recognized 224 targets (of 288 possible). Of these 224, 146 were correctly identified for a resultant 65% identification rate. The white bars present identification performance for all detected targets, regardless of recognition performance. In this case, Bravo again correctly identified 146 targets, but a total of 272 targets were detected resulting in 54% identification performance.

The data is presented in these two ways because the process of target detection, recognition, and identification is clearly a conditional process, that is, one must detect the target if it is to be recognized, and it must be successfully recognized to be accurately identified. However, many studies of target acquisition performance do not conditionalize their results; each stage in the process is scored against the total number of target presentations. Conditioning on at least detection has been maintained here; using total target presentations reduces the percentages a small amount (zero to three percentage points) but does not alter the overall pattern.

Target identification performance on recognized targets was equivalent across VICs, i.e., there was no significant difference found ($p = 0.09$; $p < 0.05$ used for significance threshold). It can be seen that the conditional results are somewhat misleading in that Alpha appears to have the best overall identification performance, although it correctly recognized the second fewest number of

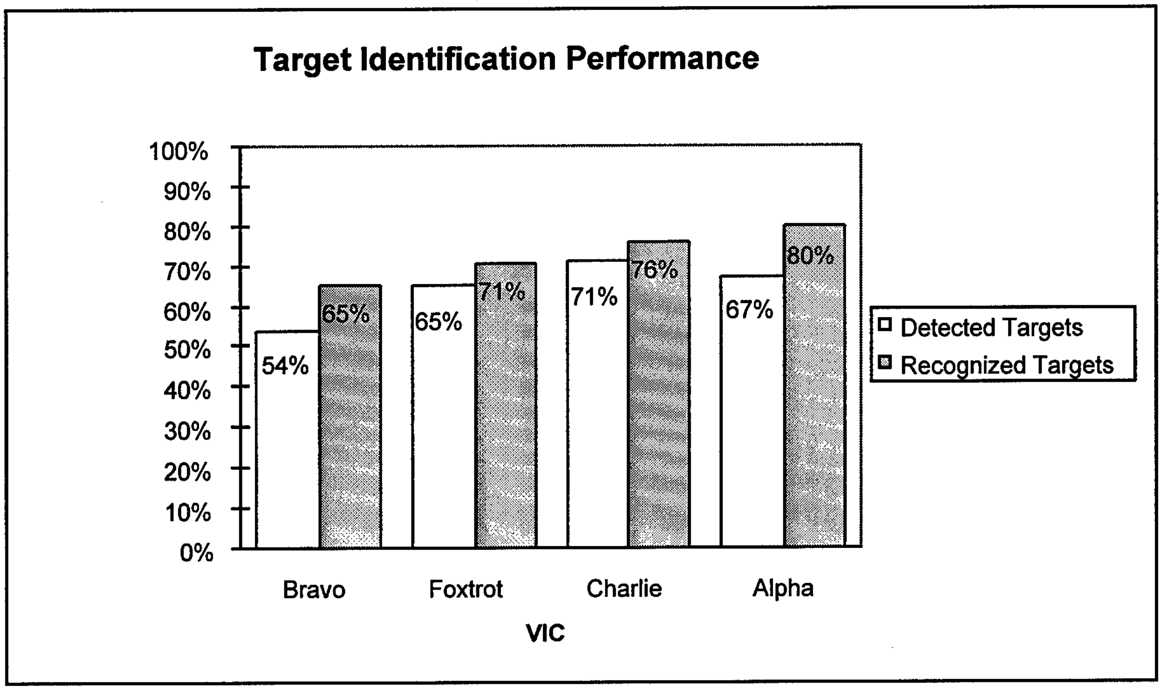


Figure 4.5.2.2-2. Overall VIC Target Identification Results

targets. In the extreme, a VIC could have recognized only 5 targets out of the 288 total, and if it had correctly identified 4 of these it would have a conditional identification rate of 80%.

Comparing identification performance for detected targets, there is a significant difference among the VICs (p = 0.0345), although pairwise comparison show this is due to differences between Bravo and Charlie, i.e., only the extreme difference (54% vs 71%). However, the overall pattern is generally more consistent with the identification performance predictions based on visual system resolution.

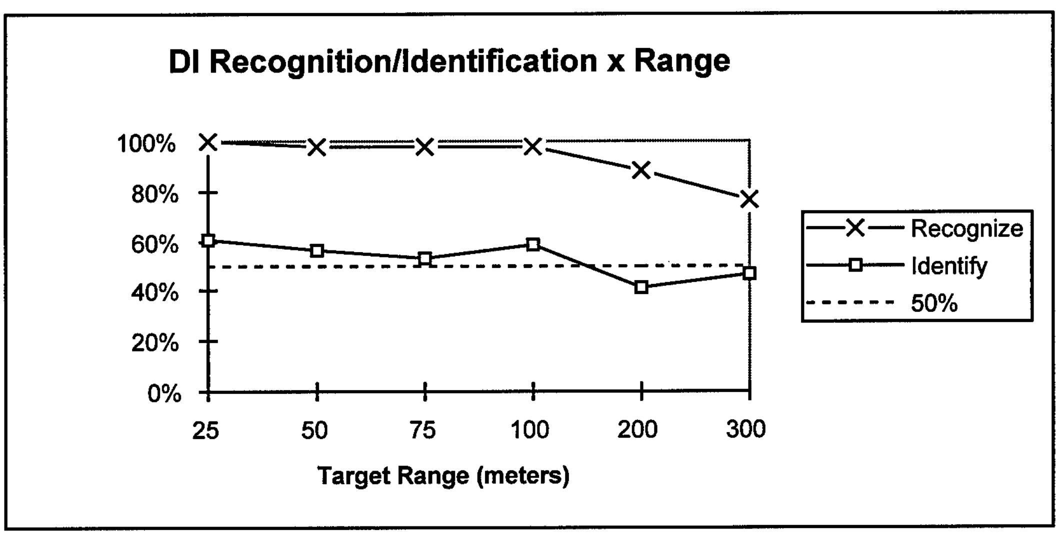


Figure 4.5.2.2-3. DI Target Recognition and Identification Performance by Target Range

As previously stated, the target ranges were selected to bracket the predicted recognition and identification ranges for each system. The following Tables 4.5.2.2-3 through 4.5.2.2-5 show overall target acquisition performance as a function of target range. Since DI targets used a different set of ranges than did the tank and vehicle targets, these results are presented separately.

Figure 4.5.2.2-3 shows performance on both target recognition and identification for DI targets, although a range effect was found only on target recognition (p = 0.0001, for identification, p = 0.07). As can be seen, target identification performance hovered around the chance (50%) level regardless of range. Target recognition performance begins to fall off after 100 meters, but never achieves the 50% limit that defines the recognition range performance limit. The model predicts that *identification* should be possible out to approximately 112 meters (average for all VICs), which is more difficult than recognition. Clearly, the observed results do not follow the predicted performance.

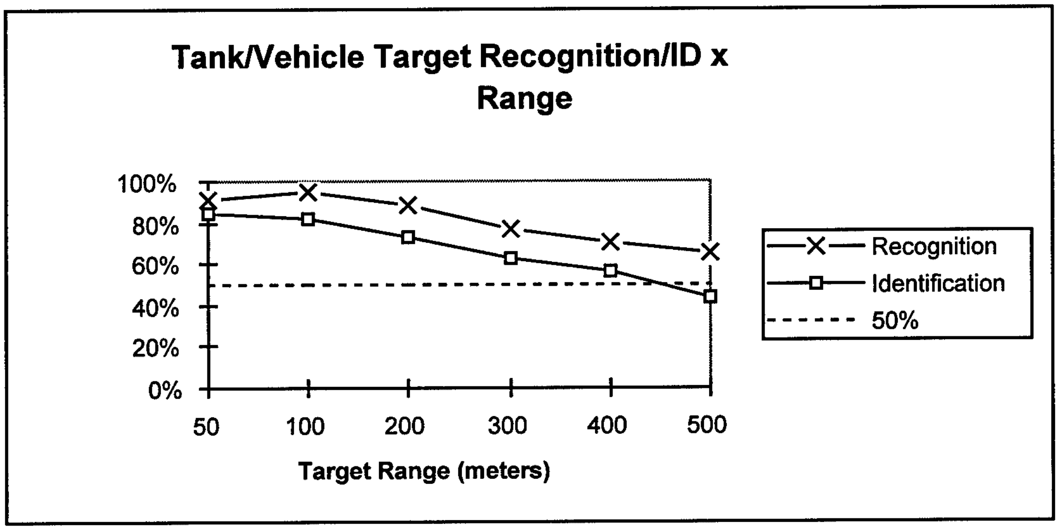


Figure 4.5.2.2-4. Combined Tank/Vehicle Target Recognition and Identification Performance by Target Range

Turning to the other, non-DI targets (tanks and vehicles), Figure 4.5.2.2-4 provides a comparison corresponding to that of Figure 4.5.2.2-3 for DI targets. Observed range effects are significant for both recognition (p = 0.0001) and identification (p = 0.0001). Again, overall recognition never reaches its definitional range limit, and identification reaches it at about 450 meters versus the predicted 150 meters (again, overall average for all VICs). Looking at the individual target classes, a difference between tanks and vehicles was found only for target identification (p = 0.007). This is illustrated in Figure 4.5.2.2-5. Tank targets, upon which the estimates were based, seem to better conform to the predicted range thresholds, although performance is still substantially better than anticipated by the model.

Since the model predictions vary by VIC, comparing VIC performance as a function of range would provide a direct examination of performance versus the predicted thresholds. Using target identification results for the combined tank and vehicle targets, individual VIC performance is

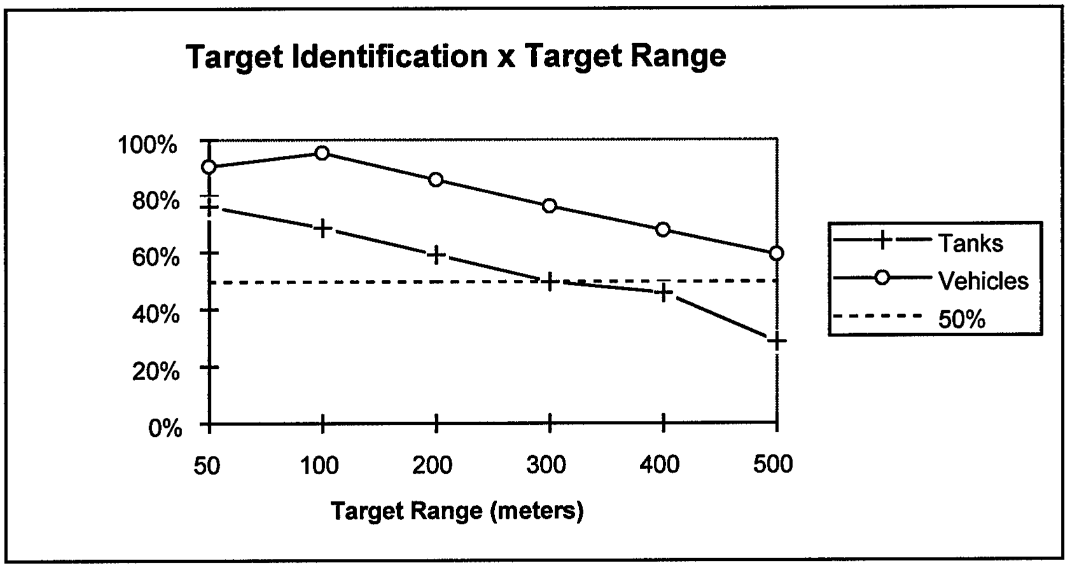


Figure 4.5.2.2-5. Tank and Vehicle Target Identification by Target Range

plotted as a function of range in Figure 4.5.2.2-6. A two-factor repeated measures ANOVA revealed no VIC effect ($p = 0.14$), a strong range effect ($p = 0.0001$) as previously seen, and a marginal VIC x range interaction ($p = 0.05$). As anticipated, Alpha and Bravo were more sensitive to increasing target range. A separate analysis was performed for each VIC comparing identification performance for each target type as a function of range. This analysis (not shown) revealed no DI target range effects (again as previously seen), a tank by range effect for VICs Alpha, Bravo, and Foxtrot, and a vehicle by range effect for VICs Bravo and Alpha. All VICs outperformed their respective model predictions for identification range limits.

The picture developed from all the target recognition and identification data is that the performance trends that one would expect given the parameters of the visual system of each VIC were basically supported. However, the absolute performance does not correspond to that expected from real-world systems, assuming that the Johnson model reflects this reality. This is anecdotally supported by user comments from computer graphics-based training simulators built by LMIS and others. The reports from fielded systems is that it is easier to locate targets in the simulators than in the real-world systems (Plamondon, personal observations while conducting user interviews during Advanced Gunnery Training System (AGTS) development). Best [ref 9] also cites factors that may be relevant to these findings. The aborted target detection experiments also support the conclusion that the way the simulators treat target models as a function of distance from the observer is not highly correlated with real world performance.

The final piece of data generated by this target identification visual task is the detection of target motion. The reason it was expected that this data might be interesting was that it was hypothesized that systems using head-coupled visual displays, i.e., VICs Alpha and, to a lesser extent, Foxtrot, might have trouble isolating whether apparent motion of targets in the environment was due to target motion or head motion. A similar phenomenon has been observed

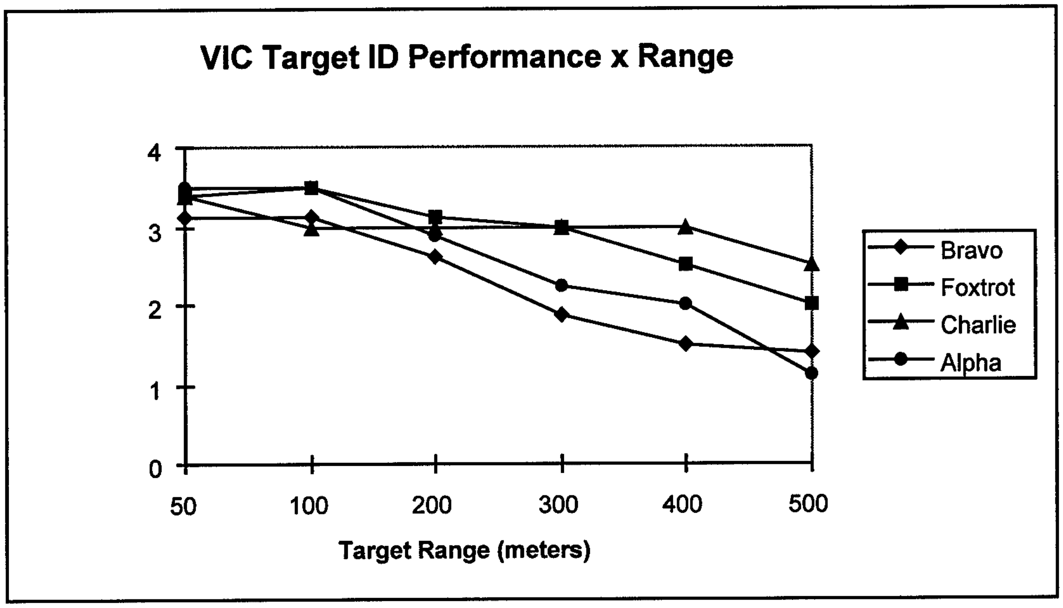


Figure 4.5.2.2-6. Individual VIC Target Identification by Target Range

in rotary- and fixed-wing simulators using HMDs; pilots sometimes have problems separating aircraft motion from head motion.

Figure 4.5.2.2-7 graphically shows the percent of correct target motion assessments by VIC. The observed differences are significant (p = 0.0001) and are due primarily to VIC Alpha's relatively poor performance as compared to the other VICs. This result is consistent with the hypothesized effect.

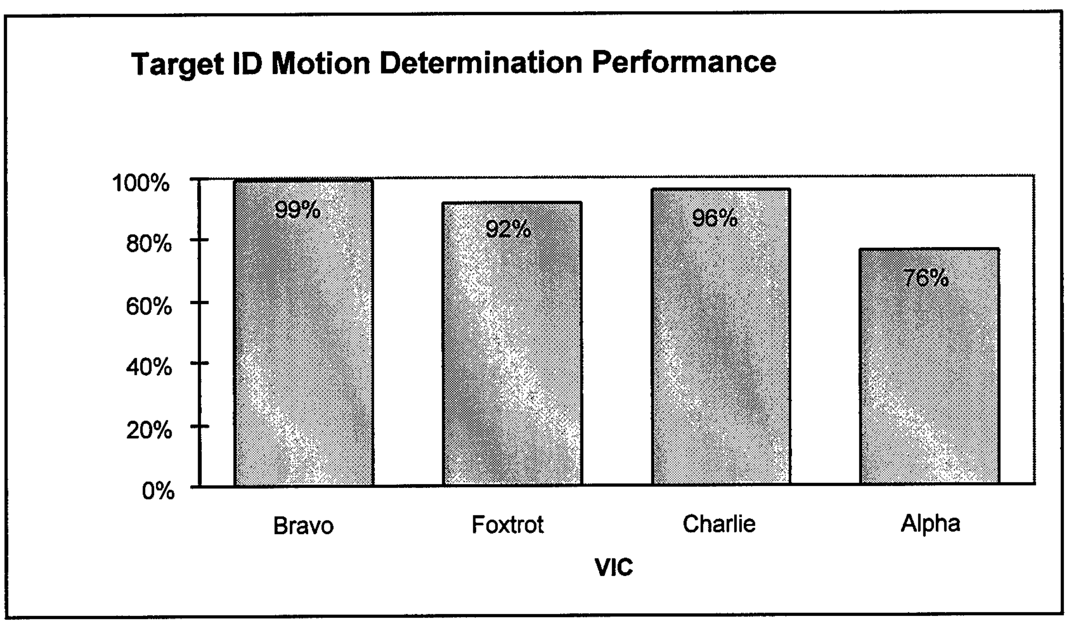


Figure 4.5.2.2-7. Overall VIC Target Motion Assessment Results

4.5.2.3 Target Search

Task: From a fixed location in the 29 Palms database, subjects were to locate DI-only targets and estimate their range, azimuth location, and speed of motion. Targets were presented at varying ranges at azimuth offsets within the forward 270° of the initial line-of-sight.

Task Conditions: Target range: 50, 100, 150, 250 meters

Target azimuth: 80, 130, 230, 315 degrees (offset from initial line-of-sight)

Target motion: Moving or stationary

MOPs: Time to locate target; distance, azimuth, and motion estimation accuracy

The intent of this visual task was to assess the ability of the VICs' systems to dynamically search the environment for targets over a wide azimuth range and after doing so be able to assess what direction the VIC is looking in and where things are in the world (azimuth angle primarily). The search is primarily a function of the visual system (ability to slew line-of-sight and instantaneous FOV, for example). The ability to figure out where things are in the world in relation to where one started relates to how well the system provides for a constant sense of spatial or situational awareness. In addition, since all targets are known to be DI, then range estimation based on target size should be easier since any target detected will be a DI, regardless of whether it is identified as such, and the size will be the same for all targets. Finally, since there is a mixture of moving and stationary targets, the task provides an additional opportunity to assess motion detection performance (see also 4.5.2.2).

The first series of comparisons relate to time to acquire the targets. Time should be correlated with the parameters of the visual system that influence search, such as FOV, ease of line-of-sight (LOS) slewing, and static and dynamic resolution. Given that there is an overall search time effect for the VICs, the time to acquire as a function of distance and angle could provide additional insight into the reasons for the differences.

Figure 4.5.2.3-1 shows overall VIC search time performance. The observed differences are significant ($p = 0.0001$), primarily due to Alpha's greater search time as compared to the other VICs. The obvious difference between Alpha and the remaining VICs is visual system FOV; Alpha's is the smallest at 45° horizontal x 33° vertical. However, Alpha's visual system resolution is also the lowest in terms of number of pixels (420 x 230), so it is unclear which is the causative factor, or whether other factors such as dynamic resolution are also involved.

If system resolution was playing a significant role in search (or response) times, one might expect for search time to increase as a function of increasing target range, since it would be more difficult to detect the target. Figure 4.5.2.3-2 shows search response time as a function of range for each of the VICs. Analysis shows that the range had a significant effect ($p = 0.0004$) and that there was a difference among VICs as well (as we had already seen). There also was a significant interaction between VICs and target range ($p = 0.006$), meaning that range did not have the same effect on performance for all VICs. Looking at the figure, the most obvious differences are the

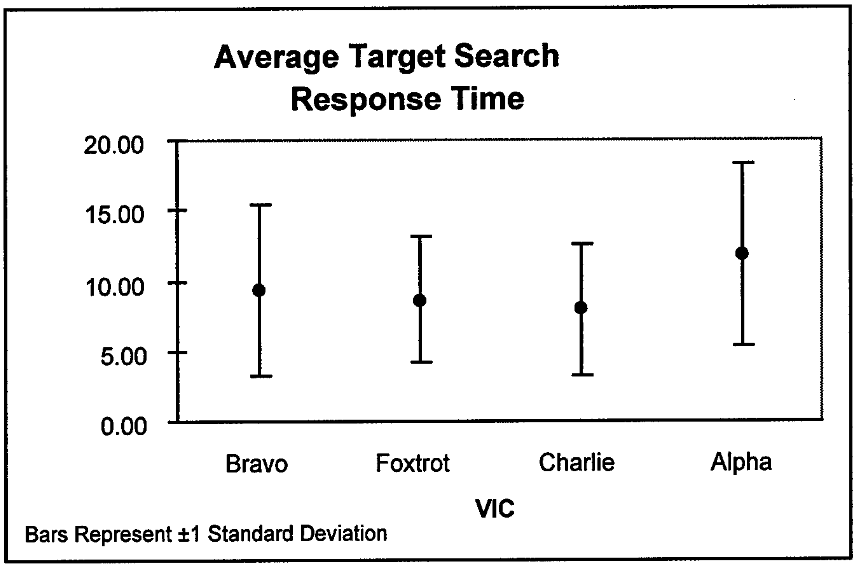


Figure 4.5.2.3-1. Overall VIC Target Search Response Time Results

relatively steep increase in response time for VIC Bravo from 50 to 100 meters, and an overall increasing spread in the differences in response time among the VICs with increasing range. Charlie showed the least degradation in performance over range, Bravo showed the greatest overall increase in time, and Alpha had the second greatest change along with overall greater response times. This would seem to imply that resolution was a factor, since Bravo and Alpha were not as good as Charlie and Foxtrot in this parameter.

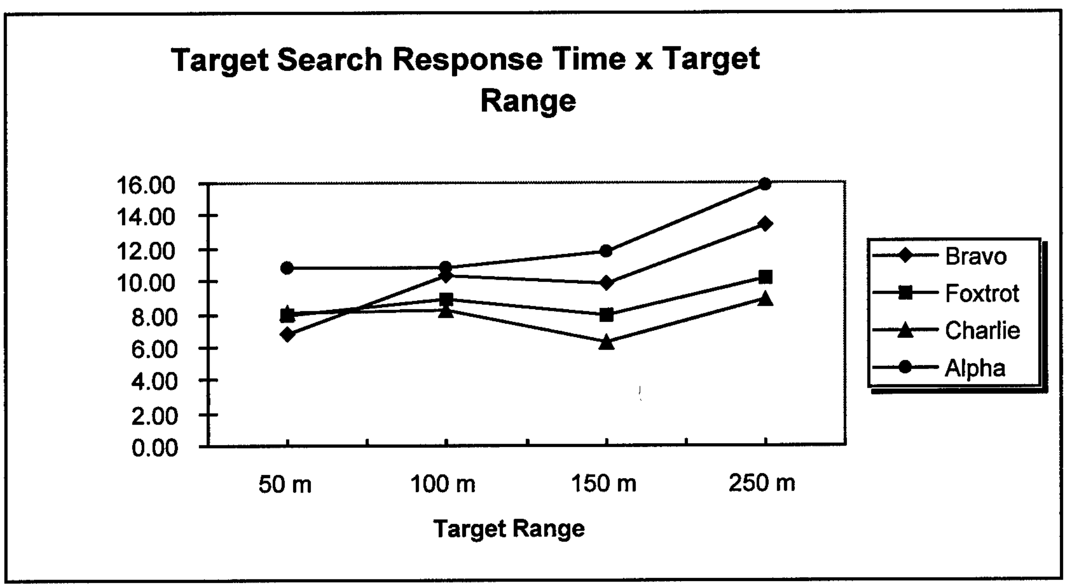


Figure 4.5.2.3-2. VIC Target Search Response Time as a Function of Target Range

If system FOV was a major contributing factor to the difference in search times among the VICs, one might expect an effect of target offset, that is, it may take longer to find targets that are farther out to the sides of the subject if he is searching with a more limited FOV. Figure 4.5.2.3-3 shows VIC performance as a function of target offset angle. Although no angle main effect was found (p = 0.07), that is there is no statistical difference in performance over the different angles, there is a significant VIC by angle interaction (p = 0.0001). Looking at the figure, the obvious difference is Bravo's atypical performance. One explanation may have to do with Bravo's unique display system. All of the VICs except Bravo had a single display/projection system to generate the visual view - Alpha its HMD, Charlie a CRT, Foxtrot a single projector. Bravo had four separate projection systems - one for each screen, with each screen subtending 90° FOV. With 0° (north) centered on the forward screen, the target presentation angles fell 1) near the center of the right screen for 80°, 2) near the back edge of the right screen for 130°, 3) near the back edge of the left screen for 230°, and 4) at the front left corner where the front and left screens met for 315°. With a fixed visual environment that had corners, targets falling nearer the edges of the screens or in a corner may not be as clear as those in the center of the screens (a typical display phenomenon). Also, some display screens could have been clearer than others due to projector differences, light interference, or other factors. The other systems could slew their LOS to bring the target into the center of the display; Bravo could not. So a possible explanation for the Bravo results are that the 80° target display was the clearest, the 130° display area may not have been as good as the 230°, given that both were near the edges of the displays, and the 315° target in the corner was difficult to acquire.

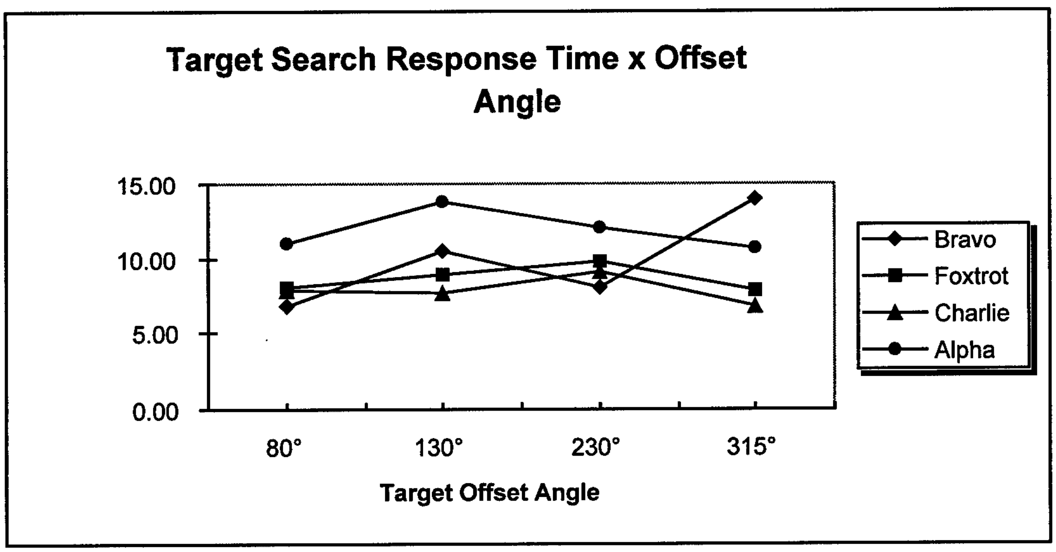


Figure 4.5.2.3-3. VIC Target Search Response Time as a Function of Target Offset Angle

Beyond search times, the other obvious performance metric is how successful the VICs were at locating the targets. Figure 4.5.2.3-4 shows the percent of targets successfully located for each VIC out of the total of 256 target presentations. The observed differences are significant (p = 0.0001), with differences in performance between all VICs except Foxtrot and Charlie. These results are consistent with the visual resolution differences among the VICs. If visual resolution is the cause of these differences, then one would expect to see performance differences over target range, somewhat reproducing what would have been expected from the DI detection experiments.

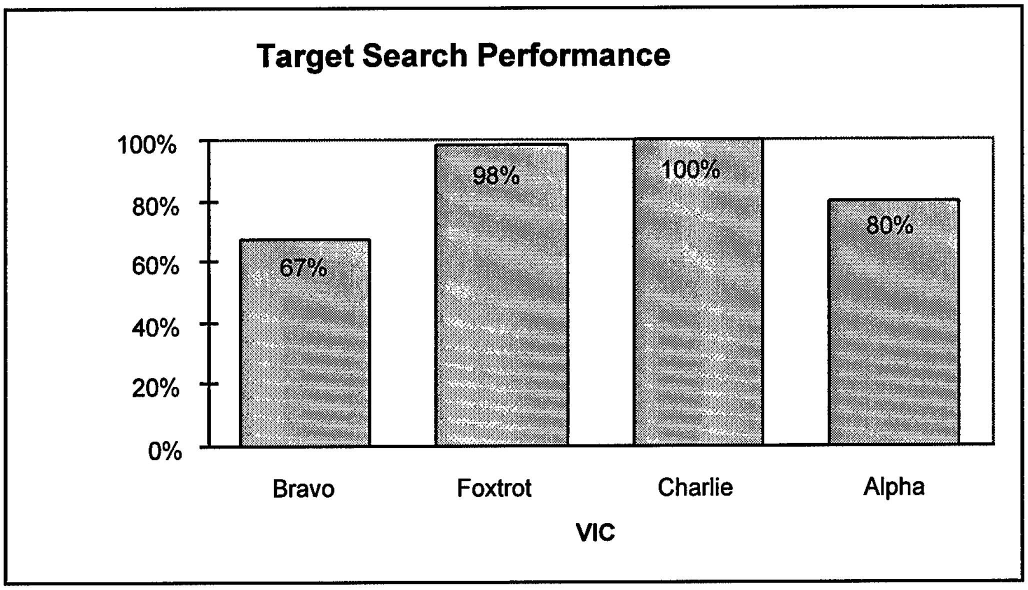


Figure 4.5.2.3-4. VIC Target Search Performance

The plot of target location (detection) performance over target range is shown in Figure 4.5.2.3-5. The is a significant range (p = 0.0001) effect and range by VIC interaction (p = 0.0001). It is obvious that the majority of the observed differences in overall VIC target location performance is due to decreased performance by VICs Alpha and Bravo at the outer ranges (150 and 250 meters) (this is the VIC x range interaction effect). Using this data as comparison with the predicted DI detection performance (via Johnson criteria), Alpha and Bravo's limit at around 200 - 250 meters is well below the predicted ranges of 380 and 340 meters, respectively. It is impossible to extrapolate Charlie and Foxtrot's performance from this data.

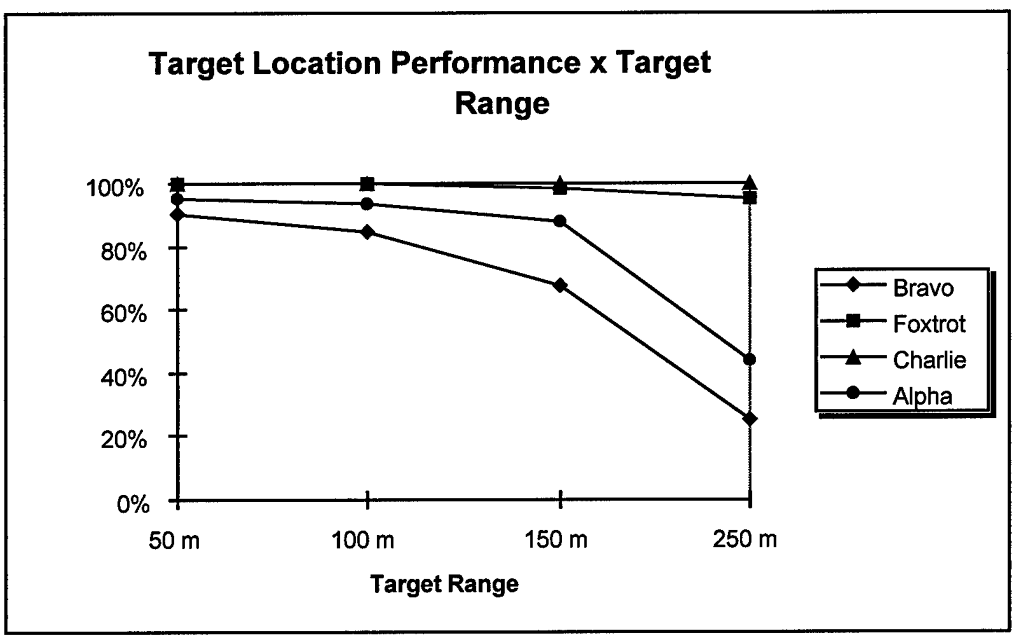


Figure 4.5.2.3-5. VIC Target Search Performance as a Function of Target Range

These detection results seem to be somewhat inconsistent with the data presented in Figure 4.5.2.2-3, which shows overall DI recognition performance above chance levels at ranges beyond 300 meters. While the drop-off at the 200 and 300 meter ranges is primarily due to Alpha and Bravo (19 of the 21 non-detected DI targets at these ranges were due to Alpha and Bravo), it still doesn't match the performance decrement seen here.

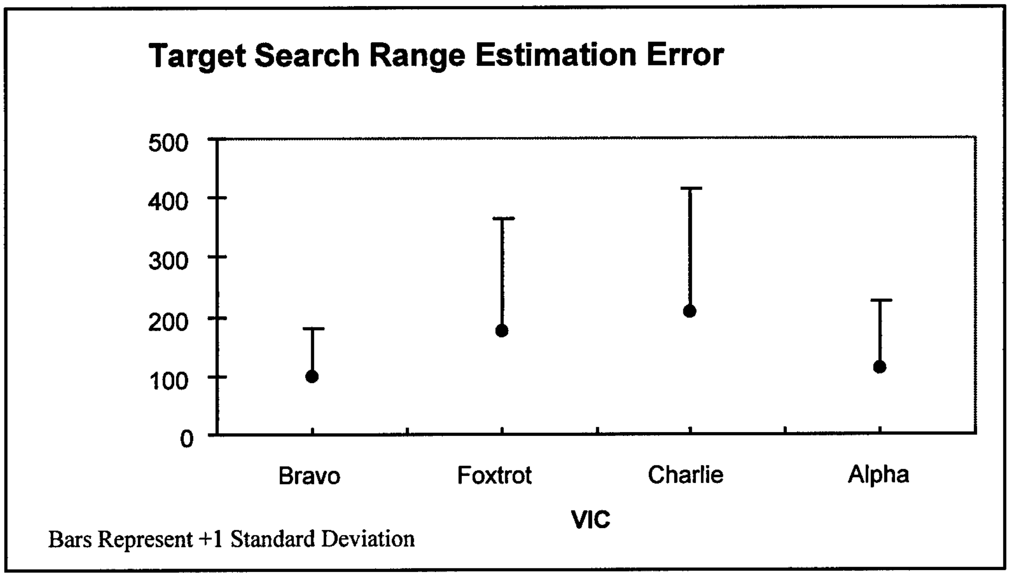


Figure 4.5.2.3-6. VIC Target Range Estimation Error

As discussed above, secondary measures for this visual search task include range and azimuth position estimation accuracy, as well as target motion detection. The data from these measures are presented in Figures 4.52.3-6 through 8. The average absolute error for the estimations are plotted along with the standard deviation for each (only the +1 deviation is plotted; plotting ±1 standard deviation caused the y-axis to have negative values which are meaningless for this data). Absolute error was used because using average error alone can be misleading; a zero average error can mean errors were non-existent, or they were generally equal in magnitude and opposite in sign. Average error can provide insights into biases in the estimates and will be discussed for this purpose where applicable.

As seen in Figure 4.5.2.3-6, there was variation among VICs for both magnitudes and variability of range estimation errors ($p = 0.045$ for average absolute error). Average signed error showed an overall tendency to over-estimate target range by about 100 to 200 meters, depending on VIC. Since analysis of the data showed that absolute range error (and standard deviation) is positively correlated with actual range (resultant regression equation was: average absolute range error = 0.79 x actual distance + 54.5, $R^2 = 0.96$), the fact that Bravo and Alpha performed better may be due to a *de facto* self-selection process, that is, significantly fewer targets at the longer ranges were located, so fewer range estimations were made where errors tended to be greater.

Azimuth location, given in real-world coordinates where 0° is due north, 90° is east, etc., is depicted in Figure 4.5.2.3-7. Absolute error estimates were again significant for the VICs (p =

0.008), where Bravo performed much better than any of the other VICs, both in absolute error and variability. This does not appear to be an artifact such as with range estimation. Although Bravo had proportionately fewer data points at all azimuth values, this was proportionately the same for all azimuths except for 315°. Performance at this azimuth was intermediate of the others, so should not have skewed the data.

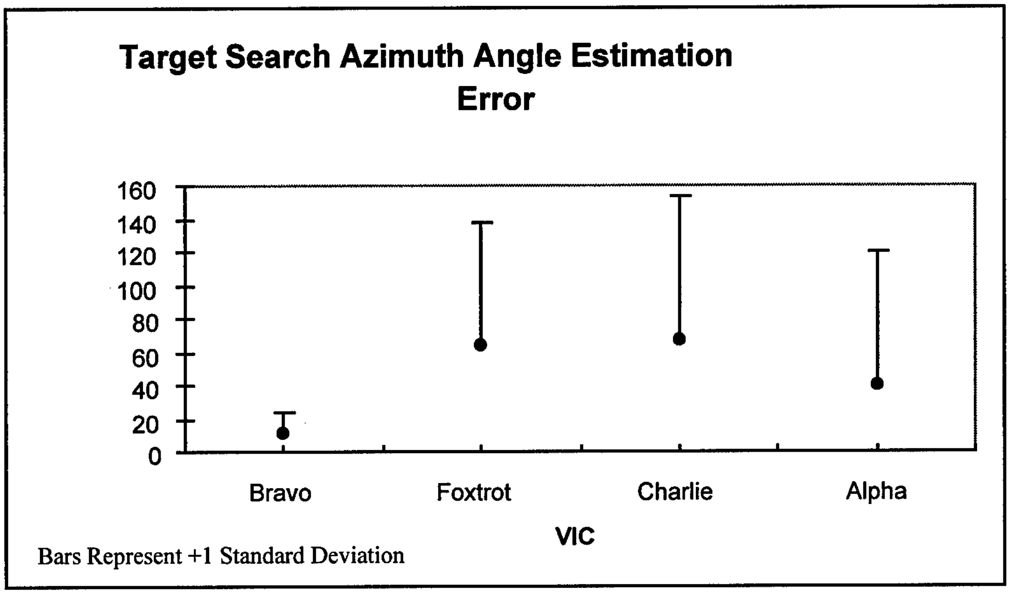


Figure 4.5.2.3-7. VIC Target Azimuth Estimation Error

Given that Bravo's superiority in this phase of task is real, a possible explanation is tied to the stability of its spatial representation of the world. As previously stated, Bravo's visual presentation of the world environment is most like the real-world of all the VICs. The 360° azimuth view of the world is constantly displayed and fixed - north is always the front screen and south the rear screen, etc. Other cues within Bravo - the ODT orientation, braces, etc., can all serve as orientation locators for the user's body or LOS within the larger world environment. The other VICs, which show a portion of the world that may change orientation without corresponding movement of the user (except for Alpha), rely totally on the displayed visual environment to provide orientation cues. When the environment is relatively barren such as the 29 Palms database used for these experiments, then there isn't much upon which to base judgments and errors and variability will increase.

Finally, the comparison of how well the VICs assessed whether a target was moving or not is presented in Figure 4.5.2.3-8. The differences are significant ($p = 0.0001$) and are due primarily to the reduced performance of VIC Alpha relative to Bravo and Charlie. Again, the rationale for this comparison was a belief that VICs using head-coupled display systems (Alpha and Foxtrot) may experience confusions in separating self-motion from other world motion, and would therefore perform at lower levels as compared to the other VICs not employing such display systems (Bravo and Charlie). The data is consistent with this interpretation.

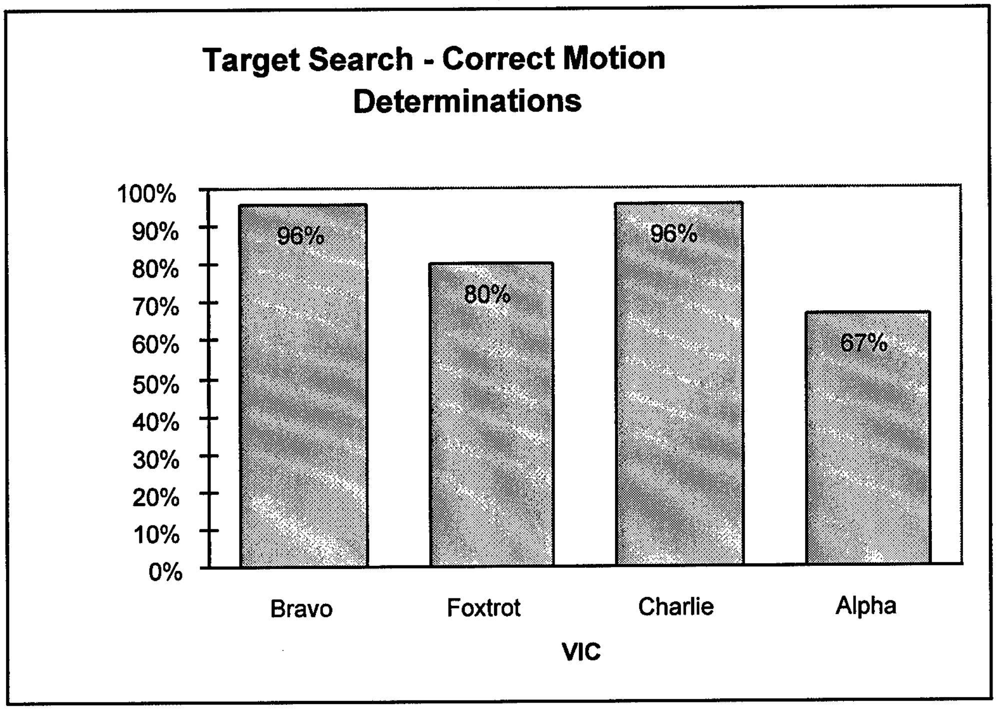


Figure 4.5.2.3-8. VIC Target Motion Detection Performance

4.5.2.4 DI Animation Detection

Task: Determine whether a moving DI model is animated with arms and legs moving as if walking or whether its limbs are stationary as the figure slides along the ground.		
Task Conditions:	Target type:	Animated or static DI model
	Target range:	50, 100, 200 meters
	Target aspect angle relative to observer:	0°, 90°, 180°, 225°, 315°
MOPs: Accuracy in determining animated target versus static target		

During the second TIM, the issue was raised that systems may not need to add animation as a level of detail for DI models until some range threshold is crossed. This could reduce display processing burden. The question was where this range threshold was. This task attempted to shed light on this question. Each VIC was give a static DI model to use, the VICs used their normal DI models (DI Guy, Biomechanics, or JackML) for the animated figures.

The overall VIC animation detection performance results are shown in Figure 4.5.2.4-1. The heavy line represents the main effect ($p = 0.007$), with the other light solid and dashed lines illustrating the effects of target type (animated versus static, $p = 0.03$). The target type by VIC interaction failed to achieve significance ($p = 0.075$). The main effect seems to mirror VIC visual system resolution performance results, with Alpha and Bravo performing less well than Charlie and Foxtrot. This holds for both target types, but overall animated figures are correctly identified more often than static. This may be due to the fact that if you can see the target fairly well, and it is moving, then this can be detected fairly readily. However, targets that are unclear, particularly targets at greater range, may appear to have an animation component due to pixel filling and drop-off in front of and behind the moving target. This "pixellation" may be seen as animation if the target is small or unclear.

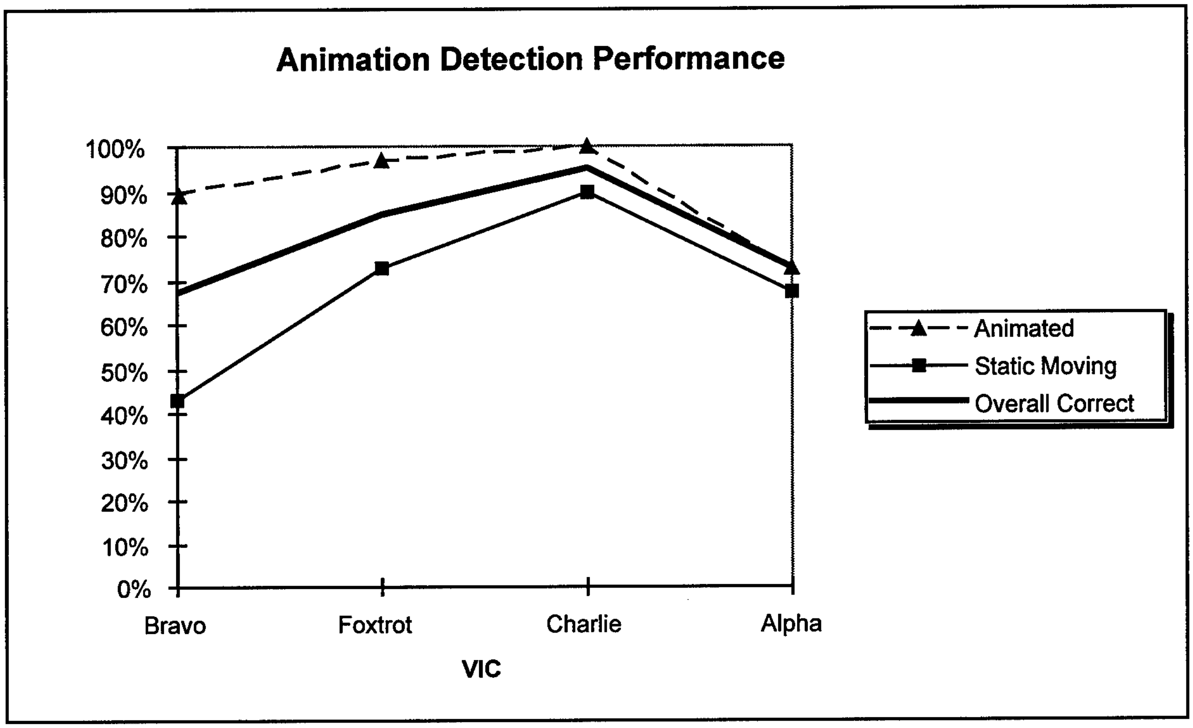


Figure 4.5.2.4-1. VIC Animation Detection Performance

If this latter explanation is correct, one would expect to see static targets incorrectly classified as animated more often as range increases, whereas the converse should not necessarily be true, that is, errors in classifying animated targets as static should not significantly increase with range. Statistically, one might expect a range by target type interaction. The results for target range main effects and target type effects are shown in Figure 4.5.2.4-2. Both the main distance ($p = 0.0007$) and target type ($p = 0.02$) effects are significant, but the target type by range interaction is not ($p = 0.13$). Thus, even though static target classification errors increase with range, animated target classification error increases by the same measure as well.

With respect to the question of range thresholds for animating DI models, if one uses a 50% criterion for establishing a range threshold, then the data collected is insufficient to answer this question. The ranges selected were expected to be at the threshold of identification for the best systems (Charlie and Foxtrot) based on the predictions. As seen in the referenced figure, these predictions did not hold for these systems. Therefore targets would need to be placed out

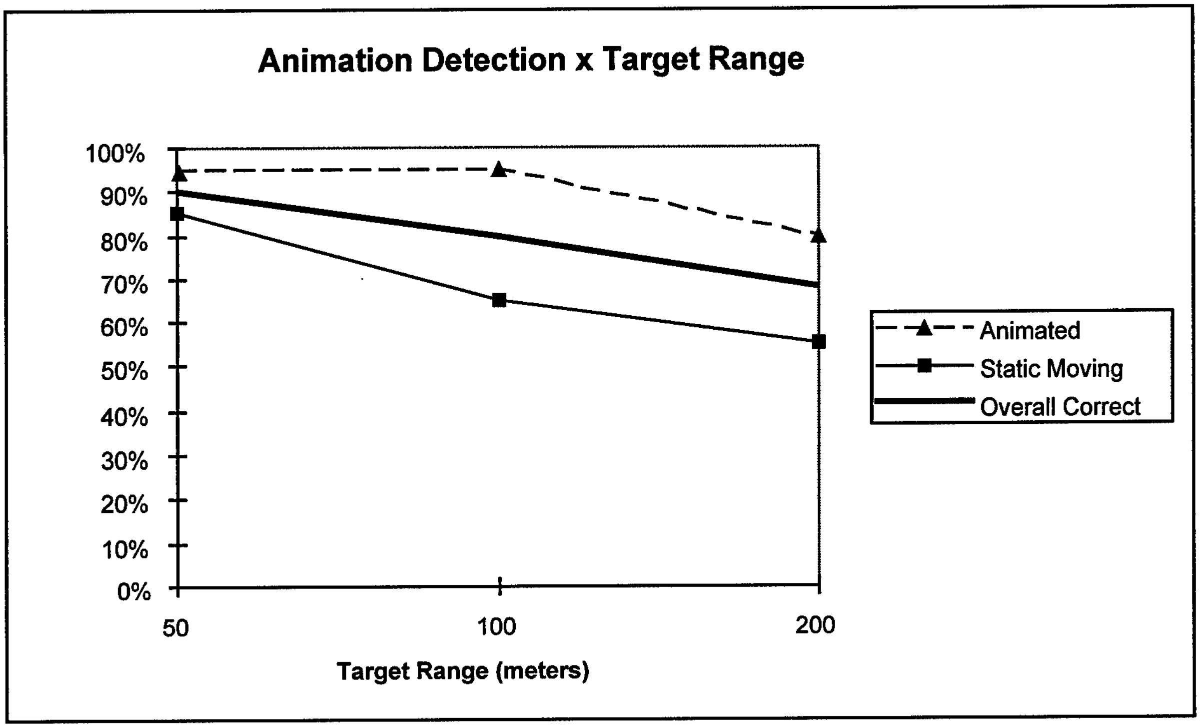


Figure 4.5.2.4-2. VIC Animation Detection Performance as a Function of Range

considerable further than 200 meters to cross the 50% threshold, if everything else is held constant.

Finally, the data was evaluated for the effect of target aspect angle on animation detection performance. No significant effect was found.

4.5.3 Weapon Aiming

As noted, the VICs presented a variety of technologies for weapon tracking and methods for weapon aiming. These are summarized here:

- VIC Alpha - Video tracking of markers on weapon. Sighting is through simulated iron sights in HMD video.
- VIC Bravo - Magnetic tracking of weapon. Sighting through head-mounted display simulating Land Warrior IHAS.
- VIC Charlie - No weapon tracking. Sighting through crosshairs on CRT controlled by joystick.
- VIC Foxtrot - Acoustic tracking of weapon. Sighting through actual weapon sights against target image on projected display.

Both Alpha and Foxtrot advertised that they supported weapon employment from all postures. Bravo and Charlie simulate posture changes by changing the eye (sight) height in response to a button press. There is no actual change in user posture or sighting process.

Based on these differences, tasks were developed to assess target acquisition and engagement from different postures, and for static and moving targets (to assess ease of tracking target with weapon). The results of these tasks are discussed below.

4.5.3.1 Aiming Postures Task

Task: Engage fixed and moving bull's eye targets from the standing, kneeling, and prone positions. All targets are presented at a range of 100 meters.		
Task Conditions:	Posture:	Standing, kneeling, prone
	Target motion:	Stationary; 2, 6 kph
MOPs: Time to engage target, target hit accuracy (error from target center)		

As discussed, the intent of this task was to assess how well the VICs could shoot in each of the three postures. It was presumed that there would be no impact on VICs Bravo and Charlie, since they only simulate posture changes. Posture changes in Foxtrot would change the sensor receiver/transmitter distance which could affect accuracy; it was unclear how posture changes might affect Alpha.

After the first session of 15 trials it was obvious that neither Alpha nor Foxtrot could engage targets reliably from the prone position. Foxtrot aiming error was so great that in many instances the soldier ended up hitting and killing himself while trying to engage the target. Alpha ended up aborting its participation prior to session termination. The video tracking system lost track of markers and apparently misassigned weapon and soldier body part markers to the detriment of body coherence and task performance. Given the self-evident and obvious nature of these results, no further sessions were conducted and no analysis was performed on the data collected during this one session.

4.5.3.2 Target Acquisition and Engagement

Task: Engage fixed and moving bull's eye targets that can appear anywhere within the forward 270° from the initial line of sight. All subjects perform this task while standing.		
Task Conditions:	Target range:	100, 200 meters
	Target offset:	33°, 93°, 270°, 315°, 355°
	Target motion:	Stationary; 2, 5 kph
MOPs: Time to engage target, target hit accuracy (error from target center)		

A significant number of the experimental sessions were allocated to assessing target acquisition and engagement performance. As stated, the major MOPs were time to engage and target hit accuracy. Figure 4.5.3.2-1 shows the overall engagement time performance for each VIC (differences significant at $p = 0.0001$). Bravo and Foxtrot were the quickest to engage, Charlie and Alpha were 3 to 6 seconds slower, depending on the comparison made. These results are consistent with observations during the experiments. Bravo and Foxtrot's aiming was relatively natural and made it easy to initially acquire targets and to complete the precision aiming. This is despite the weapon pointing offset problems seen in VIC Bravo. Tracker inaccuracies made weapon aiming at the displayed target more difficult than necessary, soldiers initially aimed the weapon at the displayed target then had to hunt around with the weapon to get the target into the FOV of the IHAS. Once within the FOV of the IHAS, it was easy to complete aiming and fire at the target.

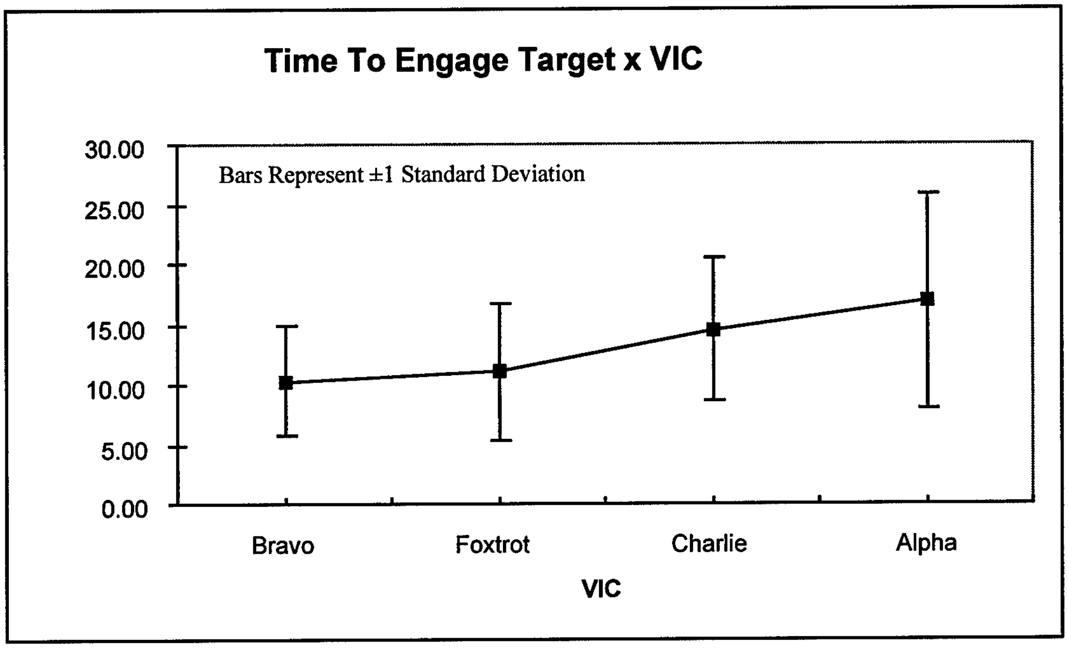


Figure 4.5.3.2-1. VIC Target Engagement Time Performance

VIC Charlie's joystick control allowed quick gross acquisition of the target, but the final fine adjustment of the crosshairs was difficult - a classic manual control problem. The output function of the joystick was modified after the first block of aiming sessions to decrease the sensitivity of small joystick excursions. This change had no effect between blocks 1 and 2, average acquisition time changed only -0.5 seconds, which is consistent with variation between the remaining 3 blocks.

VIC Alpha, like Charlie, could initially acquire the target fairly quickly. However, final aiming adjustments were often difficult because the image of the rifle and sights would "jump" off the target just as the soldier was prepared to fire. Readjustments of the sights relative to the eyeheight of the soldier was also often necessary before the target could be successfully engaged.

After acquisition and weapon firing, the results of the hit on the target was recorded in the detonation PDU. Absolute error of bullet impact from the center of the bull's eye and absolute error variability were computed, again under the assumption that a simple average would tend toward zero and so would be non-informative.

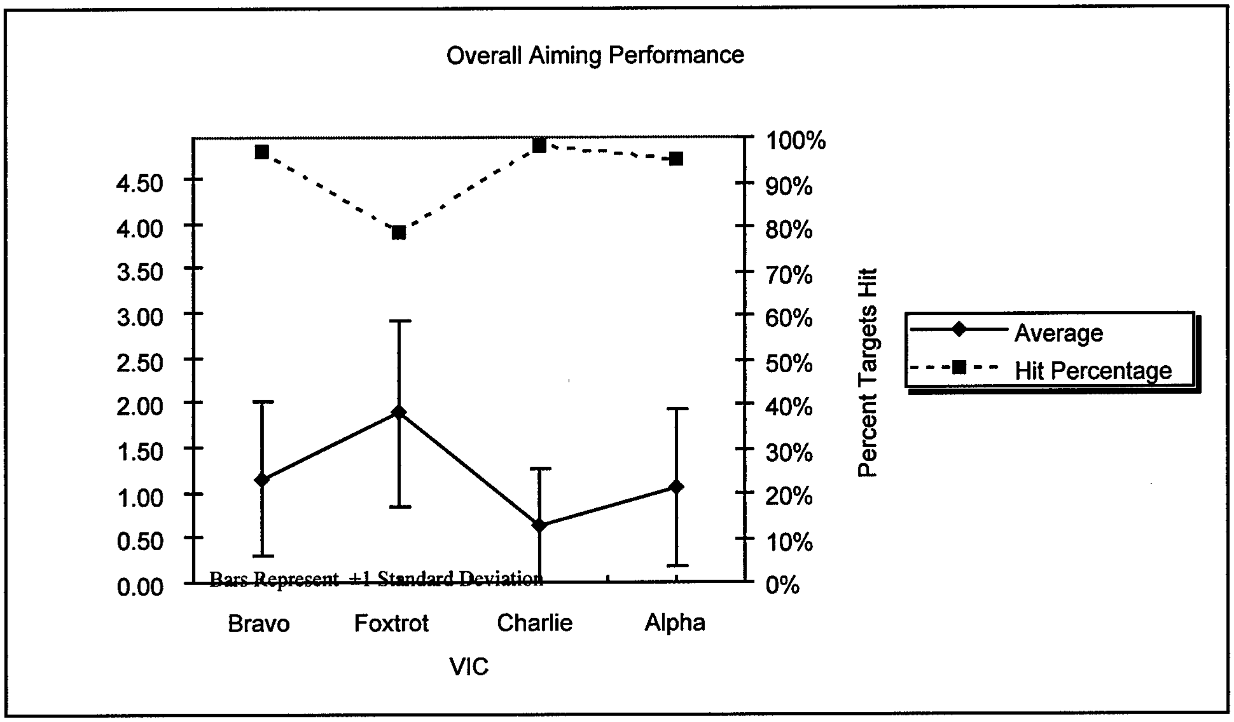


Figure 4.5.3.2-2. VIC Target Engagement Aiming Performance

Overall VIC aiming/target hit performance is shown in Figure 4.5.3.2-2. Both main effects for hit percentage and average absolute error are significant ($p = 0.001$), primarily due to differences between Foxtrot and all other VICs. The data shows that Foxtrot had a lower hit percentage and highest absolute error. The data used for the analysis excludes Foxtrot ground impact detonation PDU data.

Foxtrot was the only system that entered the world coordinates into the detonation PDU entity impact location when the shot resulted in a ground impact. This was discovered when errors of thousands of meters were computed for some Foxtrot shots. In all, 70 ground impact data points were found for Foxtrot (out of 400 total). These accounted for the majority of Foxtrot misses.

Foxtrot was the only system that used a true ballistic model for bullet flyout. All other systems used a straight line approximation. Discussions with Foxtrot engineers (Reif, personal communication) concluded that at the target ranges used, there should have been no systematic performance differences due to the differences in models. In addition to the main effects, the effects of target motion, offset angle, and range were analyzed. Of these, the only significant effect found was for target range ($p = 0.0008$), with no range x VIC interaction (Figure 4.5.3.2-3). Obviously, the effect is one of increasing error with increasing target range.

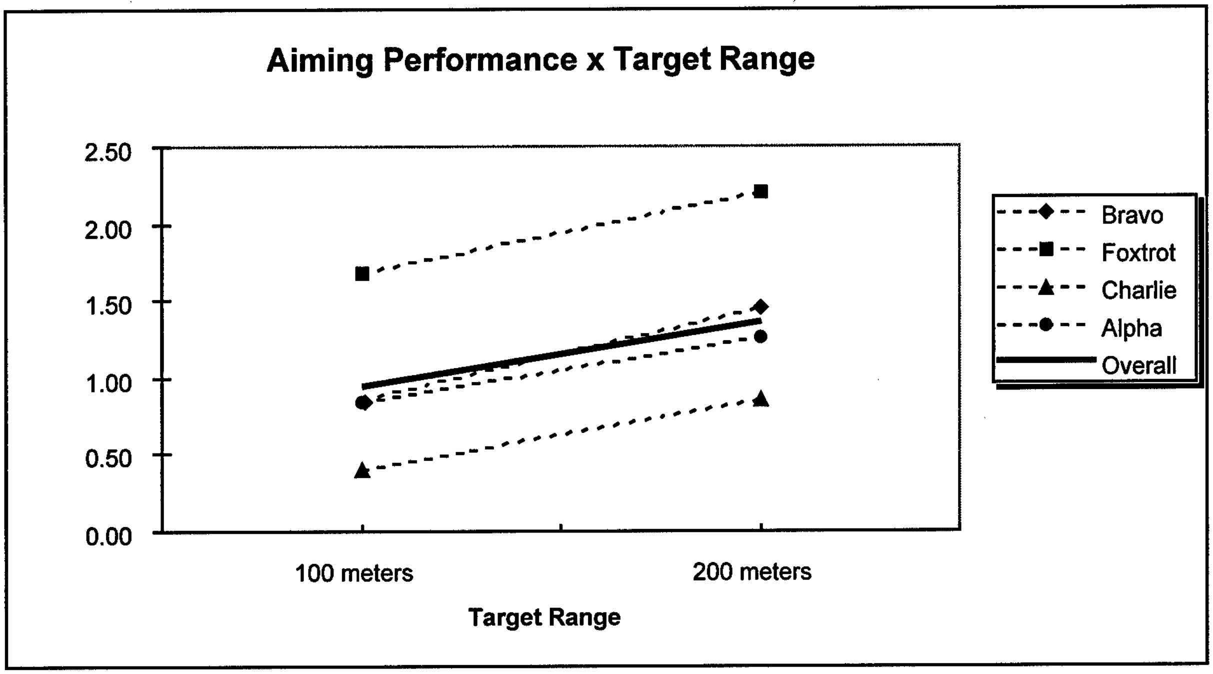


Figure 4.5.3.2-3. VIC Target Engagement Aiming Performance

To summarize the weapon aiming results, VICs Bravo and Foxtrot provided the quickest and arguably the most natural weapon aiming, but Foxtrot suffered in its aiming accuracy, presumably due to weapon tracking system inaccuracies.

4.5.4 System Characterization

As previously discussed, it had been planned to perform independent measurements to characterize all aspects of the VICs' subsystem and overall system performances. However, in most instances these measurements were not made due to technical and other limitations. However, some aspects of the VIC visual systems were measured, and target acquisition performance predicted based on engineering models (Johnson criterion). In addition, each VIC was requested to provide a write-up of its system operational concept and performance characteristics. This data is provided in this section, beginning with visual system performance.

4.5.4.1 VIC Visual Systems and Predicted Target Acquisition Performance

Each VIC's visual display system was the primary interface between the user and the synthetic environment (acoustic information was displayed via speakers or headphones and Bravo's force feedback mechanism on the ODT conveyed some ground slope information). All the engineering experiment tasks either directly or indirectly tested the visual system to a large extent.

The type of display system and some performance parameters are presented Table 4.5.4.1-1. Two field of view (FOV) measures are given for all systems except for Alpha - a stated FOV and a measured FOV. The stated FOV is the information provided by the VIC personnel when this information was requested prior to integration. The measured FOV is that calculated using

Table 4.5.4.1-1 VIC Display System Parameters

	VIC Alpha	**VIC Bravo**	**VIC Charlie**	**VIC Foxtrot**
Display Type	HMD	Projection	CRT	Projection
Resolution	420 x 230	640 x 480*	1280 x 1024	1280 x 1024
FOV (stated)	45° x 33°	90° x 77°	60° x 48°	75° x 56°
FOV (measured)	N/A	98° x 81°	36° x 29°	102° x 90°

* Each channel

measured viewing distance and display height and width. Alpha's FOV was not independently confirmed; Bravo's measured is reasonably consistent with the stated. VIC Charlie, using the BAYONET software, can define any FOV to display on the CRT monitor. The display monitor itself presents a FOV defined by the measured value. Thus, for a unity gain display, the displayed FOV should match the actual CRT FOV. However, this presents a narrow FOV that the system developers determined to be inadequate, so a 60° horizontal FOV is the normal operating mode. This mode was maintained for the experiments, even though it represents a less than unity gain (approximately 0.6X) display. This should have a minifying effect, making objects appear farther away then they really are supposed to be.

VIC Foxtrot is designed to allow the user to walk around in front of the display; providing the opportunity to look around corners, for example. Thus, a measure of FOV is dependent on where the measurements are made. The stated FOV was described as "typical" by TTES engineers; the measured value was made assuming a viewing location directly under the tracking sensors. TTES personnel bound the display FOV as between 45° and 180° (horizontal).

Using the stated VIC display parameters, the expected target acquisition performance can be predicted using the Johnson model, which defines target detection, recognition, and identification performance limits (50% threshold) as a function number of display cycles (1 cycle equals 2 display lines) over the critical target dimension. The criteria used for calculating predicted ranges are as follows:

- Detection = 1 cycle
- Recognition = 4 cycles
- Identification = 6.4 cycles
- DI target height = 1.9 meters
- Tank target height = 2.5 meters

Given this, plus display resolution and FOV, the expected range thresholds for the three levels of target acquisition can be calculated. These predicted ranges (in meters) are presented in Table 4.5.4.1-2. These predicted values can be compared with the results presented in paragraph 4.5.2.

Table 4.5.4.1-2 VIC Target Acquisition Range Predictions

		VIC Alpha	VIC Bravo	VIC Charlie	VIC Foxtrot
Detection (meters)	DI	380	340	1161	995
	Tank	500	446	1528	1310
Recognition (meters)	DI	95	85	290	249
	Tank	125	112	382	327
Identification (meters)	DI	60	53	182	156
	Tank	78	70	239	205

One final visual system performance test was conducted. Using one set of two subjects per VIC, a model of a Snellen visual acuity chart was presented facing the subject at a distance of 20 feet. The top line of the chart corresponded to a visual acuity of 20/70, the smallest line corresponded to a visual acuity of 20/15. The subjects were asked to read the smallest line that they could. The results are as follows:

- VIC Alpha - 1 of 2 subjects read top line only, second couldn't read any lines
- VIC Bravo - Neither subject read any lines
- VIC Charlie - Both read through the third line (20/50), 1 read the entire fourth line and the other read 3/4 of the letters correctly (20/40)
- VIC Foxtrot - Both read through the third line (20/50), 1 read 3/4 of the letters correctly on the fourth line and the other read 2/4 of the letters correctly (20/40)

While obviously not a precise measure of visual system performance, it does provide an intuitive understanding of how well the subjects could see in the VICs, and performance patterns are consistent with expectations.

4.5.4.2 VIC Characterizations

As previously stated, responsible personnel for each VIC were asked to provide a write up on their VICs performance. The following sections present these write-ups edited only for format and spelling. The questions asked for response are included in VIC Alpha's response. RBD did not provide a write-up. Their BAYONET software provided the visuals for VIC Bravo and drove the VIC Charlie simulator. Data collected during the experiments will be reported to the level of precision available.

4.5.4.2.1 VIC Alpha

LOCOMOTION

1. Controller sensitivity, controller output functions (output per unit input), deadbands, hysteresis (*requested information*).

VIC alpha uses a "human joystick" to control the direction that the virtual individual combatant moves over long distances. Movement within a 3 foot diameter circle in the middle of the capture area will force the virtual IC in the same direction as the human is facing. The direction is based on a single precision 32-bit floating point number. The speed of movement is based on how long the human remains in a given direction. Speed steadily increases from 0 meters per second to a maximum speed of 3.5 meters per second. The rate of increase is 1/120 meters per second per unit loop time. Assuming an average loop time of 30 frames per second, this means that acceleration is .25 meters per second squared. When the human turns more than 15 degrees from the previous marked orientation, the speed gets reset to 0 meters per second, and the orientation is marked. When the human is outside of the forced movement area, movement of the virtual IC corresponds exactly to the movement of the human within a 32-bit floating point value.

2. Maximum output

Speed is limited to 3.5 meters per second within the forced movement circle. Speed is not limited outside of the movement circle.

3. System lag (control input through visual system response)

Prior testing has indicated roughly a 1/15 second delay from control input through visual system response. Of the 1/15 second delay, 1/30 is caused by the optical motion system.

VISUAL SYSTEM

1. Resolution (acuity measured via system display), field of view, color registration.

The resolution of the head mounted display is 420x230 pixels. The field of view is 45 degrees horizontal by roughly 25 degrees vertical. Color registration matches that of the RGB monitor.

2. Subject viewing distance from display

This data was captured through the engineering experiments.

3. IG update rates

The average 30 Hz for both the 29 Palms and McKenna database. Update rates are maximized at 60 Hz.

4. System lag

As stated under the locomotion testing, there is a 1/15 second delay from control input to visual. 1/30 of a second is due to the visual system.

WEAPON AIMING

1. Tracking system resolution

The average "point error" of the system is .20 inches. The point error is the maximum distance that each camera disagrees about the position of each marker. Considering a front and back marker on the weapon and a length of roughly 1 meter, this translates to a calculable maximum error. The most that the weapon aiming could be off is by 0.5 meter at a distance of 100 meters.

2. Repeatability (reliability)

The error in aiming should remain constant due to the nature of the optical tracking system.

3. Update rates, system lag

The update rates for weapon tracking is 30 Hz. System lag is the same as the locomotion lag. 1/15 second is for the motion capture plus 1/15 second for visual system update.

4.5.4.2.2 VIC Bravo

LOCOMOTION

1. The ODT provides one unit output per one unit input in the direction of navigation. That is, if the soldier walks 1 meter on the ODT, the VIC walks one meter within the scenegraph. Likewise for steady state velocity.

Acceleration is another matter. The IG receives velocity and direction updates from the ODT controller, so it's not strictly tied to user position. Another way of stating this is that if the user move in such a way that doesn't for some reason correspond to ODT surface motion, then the IG doesn’t respond to the user; it responds to the ODT.

This is typically a small variance. In practice, for instance, the soldier might take a step forward before the ODT surface actually moves. They “see" themselves move because the display is fixed and they are moving. Once the ODT begins to move, it moves them back towards the center, with an equal movement of the display. The “instantaneous” velocity of the ODT/IG display is not equal to the immersant’s relative surface velocity. Rather, it is a combination of user velocity and correction velocity. Because the user is kept relatively close to the center of the ODT with respect to display objects, the differences are not noticeable.

Deadband has little effect on fidelity because, as stated, the user might move without the display changing, but that's just like the real world. We move, and the display stays fixed.

It is in the area of deadband control that we anticipate doing more future work. Our controls are now tuned more towards normal walking speed with gentle turns. A user who is stopped can too easily be unexpectedly swayed to the limits of the resting deadband. Worse, a user transitioning between stopping and starting, as is common with soldier motion, causes switching between dynamic control that has no deadband, and stopped control, which does. The consequence of this is that the soldier, when slowing, might experience an unexpected control action that detracts from the immersive quality of the system.

2. Maximum output is currently limited to 2.0 meters/second. We can change a jumper on the servo amp and instantly double that. When you want the unit to fly apart, that's what we'll do.

3. System lag is velocity dependent. Once a user is at speed, the lag is on the order of 0.055 seconds, or about 18 Hz. We have a dead zone which permits the immersant to stand still. Once that zone is "perforated", the system becomes dynamic. The consequence of no deadband is that there is “always” some error from center, and therefore the ODT surface is “always” moving. Not good.

VISUAL SYSTEM

1. Resolution and FOV have already been reported.
2. Subject viewing distance: 39 inches
3. IG update rate: Observed to be around 15 Hz in the McKenna database, 30 in the 29 Palms. The computer that Bravo was using during the experiments had to be substituted during the last week of the USEX. The computer used during this final week was not as powerful and Bravo suffered with update rates of <10 Hz at times in the McKenna database.
4. Total system lag: Unknown

WEAPON AIMING

Weapon aiming performance is not specified, but Bravo’s electromagnetic tracking system was a known problem going into the experiments. Attempts were made by RBD to improve aiming performance with limited success. Aiming error seemed less when aiming north and appeared to increase as one aimed at targets that appeared closer behind the subject to the south. Aiming error was so great that often the target did not appear within the IHAS FOV (approximately 25° H x 20° V) when the weapon was aimed at the target projected on the screen. The soldier had to “hunt around” with the rifle to get the target into the IHAS FOV. This poor performance was repeatable.

4.5.4.2.3 VIC Charlie

LOCOMOTION

Locomotion was achieved by using the flybox joystick to control the direction of movement and a slide pot-type control for forward and backward velocity. Again, velocity was limited to 3.5 m/s.

Pushbuttons controlled posture changes between standing, kneeling, and prone.

VISUAL SYSTEM

1. Resolution and FOV have already been reported.
2. Subject viewing distance: approximately 22 inches
3. IG update rate: Observed to be around 15 Hz in the McKenna database, 30 in the 29 Palms.
4. Total system lag: Unknown

WEAPON AIMING

Aiming was accomplished by the same joystick that was used to control direction of motion and line of sight. Initially, the output function was a simple linear function of control displacement, i.e., output = k x input. This proved to be too sensitive for the final, fine control for aiming. The control function was changed to a square (output = k x input^2), which improved but clearly did not optimize performance. This once again demonstrates the control display ratio dichotomy for gross versus fine control movements.

4.5.4.2.4 VIC Foxtrot

LOCOMOTION:

1. We have been considering using weights on the foot pad for calibration purposes but haven't done that yet. The current foot pad electronics are also not adjustable for calibration yet. Also, the force sensors we are using at Ft. Benning (*and engineering experiments*) are not the ones we normally use. The correct ones are still on order. The ones at Ft. Benning do not have as good of a "feel" as the ones on our other systems.

The algorithm we use for converting force (input) to output is a simple output = input squared function with an input range of 0 to 1. This in effect gives a deadband around 0 with an exponential increase.

2. Our input device (foot pad, mouse, joystick or whatever) produces a value between 0 and +-1.0. 1.0 is full forward and -1.0 is full backward. Our motion equations use this value along with other configuration constants (maximum velocity and momentum) to determine movement rates. The same is also true for rotation rates.

We currently have the system configured with almost no rotational momentum and little linear momentum. This give us responsive movement but not necessarily realistic movement. The system can be configured for more realistic movement.

3. The foot pad (for linear movement) and the head tracker (for angular movement) are sampled at 100 Hz in a asynchronous process. The foot pad has a 1/10000 of a second lag and the head tracker has a 1/60 of a second internal lag. The simulation loop normally runs at frame rate (60 Hz for 29 palms and either 30 0r 60 Hz for MOUT). This gives a variable lag of up to 1/100 of a second. The graphics rendering system also adds a two frame delay. This gives a worst case lag (30 Hz MOUT database) of 0.093 second for rotation and 0.077 second for linear motion.

VISUAL SYSTEM:

1. The screen resolution is 1280 by 1024 pixels which gives a 10 by 8 foot screen a pixel size of about 1/10 of an inch. The field of view depends on the viewers position relative to the screen.

2. Average viewing distance is around 5 feet from screen.

3. 60 Hz for 29 Palms and either 30 0r 60 Hz for MOUT.

4. Worst case for head tracker is 1/60 for tracker + 1/100 for asynchronous communication + 2/30 for two frames at 30 Hz = 0.093 second.

WEAPON AIMING:

1. The ultrasonic tracker has a resolution of around a tenth of a millimeter with a useable accuracy of around a millimeter. This normally holds true over it's 2 meter range but we were only getting reliable samples when the range was less than a meter (standing). I believe this was due to background noise.

The magnetic tracker has a resolution of better than a tenth of an inch with a useable accuracy of around a quarter of an inch (best case). The absolute accuracy of this tracker can be off by several feet at the fringes of it's range or when the point being measured is near something metallic.

Weapon accuracy is dependent on both trackers. The ultrasonic tracker is responsible for locating the position of the weapon boresight vector in 3D space. The magnetic tracker is responsible for locating the viewer's position in 3D space so the proper image can be drawn for the viewer.

2. The ultrasonic tracker is gives good accuracy and repeatability in a laboratory environment but has given us problems in the DWN environment which has limited use to the standing position only. Kneeling and prone use are too unreliable in the DWN environment to be of any use. The magnetic tracker gives consistently inaccurate results.

3. The ultrasonic tracker has a maximum update rate of about 5 Hz which gives a lag of around 0.2 seconds. The weapon tracker is also in an asynchronous process which can add an additional 1/100 of a second for communication.

To get reasonable measurements for weapon accuracy, you will need to put the weapon and head tracker in a fixture and take measurements. These measurements will have to be made from various locations relative to the screen because the weapon accuracy varies greatly over the useable working volume.

4.5.5 Questionnaire Results

ARI personnel developed, administered, and analyzed questionnaires used to investigate general issues such as simulator sickness as well as specific VIC performance issues. This section presents the results of the analysis of this questionnaire data. Copies of all of the questionnaire instruments are provided in Appendix B.

4.5.5.1 Questionnaires and Administration

A total of nine questionnaires were administered to the participants over the course of the experiments, some on multiple occasions. Table 4.5.5.1-1 provides a list of the questionnaires and the times when they were administered. The following paragraphs provide a description of each questionnaire.

Biographical Information Questionnaire. The Biographical Information Questionnaire was used to obtain background information about the participants. The questionnaire asked for information about the participants' military background, computer use, video game use, simulator use, vision, sense of direction, and two risk factors, susceptibility to motion sickness and history of epilepsy or seizures. The Biographical Information Questionnaire was administered once, on the day prior to the start of the experimental trials.

Table 4.5.5.1-1. Dismounted Warrior Network Engineering Experiments Questionnaire Administration and Interview Schedule.

Questionnaire	When Administered
Biographical Information Questionnaire	On the first day prior to first VIC use
Immersive Tendencies Questionnaire (ITQ)	On the first day prior to first VIC use
Comfort Questionnaire (CQ)	At the beginning of each day prior to first VIC use
Simulator Sickness Questionnaire (SSQ)	At the beginning of each day prior to first VIC use After each set of two VIC sessions.
Task Difficulty Questionnaire (TDQ)	After completing all sessions on each VIC
Presence Questionnaire (PQ)	After completing all sessions on each VIC
Post Difficulty Questionnaire	After completing all sessions on all VICs
Post Realism Questionnaire	After completing all sessions on all VICs
Group Interview	After completing all sessions on all VICs and all questionnaires

Immersive Tendencies Questionnaire (ITQ). The Immersive Tendencies Questionnaire was developed by Witmer and Singer [ref 7] to assess an individual's pre-existing tendency to become involved in activities. It consists of 33 items to which the participant responds using a seven-point scale and one additional question that asks about reading preferences. Scoring produces three subscale scores: Tendency to maintain focus on current activities; Tendency to become involved in activities; and Tendency to play video games. The Immersive Tendencies Questionnaire was administered once, on the day prior to the start of the experimental trials.

Comfort Questionnaire. The Comfort Questionnaire was administered at the beginning of each of the 12 days of experimental trials. It inquired about the participant's state of health, use of medications, and amount of sleep the previous night. It also asked if there had been any delayed or after effects of previous VIC use.

Simulator Sickness Questionnaire (SSQ). Questionnaires or symptom checklists are the usual means of measuring simulator sickness. The SSQ described by Kennedy, Lane, Berbaum, and Lilienthal [ref 5], consists of 16 symptoms that are rated by the subject on a 4-point scale (0=absent, 1=slight, 2=moderate, 3=severe). These ratings form the basis for three subscale scores - Nausea, Oculomotor Discomfort, and Disorientation - as well as a Total Severity score. The symptoms making up the three factor scores are as follows: Nausea - general discomfort, increased salivation, sweating, nausea, difficulty concentrating, stomach awareness, and burping; Oculomotor - general discomfort, fatigue, headache, eyestrain, difficulty focusing, difficulty concentrating, and blurred vision; and Disorientation - difficulty focusing, nausea, fullness of head, blurred vision, dizzy (eyes open), dizzy (eyes closed), and vertigo. The Total Severity score is based on a weighted sum of symptom scores. For this experiment the SSQ was modified slightly by replacing the "sweating" symptom with two symptoms, "warm sweating" and 'cold sweating." Only the cold sweating symptom was scored. This was done to prevent SSQ scores from being artificially inflated by the sweating that results from normal physical exertion. The SSQ was administered each day before the beginning of VIC use, and after each participant completed his pair of sessions and began his break.

Task Difficulty Questionnaire. The Task Difficulty Questionnaire was administered to each participant when they completed their three-day period of use of each VIC. It consists of fifteen items which inquire about the difficulty of performing various tasks (e.g., search for targets) using the VIC. Each item is scored on a five-point scale ranging from Very Easy to Very Difficult.

Presence Questionnaire (PQ). The PQ was developed by Witmer and Singer [ref 7] to assess the degree to which an individual experiences a sense of "presence" or immersion in a virtual environment and the influence of possible contributing factors on the intensity of this experience. It consists of 32 items to which the participant responds on a seven-point scale. Scoring produces six subscale scores: Involved/Control, Naturalness, Interface Quality, Auditory, Haptic, and Resolution. The PQ was administered to each participant when they completed their three-day period of use of each VIC.

Post Difficulty Questionnaire. The Post Difficulty Questionnaire was given to participants after they had completed all of their session on all of the VICs. It used the same task list as did the Task Difficulty Questionnaire, but asked the participants to rank order the VICs from 1 (easiest VIC on which to perform the task) to 4 (most difficult VIC on which to perform the task).

Post Realism Questionnaire. The Post Realism Questionnaire was administered immediately after the Post Difficulty Questionnaire, to which it was very similar. Again, the participants had to rank order the VICs on each of the 15 tasks. However this time the ordering was on the basis of how realistic their performance of the task was on that VIC, from 1 (most realistic VIC for performing that task) to 4 (least realistic VIC for performing that task).

Group Interview. After all VIC sessions on all VICs were completed, and all questionnaires completed, all participants were assembled for a group interview. The purpose of this interview was obtain free-form ideas and comments about the VICs from and in the words of the soldiers who actually used them. Questions asked included the following:

- Which VIC would you most like to use during the user exercises? Why?
- Which VIC would you least like to use during the user exercises? Why?
- Which VIC was best for detecting targets? Why?
- Which VIC was best for estimating distances? Why?
- Which VIC was best for moving? Why?
- Which VIC was best for maintaining orientation? Why?
- Which VIC was best for engaging targets? Why?

- Why did simulator sickness decline during the three weeks??
- Which VIC caused the most simulator sickness problems?

These questions were not asked to obtain frequency counts of the responses, but to generate discussion.

4.5.5.2 Results

Participants/ Biographical Information Questionnaire

Participants were eight male soldiers from Fort Benning GA. All were between the ages of 19 and 30, and in the Mechanized Infantry MOS (11M). Two were sergeants (E-5), and the remainder were either PFCs (E-3) or PV2s (E-2). Time in service varied from 11 to 121 months, with a median (MD) of 17 months.

All reported having normal color vision and vision and seven of the eight reported normal visual acuity. None had a history of seizures. Two reported some susceptibility to motion sickness.

Computer use varied from zero to twenty hours per week (MD = 5), and video game use varied from zero to sixty hours per week (MD = 5.5). Confidence using computers varied from low (two participants) to high (also two participants), with four of the participants reporting average confidence. Five of the eight reported enjoying playing video games, and seven of the eight reported average or better video game skills. Five participants reported having some experience with VR, and five reported having some experience with simulators. Two reported having both.

Immersive Tendencies Questionnaire

The means for each item on the ITQ are shown in Appendix C. While there was considerably variability among the participants, the overall picture that emerges is that of a group of soldiers who perceive themselves as being good at concentrating on tasks and blocking out distractions (items 14, 28, 34, and 9), but are nevertheless not likely to become so involved in an activity that they do not remain aware of what is happening around them (items 2, 4, 6,11, 19, 21, 31, and 32), except perhaps if that activity is sports (items 10 and 13).

Comfort Questionnaire

Participants usually reported being in good condition or their "normal state of fitness." However, head colds were reported by four participants. Two reported colds on four separate days, and two reported colds on only one day. One participant reported taking over-the-counter cold medication on two days. The mean SSQ Total Severity score on the morning pretest for those reporting colds was 5.61, as opposed to 1.13 overall. The mean SSQ Total Severity score on the questionnaires administered after the sessions for those reporting colds was 3.62, as opposed to 1.30 overall.

The amount of sleep reported was highly variable. The mean was 6.48, but ranged from 0 to 11 hours. Individuals reported having received insufficient sleep on 10 of 96 possible occasions, averaging 4.00 hours of sleep. (Seven of the ten reports of insufficient sleep were by the same individual.) The mean SSQ Total Severity score on the morning pretest for those reporting insufficient sleep was 3.37, as opposed to 1.13 overall. The mean SSQ Total Severity score on the questionnaires administered after the sessions for those reporting insufficient sleep was 2.87, as opposed to 1.30 overall. There was only one report of delayed aftereffects, a headache.

Of the 18 participant-days involving either colds or insufficient sleep, seven were spent on VIC Charlie, six on VIC Alpha, three on VIC Bravo, and two on VIC Foxtrot.

Presence Questionnaire

Appendix C also shows the mean score for each VIC on each of the 32 items on the Presence Questionnaire. Two issues are of interest. First, what aspects of the experience were viewed most positively and most negatively, across all VIC, by the participants? Second, were there significant differences among the VICs in how the participants viewed their experience?

Each of the 32 items was scored on a 7-point scale with 1 representing the most negative response, 7 representing the most positive response, and 4 representing the midpoint. Individual item scores ranges from 2.62 to 6.19. Ten items received a mean greater than 5.50, indicating a response in one of the top two categories on the scale. These items and their means are shown in Table 4.5.5.2-1.

Taken as a whole, these items indicate that the participants felt involved in the virtual environment experience. In contrast, there were no items on which the means fell on the opposite portion of the scale (below 2.5). There were only three items on which means fell below 4.0, the mid-point of the scale. These are shown in Table 4.5.5.2-2. Two of these items inquired about the use of touch and the manipulation of objects in the VICs. Since no objects were manipulated directly or touched when using VIC Charlie, and only the individual weapons were touched when using the other VICs, it is not surprising that these means were relatively low. The third item (number 27) indicates that use of the displays and control devices did require some attention on the part of the participants.

Table 4.5.5.2-1 Presence Questionnaire items having means greater than 5.50.

Item #	Item Stem	Mean
20	How quickly did you adjust to the virtual environment experience?	6.19
11	How well could you identify sounds?	6.12
21	How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?	6.06
18	How involved were you in the virtual environment experience?	5.88
10	How completely were you able to actively survey or search the environment using vision?	5.66
25	How completely were your senses engaged in this experience?	5.66
30	Were there moments during the virtual environment experience when you felt completely focused on the task or environment?	5.66
31	How easily did you adjust to the control devices used to interact with the virtual environment?	5.66
4	How much did the visual aspects of the environment involve you?	5.62
24	How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?	5.59

Total PQ scores, subscale scores, and individual questionnaire item scores were compared between VICs using a one factor (VIC) within-subjects ANOVA to determine whether, and on which aspects of presence, the VICs may have differed. Overall Presence Questionnaire means were 97.25 for VIC Alpha, 100.63 for VIC Bravo, 92.75 for VIC Charlie, and 105.75 for VIC Foxtrot. These means were not significantly different.

Table 4.5.5.2-2 Presence Questionnaire items having means less than 4.00

Item #	Item Stem	Mean
13	How well could you actively survey or search the virtual environment using touch?	2.62
17	How well could you move or manipulate objects in the virtual environment?	3.81
27	Overall, how much did you focus on using the display and control devices instead of the virtual experience and experimental tasks?	3.94

For five of the 32 items there was a difference among the response among the VICs that achieved ($p< .05$) or approached ($.05<p<.10$) statistical significance. These items are shown in Table 4.5.5.2-3. Participants reported being able to survey or search the VE using touch better with VIC Foxtrot than the other VICs; having the most compelling sense of moving around inside the VE with VIC Foxtrot and Bravo, and least with VIC Charlie; being able to adjust to the VE most quickly with VIC Foxtrot and VIC Charlie, and least quickly with VIC Bravo and VIC Alpha (although adjustment overall was considered quick); visual display quality was most interfering with VICs Bravo and Alpha, and least with VICs Foxtrot and Charlie; identifying objects through physical interaction was easiest with VIC Foxtrot, and most difficult with VIC Alpha.

The differences among the means of the Interface Quality Subscale for the different means approached statistical significance (p=.068). In general, the participants found the display and control devices for VICs Charlie and Foxtrot to be less interfering than those for VICs Alpha and Bravo. The means are shown in Table 4.5.5.2-4.

Table 4.5.5.2-3 Presence Questionnaire Items for which the differences among VICs achieved (p<.05) or approached (p<.10) significance

Item #	Item Stem	p	Alpha	Bravo	Charlie	Foxtrot
13	How well could you actively survey or search the virtual environment using touch?	.006	1.88	2.88	1.25	4.50
14	How compelling was your sense of moving around inside the virtual environment?	.067	5.00	5.50	4.12	5.88
20	How quickly did you adjust to the virtual environment experience?	.025	6.00	5.63	6.50	6.62
22	How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?	.004	4.38	4.38	6.12	6.00
29	How easy was it to identify objects through physical interaction; like touching an object, walking over a surface, or bumping into a wall or object?	.079	3.00	4.50	4.50	5.75

Table 4.5.5.2-4 Interface Quality Subscale totals and item means, by VIC.

No.	Item Stem	p	Alpha	Bravo	Charlie	Foxtrot
	Interface Quality Subscale (Means of items 22, 23, and 24)	.068	4.79	4.91	5.71	5.59
22	How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?	.004	4.38	4.37	6.13	6.00
23	How much did the control devices interfere with the performance of assigned tasks or other activities?	NA	4.75	4.62	5.00	5.38
24	How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?	NA	5.25	5.75	6.00	5.38

<u>Task Difficulty Questionnaire</u>

The overall means of the fifteen items on the Task Difficulty Questionnaire are shown in Table 4.5.5.2-5. These were the questionnaires that were completed immediately after each participant completed using each of the VICs. The means in Table 4.5.5.2-5 are shown in order of decreasing difficulty. Perhaps the most interesting result in this table is that all of the means fall between 3.00 ("Neither Easy nor Difficult") and 1.00 ("Very Easy"). In other words, the participants did not find the tasks difficult to perform. Estimating distances to people or objects and moving without bumping into object were considered to be the most difficult tasks, while identifying landmarks and engaging stationary targets were considered to be the easiest.

Table 4.5.5.2-5 Mean Difficulty Ratings (across VICs) for Tasks and Functions, in Order of Decreasing Difficulty.

Task	Mean Difficulty
Estimate distances to people or vehicles	2.57
Move without bumping into objects	2.53
Identify people or vehicles	2.38
Move tactically	2.16
Maintain orientation while moving inside buildings	2.10
Change direction while moving	2.10
Detect people or vehicles	1.91
Detect targets while moving	1.85
Engage moving targets	1.82
Maintain balance while moving	1.78
Move in a straight line	1.69
Search for targets	1.60
Maintain orientation while moving out of doors	1.60
Identify landmarks	1.51
Engage stationary targets	1.47

Each mean is based on 32 responses.

Table 4.5.5.2-6 shows the same ratings across VICs. In addition to the individual item means, the table also shows the means for five functions, formed from groups of items. The functions are: vision, locomotion, navigation, target engagement, and tactical action. Individual items and function categories were compared between VICs using a one factor (VIC) within-subject ANOVA to determine whether, and on which aspects of difficulty, the VICs may have differed. The VICs differed significantly on five of the fifteen items and one of the five function means.

Most of the differences among the VICs involve locomotion. Overall, locomotion was considered most difficult in VIC Bravo and easiest in VIC Foxtrot and VIC Charlie. Maintaining balance while moving and changing direction while moving were particularly difficult with VIC Bravo. Other significant differences involved detecting people or vehicles and identifying landmarks. Both tasks were most difficult on VIC Bravo and easiest on VIC Charlie and VIC Foxtrot.

Table 4.5.5.2-6 Dismounted Warrior Network Engineering Experiments Post Session Difficulty Ratings

VIC	*p*	Difficulty Rating			
		Alpha	Bravo	Charlie	Foxtrot
1. Detect people or vehicles	.046	2.13	2.50	1.50	1.50
2. Identify people or vehicles		2.50	2.88	1.88	2.25
3. Estimate distances to people or vehicles		2.50	2.50	2.63	2.63
4. Search for targets		1.63	1.88	1.50	1.38
Vision Mean (items 1-4)		2.19	2.44	1.88	1.94
5. Move in a straight line	.018	2.00	2.25	1.25	1.25
6. Move without bumping into objects		2.75	2.63	2.75	2.00
7. Maintain balance while moving	.000	1.38	3.25	1.13	1.38
8. Change direction while moving	.006	2.00	3.25	1.75	1.38
Locomotion Mean (items 5-8)	.000	2.03	2.85	1.72	1.50
9. Identify Landmarks	.033	1.63	1.88	1.13	1.38
10. Maintain orientation while moving inside buildings		2.13	2.25	2.13	1.88
11. Maintain orientation while moving out of doors		1.75	1.88	1.38	1.38
Navigation Mean (items 9-11)		1.84	2.00	1.55	1.55
12. Engage stationary targets		1.50	1.50	1.75	1.13
13. Engage moving targets		2.13	1.75	2.00	1.38
Target Engagement Mean (items 12-13)		1.82	1.63	1.88	1.63
14. Move tactically		2.63	2.38	2.13	1.50
15. Detect targets while moving		1.88	2.13	1.63	1.75
Tactical Action Mean (items 14-15)		2.26	2.26	1.88	1.63

Note: Low means indicate low difficulty. Each mean is based on eight responses.

Post Difficulty Questionnaire

The Post Difficulty Questionnaire asked the participants to rank order each of the VICs, on the same tasks as on the Task Difficulty Questionnaire, from easiest (1) to most difficult (4). Ties were permitted. The results are shown in Table 4.5.5.2-7. Mean VIC rankings on individual items and function categories were compared using a Friedman non-parametric test for multiple related samples to determine whether there were differences among the VICs in terms of ranked difficulty. Overall, the pattern of results is very much the same as the Task Difficulty Questionnaire, with only the differences involving the locomotion mean and three of the locomotion tasks (move in a straight line, maintain balance while moving, and change direction while moving) being statistically significant. For each of those tasks, the same order was obtained: from easy to difficult, VIC Charlie, VIC Foxtrot, VIC Alpha, and VIC Bravo.

Table 4.5.5.2-7 Dismounted Warrior Network Engineering Experiments Post Session Difficulty Rankings

VIC	p	Difficulty Ranking Alpha	Bravo	Charlie	Foxtrot
1. Detect people or vehicles		2.69	2.94	2.31	2.06
2. Identify people or vehicles	.099	3.00	3.06	1.69	2.25
3. Estimate distances to people or vehicles		2.63	3.06	2.38	1.94
4. Search for targets		2.44	2.94	2.25	2.38
Visual Mean (Mean of items 1-4)		2.69	3.00	2.16	2.16
5. Move in a straight line	.020	2.56	3.56	1.88	2.00
6. Move without bumping into objects		2.44	2.63	2.44	2.50
7. Maintain balance while moving	.002	2.13	3.88	1.75	2.25
8. Change direction while moving	.006	3.06	3.50	1.69	1.75
Locomotion Mean (Mean of items 5-8)	.005	2.55	3.39	1.94	2.13
9. Identify Landmarks		2.31	3.19	2.31	2.19
10. Maintain orientation while moving inside buildings		2.94	2.88	1.81	2.38
11. Maintain orientation while moving out of doors		2.69	2.81	2.56	1.94
Navigation Mean (Mean of items 9-11)		2.65	2.96	2.23	2.17
12. Engage stationary targets		3.00	2.75	2.50	1.75
13. Engage moving targets		2.88	3.00	2.38	1.75
Target Engagement Mean (Mean of items 12-13)		2.94	2.88	2.44	1.75
14. Move tactically		2.38	3.38	2.25	2.00
15. Detect targets while moving		2.44	2.81	2.44	2.31
Tactical Action Mean (Mean of items 14-15)		2.41	3.10	2.35	2.16

Note: Low means low difficulty. Each individual mean is based on eight responses.

Post Realism Questionnaire

The Post Realism Questionnaire contained the same items as the Post Difficulty Questionnaire, but the participants ranked the VICs in order of the realism of the way they performed the task, rather than the difficulty. Mean rankings on individual items and function categories were compared between VICs using a Friedman non-parametric test for multiple related samples to determine whether, and on which aspects of task realism the VICs may have differed. The results are shown in Table 4.5.5.2-8. None of the differences among the means were statistically significant, although the means for two of the items ("move in a straight line" and "maintain balance while moving") approached significance. Those responses suggested that performance of those tasks was less realistic with VIC Bravo than the others.

Table 4.5.5.2-8 Dismounted Warrior Network Engineering Experiments Post Experiment Realism Rankings

VIC	*p*	Realism Ranking			
		Alpha	Bravo	Charlie	Foxtrot
1. Detect people or vehicles		2.50	2.62	2.94	1.94
2. Identify people or vehicles		2.38	2.88	2.25	2.50
3. Estimate distances to people or vehicles		2.06	2.75	3.19	2.00
4. Search for targets		2.00	2.88	2.87	2.25
Visual Mean		2.24	2.78	2.81	2.17
5. Move in a straight line	.084	2.31	3.38	2.25	2.06
6. Move without bumping into objects		2.44	3.19	2.06	2.31
7. Maintain balance while moving	.088	2.50	3.38	2.00	2.13
8. Change direction while moving		2.69	3.00	2.00	2.31
Locomotion Mean		2.49	3.24	2.08	2.20
9. Identify Landmarks		2.44	2.69	2.44	2.44
10. Maintain orientation while moving inside buildings		2.44	2.81	2.31	2.44
11. Maintain orientation while moving out of doors		2.44	2.44	2.81	2.31
Navigation Mean		2.44	2.65	2.52	2.40
12. Engage stationary targets		2.69	2.44	2.50	2.38
13. Engage moving targets		2.50	2.75	2.75	2.00
Target Engagement Mean		2.60	2.60	2.63	2.19
14. Move tactically		2.50	3.00	2.25	2.25
15. Detect targets while moving		2.06	2.63	2.75	2.56
Tactical Action Mean		2.28	2.82	2.50	2.41

Note: Low means indicate high realism.

<u>Simulator Sickness Questionnaire</u>

The results of the SSQ administrations are presented graphically in Figure 4.5.5.2-1. The "pre" scores are based on the 96 questionnaires administered in the mornings prior to the first VIC use of the day. The scores for the VICs are based on the 72 questionnaires for each VIC which were administered after each pair of sessions of VIC use. Individual items and subscales were compared using a one factor (VIC type) within-subjects ANOVA to determine whether, and for which symptoms the VICs may have differed. None of the differences among the VICs, or between the pre and post session scores, are statistically significant. The means for VIC Alpha are somewhat elevated by the scores of one soldier on one day, who reported having a head cold and obtained a TS score of 22.44 on the pre-session and four of five post-session SSQs. Had his scores for that day not been included, the VIC Alpha overall TS mean would have been 0.89 instead of 2.34.

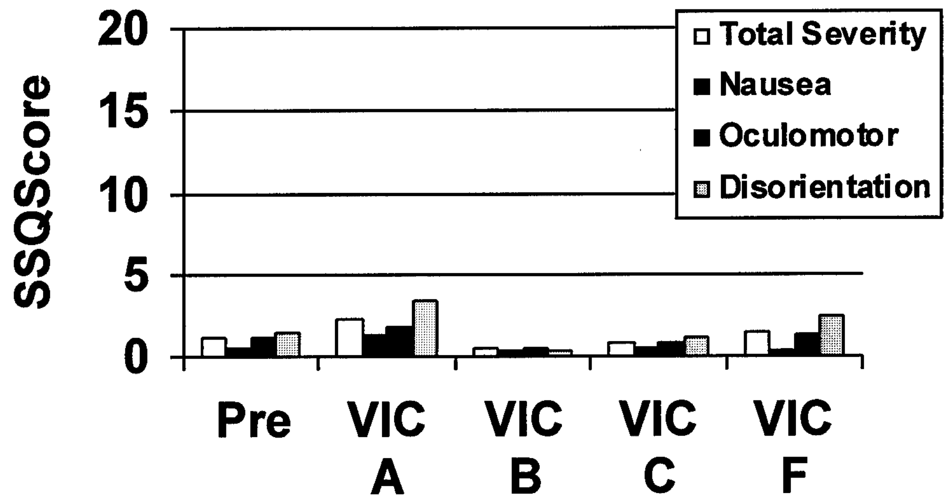


Figure 4.5.5.2-1. Simulator Sickness Questionnaire (SSQ) scores as a function of VIC.

Table 4.5.5.2-9 shows the frequency rate for each of the symptoms, across all VICs. The entries in the cells show the proportion of questionnaires that showed that particular symptom. "Fullness of the head," fatigue, general discomfort, and headache were the most frequent symptoms reported. Interestingly, each of these symptoms occurred at least as frequently before VIC use as they did after. The results do suggest that the characteristics of the VIC may affect the particular symptoms reported. For example, VIC Alpha users seemed more likely to report symptoms of full head and fatigue, while users of VIC Bravo seemed less likely to report those symptoms.

Table 4.5.5.2-9 Simulator Sickness Questionnaire. Symptom Frequency Rate by VIC

	Pre	Post	Alpha	Bravo	Charlie	Foxtrot
"Fullness of the head"	0.10	0.10	0.22	0.03	0.08	0.06
Fatigue	0.08	0.06	0.14	0.03	0.01	0.06
General discomfort	0.04	0.03	0.04	0.03	0.06	0.01
Headache	0.03	0.02	0.06	0.00	0.00	0.01
Eyestrain	0.00	0.01	0.03	0.00	0.03	0.00
Difficulty Focusing	0.00	0.01	0.00	0.00	0.00	0.06
Cold Sweating	0.00	0.01	0.03	0.01	0.00	0.01
Nausea	0.00	0.01	0.03	0.00	0.00	0.01
Blurred vision	0.00	0.01	0.00	0.00	0.00	0.04
Salivation increased	0.01	0.01	0.03	0.00	0.00	0.00
Difficulty concentrating	0.00	0.00	0.01	0.00	0.00	0.00
Dizzy eyes open	0.00	0.00	0.00	0.00	0.00	0.01

Some participants were more likely to report symptoms than others. See Figure 2. Two participants never reported any symptoms. This may reflect differences in individual susceptibility, or differences in willingness to report symptoms.

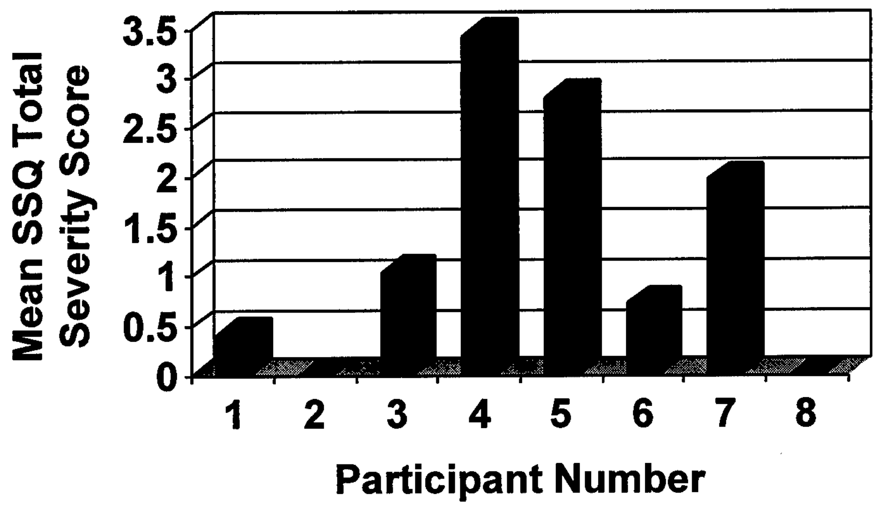


Figure 4.5.5.2-2. Mean SSQ Total Severity score for each participant.

While the prevalence of symptoms by day was somewhat erratic, as shown in Figure 3, the overall trend was for a decrease in symptoms as the participants became more familiar with the VICs.

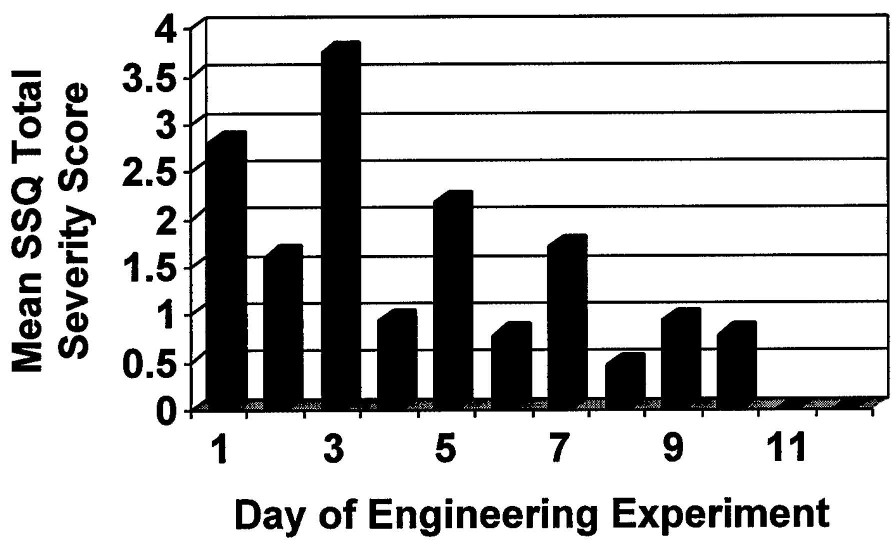


Figure 4.5.5.2-3. Mean SSQ Total Severity score as a function of the duration of the Engineering Experiment.

Group Interview Results

Soldiers had different opinions about the VICs, and the characteristics they liked and disliked. There was no consensus about which was best or which was worst, either overall or for different activities. Features or characteristics that were liked by some were disliked by others. A summary of the opinions expressed regarding each VIC follows.

VIC Alpha. Movement was difficult and unrealistic. You had to stop to make a turn, and had to alternately stop and go to maintain an intermediate speed. The small field of view made it difficult to maintain orientation. Putting on and taking off the equipment and calibrating the system are time consuming. Visual quality is poor, and makes it impossible to see anything beyond about 400 meters. The small inter-pupillary distance (authors' term) caused simulator sickness problems. (Note: Inter-pupillary distance is adjustable on Alpha's HMD).

VIC Bravo. Movement was more like the real thing than the other VICs, but the force/resistance needs adjustment. It was difficult to make a sharp turn. Movement was slower than on the others. It was involving. You were actually doing something. The visual quality was poor, partially because of the high level of background illumination. The displays provided a good 360 degree field of view, except for the corners. This made it easier to maintain orientation. The system creates oil fumes, which smell bad and cause headaches.

VIC Charlie. It was like a video game. The joystick needs adjustment, and the speed control should be on the joystick. Nevertheless, movement was easy. It was good for tactical movement, and you could do more in prone and kneeling positions than the others. Visual resolution was good, and you could look in directions other than the one you are moving in. The visual image of the weapon does not point where the crosshairs are aimed.

VIC Foxtrot. This was easy to go through buildings with, although movement was too fast. Easy, realistic target engagement. Aiming was realistic, and reloading was good. The tracers let you see where rounds were going. Visual resolution was good and you could look around corners.

4.5.5.3 Discussion

One of the more interesting findings was the general lack of perceived difficulty of the tasks that the soldiers were required to perform. None of the tasks were considered to be harder than "Neither Easy nor Difficult," the midpoint of the rating scale. This must be considered in the light of two other factors. First, the soldiers received no feedback on their performance other than that inherent in the tasks itself. Even this had some restrictions, for example, holes did not appear in targets when they were hit. Particularly on the visual tasks, soldiers may have been unable to tell whether they were performing better on one VIC than another. Second, many of these tasks, particularly the locomotion tasks ("move without bumping into objects" or "change direction without moving", for example), would have been very easy in the real world. That participants who had practiced them over a three-day period would consider then to be anything but very easy indicates that there is still room for improvement in the interfaces.

Among the means of providing self-movement, the VIC Foxtrot system which used a pedal control to move the soldier in the direction his head was pointed was considered to be the least difficult and most realistic of the alternatives. At the other extreme, the VIC Bravo Omni-directional Treadmill (ODT) was considered the most difficult and least natural. This latter result may be in part to the fact that only VIC Bravo required any real physical exertion to move at or near its maximum speed. However, based on the interview comments and observations, it appears that the ODT also required: (a) a slightly modified walking gait (feet separated laterally more than normal); and careful attention to the position and movement of the trunk of one's body in order to avoid being repositioned by the force feedback mechanism. The VIC Charlie joystick was also well received, despite comments that it required adjustment. The computer game and video game experience of the soldiers apparently made it quite easy for them to adapt to joystick use. The questionnaire data were generally consistent with the performance data. Ratings of ease of locomotion closely matched the course completion times for the VICs. The more rapidly the soldiers completed the course using a particular VIC, the easier they rated its use.

There were few significant differences among the ratings on the visual tasks, however, the overall pattern tended to mirror the visual resolution of the visual displays. The higher the resolution, the easier it was to perform visual tasks on that VIC. Thus the two VICs with 1280 x 1024 pixel displays (VIC Charlie and VIC Foxtrot) were generally considered the easiest VICs with which to perform the visual tasks. At least for the search time, target detection, target identification, and target recognition data, the rated difficulty of the visual tasks also tended to agree with the performance data.

Clearly, simulator sickness was not a problem during the engineering experiments. Post session TS scores were not significantly greater than pre-session scores, and averaged only 1.29 across VICs. For comparison, Kennedy, Lane, Lilienthal, Berbaum, and Hettinger [ref 6] expressed the view that individuals having scores above 20 require extreme care, and individuals having scores above 15 require careful debriefing. Of the 288 questionnaires administered only five reported scores over 20 and one reported a score between 15 and 20. Five of these six were reported by one individual on one day, who also had a pre-session score over twenty and reported having a head cold. The other occurred following a soldier's first use of any VIC. This represents a very low incidence of simulator sickness. It can probably be attributed to the short duration of each of the experimental sessions and the frequent breaks given the soldiers. Longer sessions or periods of extended use might produce more severe symptoms. Similarly, there was only one report of delayed symptoms, a headache that could easily have been the result of other causes.

4.6 Discussion and Lessons Learned

The DWN engineering experiments were successful in uncovering performance differences among the four VICs for all of the tasks selected for study. The results and implications are discussed below. Lessons learned that are applicable to future experiments are summarized as well.

4.6.1 Locomotion

One of the discriminators for VIC Bravo was its more "natural" locomotion simulation. Objectively, while proving to be the slowest in traversing the course, there is no performance standard to say whether this time to complete may in fact be more representative of the real world. Considering the questionnaire data, it appears that the desired naturalness of the ODT device was not realized. This will come as no surprise to its developers, since the ODT was only intended to be a proof of concept device. As a simulation man-machine interface, it was rated as interfering with task accomplishment and adjustment to the virtual environment (along with VIC Alpha), and low in realism. However, Bravo was rated as providing a compelling sense of moving around. Foxtrot was also rated high in this regard, so the greater visual FOV probably also contributed to this effect.

Foxtrot was liked for its ease of use, but seemed too fast. Objectively, it produced the fastest overall performance, but suffered in the number of collisions. Foxtrot, like Alpha to a large extent, effectively had a bang-bang controller for motion - it was either full on or full off. To achieve intermediate speeds required alternating between stop and go repetitively. Both systems would have benefited from a more continuous control method. Foxtrot also relied on head position (line of sight) to determine direction of motion. This made it difficult to look around while moving in a constant direction. Soldiers did like being able to move up to a corner, get off the control pedal, and walk up to the screen and look around the corner.

Charlie, with its video game or flight controller means of self motion, was well liked and performed well objectively. The joystick control needed to be optimized for its dual use as a motion controller and weapon aiming device.

4.6.2 Visual System

The subjective ratings correlated highly with the objective performance measures of visual system performance. Generally, performance on Charlie and Foxtrot was similar, and both were better than Alpha which in turn was better than Bravo. As was previously noted, both Bravo and Foxtrot were rated as providing the most compelling sense of motion. This was most probably due to their greater fields of view, which stimulated the visual peripheral motion sensors.

The performance of the visual systems as compared to the predictions of classical target acquisition models (Johnson criteria) was inconsistent. Generally, observed performance was significantly better than predicted for all systems. The reason for this performance advantage is unclear. This effect should be further investigated if simulator performance is ever to be correlated with real-world performance, such as for TEMO or certain ACR applications. This effect impacted the attempt to determine animation detection performance as well.

Finally, head-coupled systems such as Alpha's apparently made it difficult to determine if perceived target motion was due to actual target movement or due to self-motion (head movements). This phenomenon has been seen fixed- and rotary-wing applications and appears to carry over to dismounted infantry simulators as well.

4.6.3 Weapon Aiming

The basic result of the aiming experiments is that none of the weapon tracking technologies employed by the VICs were adequate for precision aiming. Foxtrot was perceived by the soldiers as having the most realistic and easiest target acquisition simulation, which is not unexpected since it used an actual (instrumented) rifle and aimed at projected targets using the rifle's own sights. However, Foxtrot's acoustic tracking system proved inadequate for the task. Systems that aimed via sights or crosshairs presented in the imagery all proved to be reasonably accurate even if weapon tracking itself was not very good (e.g., Bravo).

Finally, the VICs that advertised that they could fire from the kneeling and prone positions proved that they could not, at least with the configuration and operational performance they were experiencing from their tracking systems.

4.6.4 Lessons Learned

The major lesson learned is that such an experiment is possible, and that reliable, usable data can be obtained. This has implications beyond the investigation of DI simulation technology to using manned DI simulators for TEMO and ACR/RDA applications. The PDUs provide access to quantitative performance data, and the subjective questionnaire data aids in the interpretation of this performance information.

Specific areas where improvements could be made became apparent during the conduct of the exercises and subsequently during data reduction. The first observation was that using ModSAF to generate the targets added time and unwanted variability to the process of conducting the experimental trials. The targets were at most four single targets with simple motion paths, if any. In most experiments a program would be written to initiate and control the presentation of the targets so onset times could be precisely determined. With ModSAF, target loading was slow, sometimes excruciatingly so, the actual time of their appearance in the database was uncertain and variable, especially for moving targets. In the time required to generate the scenario files for each trial and verify each one, a software program to present the targets could have easily been written by a competent software engineer. In fairness, ModSAF was not developed to be used in the manner it was used during the engineering experiments. This became painfully apparent.

Simulyzer, developed by TASC, was a free data logging software package and performed its function reliably. It's ability to customize which PDUs and which fields within PDUs are recorded was used to our advantage. However, the manner in which it requires a separate file for each PDU type was cumbersome. Even with a fairly long period between trials, the Simulyzer operator was usually furiously clicking and typing on the GUI interface to start and stop recording for each of up to three file and rename files for the next trial. Requiring such heavy operator intervention in the recording process created the opportunity for errors and missed or corrupted data. The fact that this happened so little is a testament to dedication and competence of the Simulyzer operator and is in spite of Simulyzer itself.

Entity state PDU data was recorded for every trial. This turned out to be a mistake. The VICs generated a generous quantity of entity state PDUs, even when the soldiers were "stationary" during visual system trials. During the subsequent data analysis, the entity state PDUs were not used except to determine the start time of a trial, except for locomotion trials data analysis. Location information provided by other PDUs including fire and detonation, can be used in many instances instead of entity state. The volume of entity state data created very large data files that choked Pentium PCs during the reduction process.

Three of the four systems required at least slightly different data formats for location information. Alpha required geocentric coordinates, Foxtrot needed elevation data and at first had problems establishing the correct origin. Bravo and Charlie were the same software so could use the same formats. The geocentric coordinate data used for position and rate information in the entity state PDUs had to be converted prior to analysis. Geocentric data is useless when human interpretation is required, and is a cumbersome nuisance to translate from lat/long, grid, or any other coordinate system that a human is likely to be dealing with.

Finally, more planning was required for the collection of engineering data. Procedures and tools need to be developed and identified well prior to the anticipated data collection period. Many of these tools and procedures are not common or well defined, and creative input from the entire team is needed.

5. User Exercises

5.1 Introduction

As previously discussed in paragraph 1.2.5, the DWN user exercises (USEX) were initiated as a Phase 5 activity that was awarded fairly late in the DWN schedule. The USEX was intended to evaluate the capability of the DWN VIC systems and the overall system of systems to enable the execution of DI small unit tasks and missions within a virtual environment. The data to be collected was more qualitative than during the engineering experiments, with the focus on how well the technology enabled task performance rather than defining specific absolute or relative levels of performance.

The experiments were conducted at the Land Warrior Testbed (LWTB), Ft. Benning, Georgia over a three-week period (May 27 - June 13). Soldiers from Ft. Benning served as subjects; three of the eight soldiers also participated in the earlier engineering experiments. Personnel from Reality by Design (RBD), Veda, VSD, TRAC WSMR and NAWC/TSD provided operational support for the VICs. Additional experiment and site support was provided by LMIS and LMSG personnel from Orlando and Ft. Benning. TRAC-WSMR, who did not participate in the engineering experiments, was involved in this phase of DWN. Their Soldier Station, also designated as VIC Charlie during the USEX, replaced the BAYONET station from RBD used during the engineering experiments. In order to minimize confusion, the name VIC Charlie will be dropped during the USEX discussion and will be replace by explicitly calling this VIC "Soldier Station". If any references to VIC Charlie or VIC C remain in tables or other USEX information, they should be interpreted as referring to Soldier Station.

This section of the report summarizes the experiment purpose (5.2), plan (5.3), results (5.4), and lessons learned (5.5). Experimental results are presented, along with a discussion of these results and overall lessons learned from the experiments.

5.2 Purpose

The USEX was intended to:

- Focus on user needs versus technology capabilities
- Extend testing from the component level to the system and system of systems level
- Assess the ability of the systems to enable small unit task- and mission-level performance versus individual subtask- to task-level performance

With the user focus, much of the USEX planning was conducted by LMIS, LMSG, and Ft. Benning infantry subject matter experts (SMEs), with feedback from the entire DWN team. The data collection requirements, collection instruments, and subsequent data analysis was performed by ARI researchers resident at Ft. Benning. The results of their analyses are summarized in this section; a more detailed treatment will be forthcoming in a separate ARI Ft. Benning report.

5.3 Experiment Plan Overview

The DWN USEX Plan is presented in Appendix D to this report. It is briefly summarized in the following paragraphs.

The basis for the USEX is a series of squad-level mission scenario segments or vignettes. The squad consists of one fireteam of VICs and one of DI SAF, with a manned BAYONET station representing the squad leader. The missions consist of open terrain (29 Palms) exercises in which the squad assaults an enemy position (2 segments) or defends a position against an enemy assault (1 segment), and MOUT (McKenna) exercises in which the VIC fireteam attacks and enters a building in a sniper clearing operation. The DI SAF fireteam, along with Soldier Station, provides cover from enemy forces, since both cannot currently enter buildings. Since Soldier Station was not able to enter buildings, all building clearing operations were conducted with a 3-man (VIC) fireteam. This was unavoidable given system capabilities.

The four VICs from the engineering experiments took part in the USEX basically without modification, with the exception of substituting Soldier Station for BAYONET as VIC Charlie. As mentioned DI SAF were integrated into the scenarios. One SAF station (with operator) generated the BLUFOR fireteam that worked in conjunction with the VICs to complete the squad; a second SAF station (with operator) generated OPFOR for both the 29 Palms and McKenna MOUT scenarios. A manned BAYONET station provided an additional OPFOR entity, primarily as the sniper inside of buildings during the MOUT scenarios.

The layout of the equipment at the LWTB is shown is Figure 5.3-1. VIC Bravo was located in a separate room from the other VICs to minimize noise interference problems. Placing Bravo in a different room also help the light interference problem with VIC Alpha, as did the placement of VIC Foxtrot relative to Alpha. Foxtrot was also enclosed in black plastic to further reduce this problem.

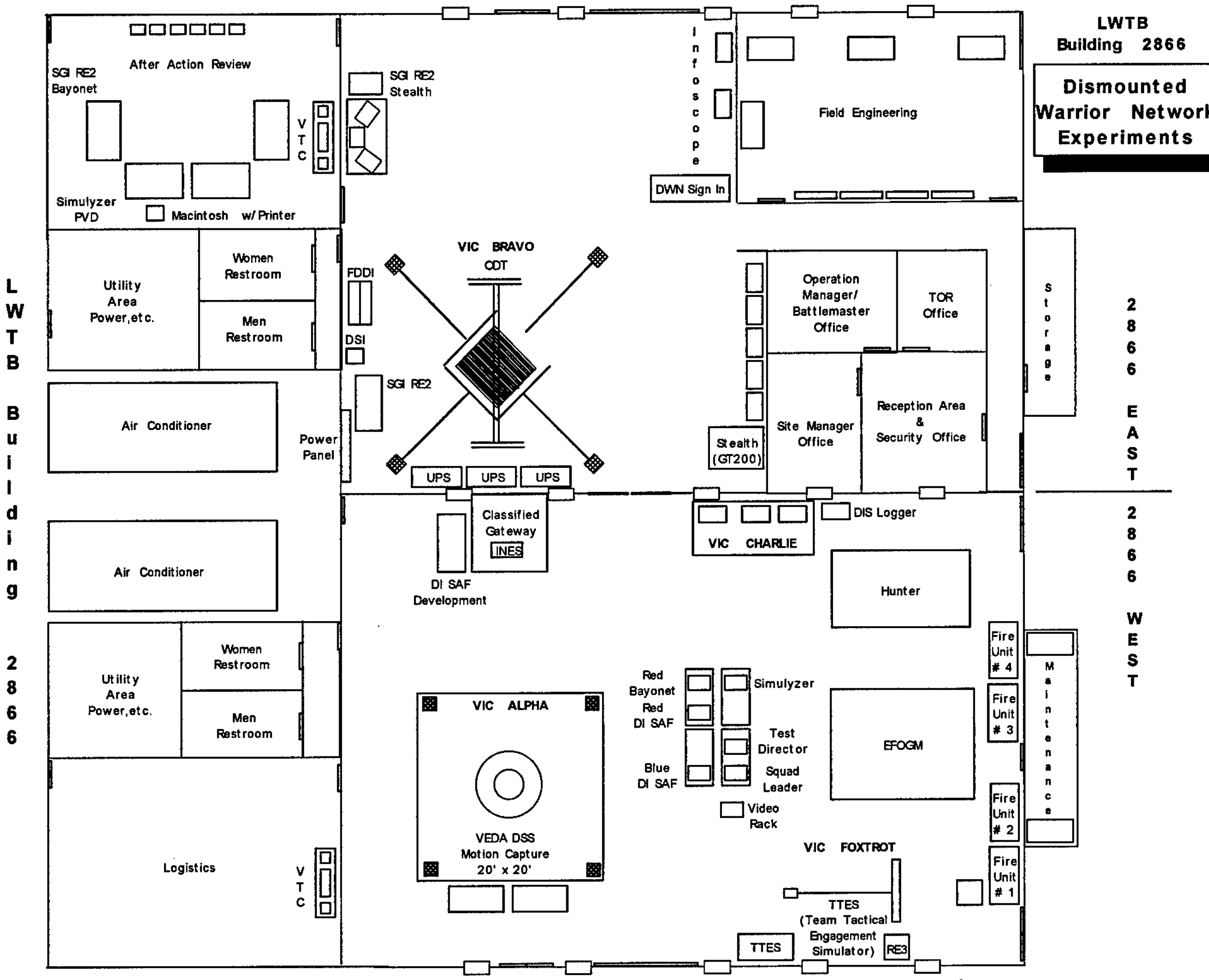


Figure 5.3-1: User Exercise Set-up at the LWTB at Fort Benning

Data collection was primarily through observation and manual event recording by ARI Ft. Benning personnel during the exercises, questionnaire administration during AAR, and follow-up debriefings. All exercise PDUs were logged in a binary logger file using Simulyzer. These were replayed during AAR. Fire and Detonation PDUs were collected in text files at ARI's request. Copies of the questionnaires administered are included in Appendix E.

The first week consisted of training the soldiers on exercises similar to those to be conducted during the data collection sessions. The second week and first two days of the third were data collection exercises. The final three days were reserved for make-up and demonstrations. During the final week, VIC Bravo operated with a less powerful Silicon Graphics computer because the one used up to that point was a leased machine that had to be returned after the second week of the USEX.

5.3.1 Soldier Participants

Eight active duty soldiers stationed at Ft. Benning were provided to serve as subjects over the full three-week period of the USEX. Two were SGTs, three were SPCs, two were PFCs, and one was a PVT.

5.3.2 Training

As previously stated, the first week was allocated to training, including VIC familiarization and any special initialization or calibration required. Training was conducted on both 29 Palms and McKenna MOUT scenarios (given coin and automobile names, respectively, in the USEX plan). During training, it was realized that since Soldier Station could not go into buildings, it was undesirable to have the soldier assigned to Soldier Station be the team leader during MOUT exercises. Therefore, the planned soldier allocation to VICs was modified so that the team leader would not be on Soldier Station for the MOUT scenarios.

5.3.3 Mission Vignette Conduct

The data collection trials, given color names in the USEX plan, were conducted during the second and third weeks of the exercise. The 29 Palms exercises were conducted in their entirety first, followed by all of the McKenna MOUT exercises.

Each exercise began with informing the squad leader role-player which mission vignette was to be run. He then brought the four soldiers who were to man the VICs into a conference room for a prebrief on the mission and tactics. The "off" soldiers also attended the prebrief, observed their counterpart on the VIC to which they had been assigned during the exercise, and attended the subsequent AAR. Meanwhile, the DWN team readied the simulators and initialized the DI SAF stations and data collection station (Simulyzer). Simulyzer recorded a binary log file of the entire exercise that was replayed during after-action review (AAR), as well as logged detonation and fire PDUs for subsequent analysis.

After the prebrief, the soldiers manned the simulators and the data collection exercise was conducted. ARI Ft. Benning data collectors observed each soldier on each VIC and recorded observations on system and soldier performance. The exercise continued until the objective had been achieved or until 3/4 or all of the VIC fireteam had been killed. The exercise was then terminated, the log file transferred to the AAR replay computer, and the squad leader and soldiers (along with the ARI Ft. Benning personnel) went to the conference room for the AAR and post-session debrief. Personnel with a vested interest in a particular VIC were requested not to attend these AAR and debrief sessions to encourage a frank and honest exchange of information between the soldiers and ARI Ft. Benning researchers. Following the AAR, the questionnaires were administered to the soldiers. This entire process was then repeated for the next group of four soldiers. Each session lasted approximately one hour, including the prebrief and AAR.

5.4 Results

The data collection and analysis for the USEX was conducted under the auspices of Ft. Benning ARI personnel. The results reported here were summarized by ARI Ft. Benning and provided to LMIS for inclusion in this report. A more complete presentation and interpretation of the USEX data will be forthcoming in a separate ARI Ft. Benning report.

The primary data was collected using four questionnaire instruments (Appendix E):

1. VIC Capability Assessment Questionnaire

2. VIC Evaluation Questionnaire
3. VIC Comparison Questionnaire
4. VIC Observation Form

Results from each of these instruments are presented below followed by a general discussion of USEX issues. Detailed tabular results from all questionnaire data is presented in Appendix F.

5.4.1 VIC Capability Assessment Questionnaire

The results for this questionnaire are summarized for the 29 Palms and MOUT exercises. Tables present tasks that were identified as being unable or difficult to perform.

5.4.1.1 Summary Results-29 Palms

For this instrument, soldiers were asked to rate the difficulty of performing selected tasks in four areas, i.e., movement, orientation (of self and others), visual recognition (person, target, object), and weapon engagement, for each VIC. Tasks were rated using a four point scale with the following anchor points: 1 = No opportunity to perform; 2 = Unable to perform; 3 = Could perform easily; 4 = Could perform with difficulty. The results are summarized below by area based on the soldiers' experiences in the 29 Palms data base. Tables 5.4.1.1-1 and 5.4.1.1-2 summarize subjects' responses on tasks that were unable or difficult to perform in the 29 Palms environment. Summary tables by task are presented in Appendix F.

It should be noted that the sample (n = 8), which was small, was further reduced for certain areas. For example, the visual recognition tasks "identify assigned sectors", "identify dead space", and "detect enemy soldiers", a number of soldiers indicated that they had no opportunity or could not perform these tasks.

Similarly, for the weapon engagement area, tasks such as "detecting enemy fire" (for all VICs), and to a lesser extent "fire from tactical positions" (VICs Alpha and F), and "fire your weapon (VIC F), small samples are reduced further by soldiers who either had no opportunity or were unable to perform these tasks. Interpretations of these findings should, therefore, be made cautiously. (Note: ARI Ft. Benning in this section refers to the VICs only by the first letter, thus A=Alpha, B=Bravo, C=Charlie (SS = Soldier Station), F=Foxtrot.)

Table 5.4.1.1-1. Tasks Unable to be Performed by Soldiers Across VICs – 29 Palms.

	VIC				Total
TASK	**A**	**B**	**SS**	**F**	**Responses**
MOVEMENT	**1**	**0**	**0**	**0**	**1**
• *Move over open, flat terrain.*	*0*	*0*	*0*	*0*	*0*
• *Move over hills and cross compartments.*	*0*	*0*	*0*	*0*	*0*
• *Move tactically.*	*1*	*0*	*0*	*0*	*1*

TASK	VIC A	VIC B	VIC SS	VIC F	Total Responses
ORIENTATION	**0**	**3**	**0**	**3**	**6**
• *Determine own movement direction.*	*0*	*0*	*0*	*1*	*1*
• *Maintain position relative to other personnel.*	*0*	*0*	*0*	*0*	*0*
• *Determine where team members are in open, flat terrain.*	*0*	*1*	*0*	*1*	*2*
• *Determine where team members are over hills and cross compartments.*	*0*	*2*	*0*	*1*	*3*
VISUAL RECOGNITION	**4**	**5**	**4**	**5**	**18**
• *Estimate distance to other personnel.*	*2*	*1*	*0*	*1*	*4*
• *Locate your fire team members.*	*0*	*0*	*0*	*1*	*1*
• *Determine activity of your team or enemy.*	*1*	*0*	*0*	*0*	*1*
• *Identify specific fire team members.*	*0*	*0*	*0*	*1*	*1*
• *Identify assigned sectors.*	*0*	*1*	*0*	*1*	*2*
• *Identify dead space.*	*0*	*1*	*2*	*0*	*3*
• *Detect enemy soldiers.*	*1*	*2*	*2*	*1*	*6*
WEAPON ENGAGEMENT	**2**	**5**	**1**	**7**	**15**
• *Aim your weapon.*	*0*	*0*	*0*	*1*	*1*
• *Fire your weapon.*	*0*	*0*	*0*	*1*	*1*
• *Detect enemy fire.*	*2*	*5*	*1*	*3*	*11*
• *Fire from tactical positions.*	*0*	*0*	*0*	*2*	*2*
TOTALS					
• **Total Instances of Unable to Perform Reported**	**7**	**13**	**5**	**15**	**40**
• **Number of Tasks Soldiers Were Unable to Perform**	**5**	**7**	**3**	**12**	**27**

<u>Movement</u>

The majority of respondents (75 - 100 %) indicated that they could move over open, flat terrain and hills and cross compartments easily across all VICs. Moving tactically was easiest to perform in VIC Foxtrot, according to the majority of respondents (83.3%). VICs Alpha and Bravo were rated the most difficult to move tactically. [Fifty-seven (VIC A) and sixty-two (VIC B) percent of the respondents said they could perform these tasks easily].

<u>Orientation (of Self and Others)</u>

The majority of respondents (62.5 -100 %) indicated that they could perform the various orientation tasks, i.e., determine own movement direction; maintain position relative to other personnel; determine where team members are in open, flat terrain; and determine where team members are over hills and cross compartments, easily across all VICs. From a relative standpoint, however, VIC Bravo was the most difficult when it came to performing the orientation tasks (62.5% - 75.5% of the respondents could perform orientation tasks easily in VIC B). Overall, orientation tasks were easiest to perform in Soldier Station (87.5% - 100% of the respondents reported that they could perform the specified orientation tasks easily).

Table 5.4.1.1-2. Tasks Performed with Difficulty by Soldiers Across VICs – 29 Palms.

TASK	VIC A	VIC B	VIC SS	VIC F	Total Responses
MOVEMENT	**3**	**6**	**1**	**1**	**11**
• *Move over open, flat terrain.*	*1*	*1*	*0*	*0*	*2*
• *Move over hills and cross compartments.*	*0*	*2*	*0*	*0*	*2*
• *Move tactically.*	*2*	*3*	*1*	*1*	*7*
ORIENTATION	**7**	**8**	**2**	**3**	**20**
• *Determine own movement direction.*	*2*	*3*	*0*	*0*	*5*
• *Maintain position relative to other personnel.*	*2*	*3*	*1*	*2*	*8*
• *Determine where team members are in open, flat terrain.*	*1*	*1*	*0*	*0*	*2*
• *Determine where team members are over hills and cross compartments.*	*2*	*1*	*1*	*1*	*5*
VISUAL RECOGNITION	**15**	**18**	**17**	**14**	**64**
• *Estimate distance to other personnel.*	*2*	*2*	*4*	*3*	*11*
• *Locate your fire team members.*	*1*	*2*	*0*	*0*	*3*
• *Determine activity of your team or enemy.*	*1*	*4*	*2*	*2*	*9*
• *Identify specific fire team members.*	*0*	*0*	*0*	*0*	*0*
• *Identify assigned sectors.*	*2*	*3*	*4*	*0*	*9*
• *Identify dead space.*	*3*	*3*	*3*	*5*	*14*
• *Detect enemy soldiers.*	*6*	*4*	*4*	*4*	*18*
WEAPON ENGAGEMENT	**6**	**5**	**6**	**2**	**19**
• *Aim your weapon.*	*3*	*1*	*1*	*0*	*5*
• *Fire your weapon.*	*0*	*0*	*0*	*0*	*0*
• *Detect enemy fire.*	*2*	*2*	*4*	*0*	*8*
• *Fire from tactical positions.*	*1*	*2*	*1*	*2*	*6*
TOTALS					
• **Total Instances of Difficult to Perform Reported**	**31**	**37**	**26**	**20**	**114**
• **Number of Tasks Rated as Difficult to Perform**	**15**	**16**	**11**	**8**	**50**

Visual Recognition (Person, Target, Object)

Certain visual recognition tasks could be performed much easier than other tasks. Locating fire team members and identifying specific fire team members could be accomplished easily across all VICs (75% - 100% of the respondents could perform these tasks easily).

Determining the activity of your team or enemy was more difficult to do. Only 50 - 75 percent of the respondents reported they could perform these tasks easily. This task was easiest to perform in Soldier Station and hardest to perform in VIC Bravo.

Estimating distance to other personnel was also difficult to perform (33.3 - 62.5% of the respondents could perform this task easily). Estimating distance to other personnel was easiest to perform in VIC Bravo and most difficult in VIC Foxtrot. Some respondents (28.6%), particularly in VIC Alpha, were unable to perform this task.

Detecting enemy soldiers was extremely difficult to do (50 - 85.7% of the respondents could perform this task with difficulty). The respondents indicated that detecting enemy soldiers was most difficult to perform in VIC Alpha (85.7% could perform this task with difficulty). This task could be performed with the least difficulty in VICs Bravo and Soldier Station. Some respondents indicated that they were unable to perform this task.

Similarly, identifying dead space was also very difficult to perform (37.5 - 83.3% of the respondents found this task difficult to perform). The majority of respondents (83.3%) indicated that identifying dead space was most difficult to perform in VIC Foxtrot. Respondents could perform this task with the least amount of difficulty in VIC Bravo. A number of respondents (25 - 37.5%) indicated that they either had no opportunity or were unable to perform this task in VICs Alpha, Bravo, and Soldier Station.

Identifying assigned sectors was difficult to perform (28.6 - 50 % of the respondents could perform this task with difficulty). A number of respondents indicated that they either had no opportunity to perform this task or were unable to perform this task (25 - 50%) across all VICs. This task was most difficult to perform in Soldier Station and least difficult to perform in VIC Foxtrot.

Weapon Engagement

All respondents indicated that they could fire their weapon easily in VICs Alpha, Bravo, and Soldier Station (100%). This task was also performed easily by most respondents in VIC Foxtrot (66.7%). However, some respondents in VIC Foxtrot indicated that they had either no opportunity or were unable to fire their weapon.

Aiming the weapon was performed easily by the majority of respondents (83.3 - 87.5%) in VICs Bravo, Soldier Station, and Foxtrot. Aiming was most difficult to perform in VIC Alpha (57.1% of the respondents could perform this task easily in VIC A).

Firing from tactical positions was easiest to perform in VICs Bravo and Soldier Station (75 - 87.5%). Respondents had the most difficulty firing their weapon from tactical positions in VIC Foxtrot. Only about 17 percent of the respondents indicated that they could perform this task easily. However, 50 percent of the respondents in VIC Foxtrot indicated they either had no opportunity or were unable to fire tactically. Twenty-nine percent (28.6%) of the respondents said they had no opportunity to fire tactically while in VIC Alpha.

For detecting enemy fire, many respondents indicated that they had no opportunity or were unable to perform this task. This was particularly true for VICs Foxtrot (66.7%) and Bravo (62.5%), and to a lesser extent, for VIC Alpha (42.9%). The percentage of all respondents who said they could easily detect enemy fire ranged from twelve percent for VIC Bravo (12.5%) to thirty-three percent (33.3%) for VIC Foxtrot.

5.4.1.2 Summary Results-MOUT

The following sections summarize the soldiers' responses to the VIC Capability Questionnaire based on their experiences in the MOUT data base. As was the case in the 29 Palms data base, interpretations are particularly tenuous for certain tasks.

Because of the configuration of Soldier Station - that is, because it could not go inside of buildings - soldiers had no opportunity or were unable to perform certain weapon engagement, movement, orientation, and visual recognition tasks. System configuration and/or other factors also made it difficult for soldiers in VIC Alpha to perform selected weapon engagement and visual recognition tasks. To a lesser extent, soldiers in VICs Bravo (movement, orientation, visual recognition, and weapon engagement) and Foxtrot (visual recognition, and weapon engagement) were unable or did not have the opportunity to perform certain tasks. Tables 5.4.1.2-1 and 5.4.1.2-2 summarize subjects' responses on tasks that were unable or difficult to perform in the MOUT environment. Summary tables by task are presented in Appendix F.

Table 5.4.1.2-1. Tasks Unable to be Performed by Soldiers Across VICs –MOUT

	VIC				Total
TASK	**A**	**B**	**SS**	**F**	**Responses**
MOVEMENT	**0**	**3**	**6**	**0**	**9**
• *Move around and inside of buildings*	*0*	*1*	*3*	*0*	*4*
• *Enter door, window, hole.*	*0*	*2*	*3*	*0*	*5*
• *Move tactically.*	*0*	*0*	*0*	*0*	*0*
ORIENTATION	**0**	**0**	**4**	**0**	**4**
• *Move through a building knowing which rooms are cleared.*	*0*	*0*	*2*	*0*	*2*
• *Determine where team members are around and inside of buildings.*	*0*	*0*	*2*	*0*	*2*
• *Determine own movement direction.*					
• *Maintain position relative to other personnel.*	*0*	*0*	*0*	*0*	*0*
	0	*0*	*0*	*0*	*0*
VISUAL RECOGNITION	**3**	**2**	**2**	**2**	**9**
• *Estimate distance to other personnel.*	*0*	*0*	*0*	*1*	*1*
• *Locate your fire team members.*	*0*	*0*	*0*	*0*	*0*
• *Determine activity of your team or enemy.*	*0*	*0*	*1*	*0*	*1*
• *Identify specific fire team members.*	*0*	*0*	*0*	*0*	*0*
• *Identify assigned sectors.*	*1*	*1*	*0*	*1*	*3*
• *Identify dead space.*	*1*	*1*	*0*	*0*	*2*
• *Detect enemy soldiers.*	*1*	*0*	*1*	*0*	*2*
WEAPON ENGAGEMENT	**3**	**2**	**2**	**2**	**9**
• *Aim your weapon.*	*0*	*0*	*1*	*0*	*1*
• *Fire your weapon.*	*0*	*0*	*0*	*1*	*1*
• *Detect enemy fire.*	*3*	*2*	*1*	*1*	*7*
• *Fire from tactical positions.*	*0*	*0*	*0*	*0*	*0*
TOTALS					
• **Total Instances of Unable to Perform Reported**	**6**	**7**	**14**	**4**	**31**
• **Number of Tasks Soldiers Were Unable to Perform**	**4**	**5**	**8**	**4**	**21**

<u>Movement</u>

The majority of respondents indicated that they could easily move, from a tactical standpoint, in a MOUT setting (outside of buildings) for VICs Bravo (83.3%), Soldier Station (80%), and Foxtrot (100%). Respondents had slightly more trouble moving tactically in VIC Alpha (66.7% of the respondents could perform this task easily).

With regard to moving around and inside of buildings and entering a door, window, or hole, eighty percent of the respondents indicated that they had either no opportunity or were unable to perform these tasks in Soldier Station. Moving around and inside of buildings and entering doors, windows or holes were easiest to perform in VIC Foxtrot (100% of the respondents indicated

Table 5.4.1.2-2. Tasks Performed with Difficulty by Soldiers Across VICs –MOUT.

	VIC				Total
TASK	**A**	**B**	**SS**	**F**	**Responses**
MOVEMENT	**4**	**3**	**3**	**0**	**10**
• *Move around and inside of buildings*	*1*	*2*	*1*	*0*	*4*
• *Enter door, window, hole.*	*1*	*0*	*1*	*0*	*2*
• *Move tactically.*	*2*	*1*	*1*	*0*	*4*
ORIENTATION	**5**	**3**	**5**	**1**	**14**
• *Move through a building knowing which rooms are cleared.*	*3*	*0*	*2*	*1*	*6*
• *Determine where team members are around and inside of buildings.*	*1*	*1*	*3*	*0*	*5*
• *Determine own movement direction.*					
• *Maintain position relative to other personnel.*	*0*	*1*	*0*	*0*	*1*
	1	*1*	*0*	*0*	*2*
VISUAL RECOGNITION	**8**	**4**	**7**	**3**	**22**
• *Estimate distance to other personnel.*	*2*	*1*	*1*	*1*	*5*
• *Locate your fire team members.*	*1*	*0*	*0*	*0*	*1*
• *Determine activity of your team or enemy.*	*1*	*1*	*0*	*1*	*3*
• *Identify specific fire team members.*	*1*	*0*	*1*	*0*	*2*
• *Identify assigned sectors.*	*1*	*0*	*0*	*0*	*1*
• *Identify dead space.*	*0*	*0*	*2*	*1*	*3*
• *Detect enemy soldiers.*	*2*	*2*	*3*	*0*	*7*
WEAPON ENGAGEMENT	**3**	**4**	**2**	**3**	**12**
• *Aim your weapon.*	*2*	*2*	*1*	*0*	*5*
• *Fire your weapon.*	*0*	*0*	*0*	*1*	*1*
• *Detect enemy fire.*	*1*	*1*	*0*	*0*	*2*
• *Fire from tactical positions.*	*0*	*1*	*1*	*2*	*4*
TOTALS					
• **Total Instances of Difficult to Perform Reported**	**20**	**14**	**17**	**7**	**58**
• **Number of Tasks Rated as Difficult to Perform**	**14**	**11**	**11**	**6**	**42**

that they could perform these tasks easily). These tasks were next easiest to perform in VIC Alpha (83.3%).

Orientation (of Self and Others)

Determining own movement direction and maintaining position relative to other personnel were performed easily by the majority of respondents (83.3 - 100%) across all VICs.

Determining where team members are around and inside of buildings was, again, performed easily by the majority of respondents (83.3 - 100%) for VICs Alpha, Bravo, and Foxtrot. Forty percent of the respondents indicated that they were unable to perform this task for Soldier

Station. Sixty percent of the respondents indicated that while they were operating Soldier Station, they could determine where team members were around and inside of building with difficulty.

Respondents thought that moving through a building knowing which rooms were cleared was easiest to perform in VIC Foxtrot (80%). This task was next easiest to perform in VIC Bravo (66.7%). However, thirty-three percent of the respondents indicated that they had no opportunity to perform this task while they were in VIC Bravo. Sixty percent of the respondents indicated they either had no opportunity or were unable to perform this task in Soldier Station. This task was most difficult to perform in VIC Alpha (50%).

Visual Recognition (Person, Target, Object)

Locate your fire team members, determine activity of your team or enemy and identify specific fire team members were easily performed by the majority of respondents (80 - 100%) across all VICs. Estimating distance to other personnel was accomplished the easiest in VICs Bravo and Soldier Station. VICs Alpha (66.7%) and Foxtrot (60%) were rated next easiest with respect to estimating distance to other personnel.

Identify assigned sectors was easiest to perform in VIC Bravo (83.3%). For VICs Alpha, Soldier Station, and Foxtrot, a number of respondents (33.4 - 40%) indicated that they either had no opportunity or were unable to perform this task. For these three VICs, the percentage of respondents who said they could perform this task easily ranged from fifty to sixty percent.

For identify dead space, many respondents (33.4 - 50%) indicated that they either had no opportunity or were unable to perform this task for VICs Alpha, Bravo, and Soldier Station. Identify dead space was easiest to perform in VICs Bravo (66.7%) and Foxtrot (60%) and most difficult to perform in Soldier Station (only twenty percent of the respondents indicated they could perform this task easily).

Respondents indicated that detecting enemy soldiers was easiest to do in VIC Foxtrot (100%). In contrast, no one could perform this task easily in Soldier Station. Sixty percent could detect enemy soldiers with difficulty and forty percent of the respondents indicated they either had no opportunity or were unable to perform this task in Soldier Station. VICs Bravo (66.7%) and Alpha (50%) were rated next easiest with respect to detecting enemy soldiers.

Weapon Engagement

Aiming the weapon was easiest to do in VIC Foxtrot (100%). In contrast, only forty percent of the respondents indicated that they could perform this task easily in Soldier Station. However, another forty percent of the respondents indicated that they either had no opportunity or were unable to perform this task in Soldier Station. Sixty-seven percent (66.7%) of the respondents indicated they could easily aim their weapon in VICs Alpha and Bravo.

Firing the weapon was easiest to perform in VICs Bravo (100%) and Alpha (83.3%). By comparison, VICs Soldier Station and Foxtrot were the more difficult systems for performing this task. Sixty percent of the respondents indicated that they could perform this task easily while operating in these VICs. Forty percent of the respondents indicated that they had no opportunity to fire their weapon in Soldier Station.

The majority of respondents indicated that for some systems (66.7% in VIC Alpha and 60% in Soldier Station) they had no opportunity or were unable to detect enemy fire. For VIC Foxtrot, forty percent of the respondents also indicated that they had no opportunity or were unable to detect enemy fire. Detecting enemy fire was easiest to perform in VIC Foxtrot (60% said they could perform this task easily). Only seventeen percent (16.7%) of the respondents could perform this task easily in VIC Alpha.

Firing from tactical positions was easiest to perform in VIC Bravo (83.3% of the respondents indicated that they could perform this task easily). Only fifty percent of the respondents said they could easily fire from tactical positions in VIC Alpha. VIC Alpha provided limited opportunities to perform this task. Fifty percent of the respondents said they had no opportunity to fire from tactical positions while in VIC Alpha. For VICs Soldier Station and Foxtrot, sixty percent said they could fire from tactical positions easily.

5.4.2 VIC Evaluation Questionnaire

For this instrument, soldiers were asked to rate each VIC across three dimensions for specific tasks. For the first dimension, soldiers were asked to rate how effective each VIC was for engaging targets, simulating movement, and for identifying objects, people, etc. For this dimension, a five-point scale was used: 1 = Very effective: 2 = Generally effective; 3 = Somewhat effective; 4 = Generally ineffective; 5 = Very ineffective. Next, soldiers were asked to rate the similarity between performing specific tasks in each VIC and performing the same tasks in the real world. Tasks included: moving over open, flat terrain; moving over hills and cross compartments; moving around and inside of buildings; weapon firing; and firing and moving as a team member. A three-point scale was used for this dimension: 1 = Very similar; 2 = Somewhat similar; 3 = Very dissimilar. Finally, soldiers were asked to compare how quickly they could engage targets, and recognize people, objects, and targets in each VIC versus performing these same tasks in the real world. A three-point scale was also used to rate this dimension:
1 = Quicker than a real weapon/in the real world; 2 = Slower than a real weapon/the real world; 3 = About the same as a real weapon/in the real world.

The results presented in the following sections were summarized by dimension and based on the soldiers' experiences in both the 29 Palms and MOUT data base. As was noted in the sections describing the results from the VIC Capability Questionnaire, sample sizes were reduced, $n < 8$, and the patterns of results described below should be interpreted cautiously. As before, tabulated data for task is presented in Appendix F.

5.4.2.1 Summary Results-29 Palms

The following sections summarize the soldiers' responses on the VIC Evaluation Questionnaire based on their experiences in the 29 Palms data base.

VIC Effectiveness

VICs Bravo and Soldier Station appeared to be the most effective for engaging targets, simulating movement, and identifying objects and people (87.5 - 100% of the respondents indicated that these VICs were generally or very effective in performing these tasks). VICs Alpha and Foxtrot appeared to be less effective (42.9 - 71.4% of the respondents reported that these VICs were generally or very effective for engaging targets, simulating movement, and identifying objects and people).

Similarity Between VIC and Real World Performance

The majority of respondents (83.4 - 100%) reported that moving over open flat, terrain, moving over hills and cross compartments, and firing and moving as a team member in VICs Bravo, Soldier Station, and Foxtrot were either somewhat or very similar to how they would perform these tasks in the real world. Forty three percent (42.9%) of the respondents indicated that performing these moving and firing tasks in VIC Alpha were very dissimilar to how they would perform them in the real world.

Weapon firing was most similar to real world performance in VIC Foxtrot (83.3 % of the respondents indicated that firing their weapon was very similar to how they would fire their weapon in the real world). Seventy-one percent (71.4%) of the respondents indicated that firing their weapon in VIC Bravo was somewhat similar to how they would actually do it in the real world. Forty-three percent (42.9%) of the respondents reported that firing their weapon in VICs Alpha and Soldier Station was very dissimilar to real world performance of the same task.

Speed in Performing Tasks in VICs and the Real World

The majority of respondents (83.3%) indicated that engaging targets in VIC Foxtrot was performed in about the same amount of time as it would take to perform this task using a real weapon. One hundred percent of the respondents reported that engaging targets in VIC Alpha was slower than a real weapon. Ratings for VICs Bravo and Soldier Station showed from fifty-seven (57.1% in VIC B) to sixty-two (62.5% in Soldier Station) percent of the respondents thought that engaging targets was slower in these VICs than using a real weapon.

Recognizing people, objects, and targets was slowest to perform in VIC Alpha. Eighty-six percent (85.7%) of the respondents indicated that these tasks were slower to perform in this VIC than in the real world. Sixty-two percent (62.5%) of the respondents in Soldier Station and fifty percent of the respondents in VIC Foxtrot reported that these recognition tasks took about the same amount of time to perform in these VICs as they did in the real world.

5.4.2.2 Summary Results - MOUT

The following sections summarize the soldiers' responses on the VIC Evaluation Questionnaire based on their experiences in the MOUT data base.

VIC Effectiveness

Most respondents (83.3 - 100%) indicated that all VICs were at least somewhat effective for engaging targets. Soldier Station, followed by VIC Foxtrot, appeared to be the most effective [100% (Soldier Station) and 80% (VIC F) felt that these VICs were generally or very effective for engaging targets]. In contrast, fifty percent of respondents reported that VIC Bravo was generally or very effective for engaging targets.

While most respondents (83.4 - 100%) indicated that all VICs were at least somewhat effective in simulating movement, VIC Bravo appeared to be the most effective. Eighty-three percent (83.4%) of the respondents indicated that VIC Bravo was either generally or very effective for simulating movement. VICs Foxtrot, Alpha, and Soldier Station appeared less effective (40 - 60% of the respondents reported that these tasks were somewhat effective for simulating movement).

With regard to identifying objects and people, most respondents (80 - 100 %) reported that all VICs were either generally or very effective in accomplishing this task. VIC Foxtrot appeared to be the most effective. Eighty percent of the respondents reported that VIC Foxtrot was very effective for identifying objects and people.

Similarity Between VIC and Real World Performance

All respondents indicated that moving around and inside of buildings in VIC Foxtrot was somewhat or very similar to how they would move in the real world. Similar ratings were also obtained for VIC Bravo (83.4% said that moving around and inside of buildings was somewhat or very similar to how they would do it in the real world).

In contrast, sixty-seven percent (66.7%) of the respondents indicated that moving around and inside of buildings in Soldier Station was very dissimilar to how they would perform this task in the real-world (recall that Soldier Station could not go inside of buildings).

With regard to weapon firing, eighty percent of the respondents indicated that performing this task in VIC Foxtrot was very similar to how they would do it in the real world. Seventy-five percent of the respondents indicated, however, that firing a weapon in Soldier Station was very dissimilar to how they would do it in the real world.

The majority of respondents (75 - 100%) indicated that firing and moving as a team member was either somewhat or very similar to how they would move in the real world across all VICs. Two VICs however, VICs Bravo (50%) and Foxtrot (40%) were seen by respondents as being very similar to the real world with regard to firing and moving as a team member.

Speed in Performing Tasks in VICs and the Real World

Eighty percent of the respondents indicated that engaging targets in VIC Foxtrot took about the same amount of time as it did with a real weapon. The overall response rates for VICs Alpha, Bravo, and Soldier Station suggested that engaging targets in these VICs required more time than when using a real weapon.

With regard to recognizing people, objects, and targets, eighty percent of the respondents in VIC Foxtrot indicated that these tasks took about the same amount of time as in the real world. Similarly, sixty-seven percent (66.7%) reported that VIC Bravo required about the same amount of time to perform these tasks as in the real world. In contrast, eighty percent of the respondents said that recognizing people, objects, and targets in Soldier Station was slower than in the real world.

5.4.3 VIC Comparison Questionnaire

For this instrument, soldiers were asked to rank order the VICs on four dimensions, i.e., how many elements or aspects of a task could be performed; how easy it was to perform the specific tasks; the extent to which the VICs allowed the soldier to perform tasks in a tactically sound manner; and the realistic manner in which the VICs allowed one to perform the tasks.

Each dimension was crossed with the following tasks/skills:

- Move as an individual.
- Move as a member as a fire team.
- Maintain situational awareness: Of your location, your fire team's location, the enemy situation, etc.
- Communicate.
- Recognize people, targets, and objects.
- Engage targets as an individual.
- Engage targets as a member of a fire team.
- Control fires (as a team leader).
- Control movement (as a team leader).

A four-point scale was used with 1 = Best and 4 = Worst, with the end points defined in the context of the four dimensions noted above. Soldiers' responses were tabulated and various descriptive statistics were computed, e.g., means and standard deviations. Tables presenting these statistics are presented in Appendix F. Following-up questionnaire results, a structured interview was conducted with the soldiers to try to determine the reasons for their rankings of the VICs as well as to address other questions not captured by questionnaire data. The results of these interviews are also presented in Appendix F.

5.4.3.1 Summary Results - 29 Palms Data Base

The results presented in the following sections summarize the soldiers' rankings based on their experiences in the 29 Palms data base.

<u>How many elements or aspects of the tasks or skills can be performed with each VIC?</u> VIC Bravo was rated as the best (i.e., more elements or aspects could be performed with this VIC than with any other) for all but one task (control fires as a team leader). VIC Foxtrot was rated best

for this task. For control movement as a team leader, VICs Alpha and Bravo had the highest ratings. It should be noted that these two tasks were rated by only the team leaders (n = 2).

VIC Alpha was rated the worst (i.e., fewer elements or aspects can be performed with this VIC than with any other) on all tasks/skills but one (control movement as a team leader). VICs Soldier Station and Foxtrot occupied intermediate points between VICs Alpha and Bravo with VIC Foxtrot perceived as slightly better than Soldier Station across the majority of tasks/skills.

How easy was it to perform the tasks/skills? Soldier Station was ranked by soldiers as the best (i.e., can be performed most easily) with respect to moving as both an individual and as a member of a fire team. VIC Bravo was ranked as the best with regard to maintaining situational awareness; recognizing people, targets, and objects; engaging targets as an individual; and engaging targets as a member of a fire team. VIC Foxtrot was unanimously ranked by team leaders as the best when it came to controlling fires and movement.

VIC Alpha was selected as the worst (i.e., hardest to perform) for the majority of tasks. Only for movement as a member of a fire team did VIC Alpha not receive the lowest ranking. VIC Bravo received the lowest ranking for this task. Given the realistic nature of moving in VIC Bravo relative to the other three VICs, this ranking is understandable. VICs Alpha, Bravo, and Soldier Station were seen by the team leaders as equally difficult when it came to controlling fires and movement as a team leader, with VIC Alpha showing a complete consensus in ratings.

To what extent did the VICs allow the soldier to perform tasks/skills in a tactically sound manner? The mean rankings of all the tasks/skills listed showed that VIC Bravo was ranked the best or tied for the best (with VIC Foxtrot for controlling fires), i.e., no differences or the fewest differences from tactical procedures, in terms of allowing the soldier to perform tasks or skills in a tactically sound manner. VIC Alpha received the lowest rankings (indicating that performance differs most from tactical procedures) across all tasks. The team leaders were unanimous in their rankings of VIC Alpha as the worst with respect to controlling fires and movement (as a team leader).

Mean rankings for VICs Soldier Station and Foxtrot fell in between the rankings for VICs Alpha and Bravo. The rankings for the majority (5 of 8) tasks, however, showed Soldier Station to be the second most preferred VIC with respect to allowing soldiers to perform tasks/skills in a tactically sound manner.

Realistic manner in which VICs allowed tasks/skills to be performed. Once again, the mean rankings across all task/skills showed that VIC Bravo was the best (i.e., tasks performed were most similar to real-world performance). VICs Foxtrot and Bravo were both ranked as the best by team leaders when it came to controlling fires and movement.

Soldier Station was ranked as the worst for the majority of tasks (i.e., tasks performed were least like real-world performance). Team leaders ranked both VICs Soldier Station and Alpha as the worst with regard to controlling movement.

5.4.3.2 Summary Results - MOUT Data Base

The same questionnaire was administered to the soldiers after completing the MOUT sessions. The results are summarized by dimension, i.e., identical to the 29 Palms data base, and presented below.

How many elements or aspects of the tasks or skills can be performed with each VIC? VIC Bravo was ranked the best (i.e., more elements or aspects of tasks could be performed with this VIC than with any other) for the following tasks: move as an individual; move as a member of a fire team; maintain situational awareness; recognize people, targets, and objects, engage targets as an individual; and engage targets as a member of a fire team. VIC Foxtrot was unanimously ranked the best by team leaders for controlling fires and movement. VICs Alpha, Bravo, and Soldier Station were all ranked equally as the worst (fewer elements or aspects could be performed) for these same two tasks. For VIC Alpha, the rankings provided by the team leaders for controlling fires and movement were unanimous.

After VIC Bravo, VIC Foxtrot appeared to be next most flexible in terms of being able to perform more elements or aspects for the majority of tasks rated. VICs Alpha and Soldier Station, in comparison, appeared to be the least flexible.

How easy was it to perform the tasks/skills? With the exception of the two tasks, move as an individual and move as a member of a fire team, soldiers indicated that tasks performed on VIC Bravo could be performed the easiest. Movement as an individual (tied with Soldier Station) and as a member of a fire team was easiest to perform on VIC Foxtrot. For the majority of the remaining tasks, soldiers ranked VIC Foxtrot as the next easiest for performing tasks.

Moving as an individual and as a member of a fire team; engaging targets, both as an individual and as a member of a fire team, and controlling fires and movement were the hardest to perform on VIC Alpha. Maintaining situational awareness was hardest to perform on Soldier Station.

To what extent did the VICs allow the soldier to perform tasks/skills in a tactically sound manner? Soldiers indicated that for all but two tasks, controlling fires and movement, that VIC Bravo was the best in terms of allowing tasks/skills to be performed with the fewest differences from tactical procedures. For controlling fires and movement, both VICs Bravo and Foxtrot were ranked the best. VIC Foxtrot appeared to be the soldiers' second choice, overall, (followed by Soldier Station) with respect to performing tasks in the most tactically sound manner.

VIC Alpha ranked last in this area. Soldiers' rankings indicated that task performance on this VIC differed the most from tactical procedures. Both VICs Alpha and Soldier Station received the lowest (poorest) rankings for controlling fires and movement by team leaders.

Realistic manner in which VICs allowed tasks/skills to be performed. The soldiers' rankings indicated that VIC Bravo was the best or tied for the best (with VIC Foxtrot for engaging targets as an individual and controlling fires and movement) in terms of allowing tasks to be performed as they would in the real world.

Soldier Station was rated over the majority of tasks as the worst, i.e., task performance was least similar to real-world performance. For controlling fires and movement, both VICs Alpha and Soldier Station were ranked as being the least realistic.

5.4.4 VIC Observation Form

This form was divided into separate sections with specific response options designed to structure the observations. Observers also had room on the form to note any critical incidents occurring during this time. Selected areas for observation included: positions used by the soldier to move (walk, run, crawl); positions used in firing (standing-unsupported, kneeling, prone, other); and enemy engagement (Did the soldier see the enemy? Did the soldier see the enemy firing? Did the soldier fire at the enemy? Was the soldier killed? What position was the soldier in when he was killed (standing, kneeling, prone)? If the soldier was not killed, what was his final position (standing, kneeling, prone)? This section presents a summary of these observations.

5.4.4.1 Summary Results - 29 Palms

The major findings are summarized in the following sections based on soldier observations from the 29 Palms data base.

Movement

Walking was the sole means of movement observed in thirty-three (33.3% - VICs Bravo and F) to forty-three (42.9% - Soldier Station) of the scenarios. Twenty to thirty-three percent (33.3%) of the scenarios observed involved some combination of walking, running, and crawling.

Fire Positions

Soldiers fired exclusively from the prone position in VICs Bravo and Soldier Station. For VIC Alpha, eighty percent of the scenarios observed showed that soldiers either fired standing-unsupported (forty percent of the scenarios) or while kneeling (forty percent of the scenarios). VIC Foxtrot showed the greatest variety in firing positions used across scenarios (standing-unsupported, kneeling, prone, standing and kneeling).

Enemy Engagement

29 Palms enemy engagement performance is summarized in Table 5.4.4.1-1. Soldiers saw the enemy in only thirty-three to forty-four percent of the scenarios observed for VICs Alpha, Bravo, and Soldier Station (33.3% in VIC A; 41.2% in VIC B; and 43.8% in Soldier Station). In contrast, soldiers saw the enemy in fifty-four percent (54.5%) of scenarios in VIC Foxtrot. Soldiers rarely saw the enemy firing. The percentage of scenarios observed in which soldiers saw enemy fire ranged from zero in VIC Foxtrot to twenty-nine percent (29.4%) in VIC Bravo.

The percentage of scenarios observed in which the soldier actually fired at the enemy ranged from thirty-three percent (33.3%) for VIC Alpha to fifty-three percent (52.9%) for VIC Bravo. The percentages for VICs Soldier Station (43.8%) and Foxtrot (45.5%) fell in between these two systems.

Table 5.4.4.1-1. Enemy Engagement by Category and VIC - 29 Palms

	VIC A		VIC B		SS		VIC F	
ENEMY ENGAGEMENT	n[a]	%	n[b]	%	n[c]	%	n[d]	%
Saw Enemy	5	33.3	7	41.2	7	43.8	6	54.5
Saw Enemy Firing	2	13.3	5	29.4	3	20.0	0	0.0
Fired at Enemy	5	33.3	9	52.9	7	43.8	5	45.5
Was Killed	12	80.0	11	68.8	10	62.5	8	72.7
Was Killed Standing	*5*	*33.3*	*4*	*25.0*	*2*	*12.5*	*1*	*9.1*
Was Killed Kneeling	*2*	*13.3*	*1*	*6.3*	*1*	*6.3*	*3*	*27.3*
Was Killed Prone	*5*	*33.3*	*6*	*37.5*	*7*	*43.8*	*4*	*36.4*
Position Unknown	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*
Survived Engagement	3	20.0	5	31.3	6	37.5	3	27.3
Standing	*0*	*0.0*	*0*	*0.0*	*1*	*6.3*	*2*	*18.2*
Kneeling	*2*	*13.3*	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*
Prone	*1*	*6.7*	*3*	*18.8*	*4*	*25.0*	*1*	*9.1*
Position Unknown	*0*	*0.0*	*2*	*12.5*	*1*	*6.3*	*0*	*0.0*

Note. n = number of scenarios that specific incident was observed.
[a]N = 15. [b]N = 17. [c]N = 16. [d]N = 11.

In the majority of scenarios, (more than 62% of the scenarios observed across VICs), the soldiers were killed. The soldiers were killed most often in VIC Alpha (80%) and least often in Soldier Station (62.5%). The observations showed that the soldiers were killed more frequently in the prone than in the standing position.

System Integrity

VIC system operational status during the 29 Palms exercises is summarized in Table 5.4.4.1-2. Soldier Station was fully operational over the largest percentage of scenarios observed (82.4%). This was followed by VIC Bravo, which was fully operational seventy-one percent (70.6%) of the time. VICs Alpha and Foxtrot were fully operational for only forty-seven percent (47.1%) of the scenarios observed. For VIC Alpha, the primary reason for system malfunction was the constant recalibration required, which resulted in frequent delays in completing the scenarios. Malfunctioning in VIC Bravo was centered around the treadmill, weapon, and visual/graphics subsystems. Total system failure was noted in VIC Foxtrot for thirty-five percent (35.3%) of the scenarios observed. The source of this failure was a malfunction in VIC F's weapon system which shut the entire system down for approximately two days. VIC Alpha was totally shutdown for twelve percent (11.8%) of the scenarios observed.

Table 5.4.4.1-2. System Integrity by VIC During the 29 Palms Scenarios

	VIC A		VIC B		SS		VIC F	
System Integrity	n	%	n	%	n	%	n	%
SYSTEM FULLY OPERATIONAL	8	47.1	12	70.6	14	82.4	8	47.1
SYSTEM MALFUNCTION								
• *Calibration*	*6*	*35.3*	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*
• *Movement*	*0*	*0.0*	*2*	*11.8*	*0*	*0.0*	*0*	*0.0*
• *Weapon*	*1*	*5.9*	*1*	*5.9*	*1*	*5.9*	*0*	*0.0*
• *Visuals/Graphics*	*0*	*0.0*	*1*	*5.9*	*1*	*0.0*	*0*	*0.0*
• *Communication/Audio*	*0*	*0.0*	*0*	*0.0*	*0*	*5.9*	*0*	*0.0*
• *Environment/Surroundings*	*0*	*0.0*	*0*	*0.0*	*1*	*5.9*	*1*	*5.9*
• *Unspecified System Malfunctions*	*0*	*0.0*	*1*	*5.9*	*0*	*0.0*	*2*	*11.8*
SYSTEM FAILURE	2	11.8	0	0.0	0	0.0	6	35.3

Note. n = number of scenarios that specific incident occurred. 17 scenarios were observed for each VIC.

5.4.4.2 Summary Results - MOUT

The sections below summarize the major findings of soldier observations from the MOUT database.

Movement

Walking was the sole means of movement in over eighty percent of the scenarios observed for VICs Alpha (84.6%) and Soldier Station (83.3%). In contrast, walking was noted as the sole means of movement in only fifty-eight percent (57.9%) of the scenarios observed for VIC Bravo and thirty-seven percent (37.5%) of the scenarios for VIC Foxtrot. A combination of walking and running were observed in a number of scenarios for VICs Bravo (31.6%) and Foxtrot (43.8%).

Fire Positions

Soldiers fired exclusively from the standing-unsupported position in VICs Alpha and Foxtrot. For VIC Bravo, seventy-seven percent (76.9%) of the scenarios observed showed that soldiers fired from the standing-unsupported position. The primary firing position used in Soldier Station was prone (66.7%) followed by the kneeling position (33.3%).

Enemy Engagement

MOUT enemy engagement performance is summarized in Table 5.4.4.2-1

Table 5.4.4.2-1. Enemy Engagement by Category and VIC - MOUT

	VIC A		VIC B		SS		VIC F	
ENEMY ENGAGEMENT	n[a]	%	n[b]	%	n[c]	%	n[d]	%
Saw Enemy	7	41.2	17	89.5	4	21.1	16	84.2
Saw Enemy Firing	4	23.5	12	63.2	0	0.0	6	31.6
Fired at Enemy	6	35.3	15	79.0	3	15.8	15	79.0
Was Killed	7	41.2	11	57.9	3	15.8	9	47.4
Was Killed Standing	*7*	*41.2*	*11*	*57.9*	*0*	*0.0*	*9*	*47.4*
Was Killed Kneeling	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*
Was Killed Prone	*0*	*0.0*	*0*	*0.0*	*3*	*15.8*	*0*	*0.0*
Position Unknown	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*
Survived Engagement	10	58.8	8	42.1	16	84.2	10	52.6
Standing	*10*	*58.8*	*8*	*42.1*	*4*	*21.1*	*10*	*52.6*
Kneeling	*0*	*0.0*	*0*	*0.0*	*3*	*15.8*	*0*	*0.0*
Prone	*0*	*0.0*	*0*	*0.0*	*9*	*47.4*	*0*	*0.0*
Position Unknown	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*

Note. n = number of scenarios that specific incident was observed.
[a]N = 17. [b]N = 19. [c]N = 19. [d]N = 19.

Soldiers saw the enemy in over eighty percent of the scenarios observed for VICs Bravo (89.5%) and Foxtrot (84.2%). In contrast, the enemy was seen by the soldiers in only twenty-one percent (21.1%) of the scenarios for Soldier Station.

The soldiers saw the enemy firing in sixty-three percent (63.2%) of the scenarios observed in VIC Bravo. In only thirty-two percent (31.6%) of the scenarios in VIC Foxtrot and twenty-three percent (23.5%) of the scenarios in VIC Alpha did soldiers actually see the enemy firing. No reports of soldiers seeing the enemy firing were noted in Soldier Station.

Soldiers fired at the enemy in almost eighty percent (79%) of the scenarios observed in VICs Bravo and Foxtrot. In contrast, soldiers in VIC Alpha fired at the enemy in thirty-five percent (35.3%) of the scenarios and in only sixteen percent (15.8%) of the scenarios that were observed for Soldier Station.

Soldiers were less likely to be killed in the MOUT scenarios than in the 29 Palms scenarios. The highest number of casualties occurred while soldiers were in VIC Bravo. Soldiers were killed in fifty-eight percent (57.9%) of the scenarios observed for this system. The percentages dropped to forty-seven percent (47.4%) in VIC Foxtrot and forty-one percent (41.2%) in VIC Alpha. Due, in large part, to the configuration of Soldier Station, soldiers were killed in only sixteen percent (15.8%) of the scenarios observed for this system. With the exception of Soldier Station, soldiers were killed primarily in the standing-unsupported position.

System Integrity

Overall system integrity is summarized in Table 5.4.4.2-2 below.

Table 5.4.4.2-2. System Integrity by VIC During the MOUT Scenarios

	VIC A		VIC B		SS		VIC F	
System Integrity	n	%	n	%	n	%	n	%
SYSTEM FULLY OPERATIONAL	9	45.0	12	60.0	15	78.9	18	90.0
SYSTEM MALFUNCTION								
• *Calibration*	*6*	*30.0*	*0*	*0.0*	*0*	*0.0*	*0*	*0.0*
• *Movement*	*0*	*0.0*	*1*	*5.0*	*0*	*0.0*	*0*	*0.0*
• *Weapon*	*0*	*0.0*	*1*	*5.0*	*1*	*5.3*	*1*	*5.0*
• *Visuals/Graphics*	*0*	*0.0*	*1*	*5.0*	*1*	*5.3*	*0*	*0.0*
• *Communication/Audio*	*0*	*0.0*	*0*	*0.0*	*1*	*5.3*	*0*	*0.0*
• *Environment/Surroundings*	*3*	*15.0*	*4*	*20.0*	*0*	*0.0*	*0*	*0.0*
• *Unspecified System Malfunctions*	*0*	*0.0*	*0*	*0.0*	*1*	*5.3*	*1*	*5.0*
SYSTEM FAILURE	2	10.0	1	5.0	0	0.0	0	0.0

Note. n = number of scenarios that specific event occurred. Twenty scenarios were observed for VICs Alpha, Bravo, and Foxtrot. Nineteen were observed for Soldier Station, as it was excluded from one exercise for VIP demonstration.

VIC Foxtrot was fully operational in ninety percent of the MOUT scenarios observed. Soldier Station was the next most reliable (fully operational) in seventy-nine percent (78.9%) of the scenarios observed. Least reliable were VICs Bravo (60%) and Alpha (45%). The primary problem with VIC Alpha was the frequent recalibration required of the system. Extensive, i.e., total system failure, was infrequent. The largest number of total system failures noted occurred in VIC Alpha. However, this system was totally shutdown in only ten percent of the scenarios observed.

5.4.5 General

Paragraphs 5.4.1 through 5.4.4 and Appendix F represent Ft. Benning ARI data summarization and analysis. As mentioned, they will be presenting this data in more detail in a forthcoming ARI Ft. Benning report. This section (5.4.5) presents miscellaneous background information, anecdotal data, and other observations made during the USEX by other members of the DWN team, primarily LMIS personnel.

During the "free-play" portion of the engineering experiments, it was observed that since each VIC used the same DI model for friendly forces, it was impossible to tell one friendly entity (VIC) from another. For the USEX, each VIC was asked to modify its DI model by attaching a placard-type letter designator for its VIC. Thus, for the USEX, each VIC DI figure in the visual environment was augmented with an "A", "B", "C", or "F" to show if the figure was VIC Alpha, Bravo, Charlie (Soldier Station), or Foxtrot. BLUFOR SAF were not similarly identified. Thus, data showing that team member identification was much easier than any other entity identification must consider this special treatment.

Also, observations during this freeplay reinforced a concern based on ModSAF experience that SAF entities tend to be exceptionally lethal - they acquire and shoot at targets more quickly and with greater effect than manned simulators. This concern had been previously discussed during the TIMs and proved to be well-founded. The basic DI SAF target acquisition model was if there was clear line of sight - however briefly - and the target was within weapon range, then the target was engaged, usually successfully. This led to frustration on the part of the soldier participants, especially during 29 Palms exercises. If they broke cover briefly they would be shot and killed. Exposure was difficult to determine at range, and was compounded by the observation that the databases used by ModSAF and the VICs are not exactly identical, especially in elevation detail. For example, the VICs were approaching the crest of a ridge on the opposite side of OPFOR SAF. As they approached the ridge, they were shot and killed by the SAF even though it appeared that the VICs were still concealed by terrain. The assumption is that the ridge was not as "peaked" in the SAF's representation of the ridge as it appeared in the VICs' view. Attempts were made to reduce the competence of the DI SAF to lessen their lethality.

A similar database correlation problem was noted between Soldier Station and the other VICs. Actually the problem was primarily within Soldier Station itself. Soldier Station is a hybrid system that uses flight data for its soldier visualization component (basically NPSNET - the predecessor to BAYONET) and a gridded, low resolution Janus database for its world knowledge and reasoning. Buildings in the MOUT site that were irregularly shaped were reduced to simple rectangles. In one vignette, Soldier Station was covering a building from the corner of the church in the McKenna village. The enemy sniper walked out of the covered building, walked up to the prone Soldier Station, apparently in plain sight of Soldier Station since the sniper could clearly see him, and shot him from close range (about 1 meter). Soldier Station never saw the sniper until he was right on top of him, too late to react. In researching this anomoly, we discovered that Soldier Station's representation of the church was a simple rectangle defined by the width of the building and its length, including the steeple. The result was that Soldier Station's reasoning model had church structure between itself and the sniper, and since there was no line of sight, it did not display the sniper. The sniper saw the church as it actually was and could plainly see Soldier Station. This difference in representation of the church is illustrated in Figure 5.4.5-1.

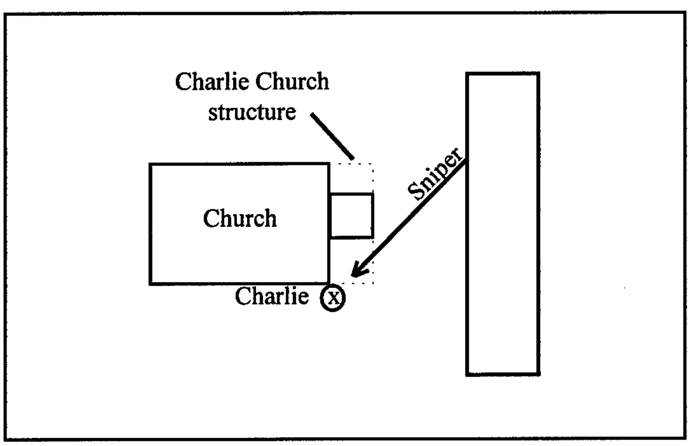


Figure 5.4.5-1. Database Correspondence Problem Illustration

What was disconcerting to the soldier in Soldier Station was that he could see the door the sniper came out of, could see the intervening terrain between the building and his position, but did not see the sniper walk across this area. This is because the visualization software (NPSNET) uses the correct database representation, but Soldier Station's reasoning software, which decided when to display detected objects, uses a different representation. It was known that this discrepancy existed with Soldier Station and issues associated with this were expected to arise. This was the clearest manifestation noted, and primarily affected only Soldier Station itself.

Other issues existed with VIC interaction with building structure. Many times during an exercise, a VIC (including the sniper who was using a BAYONET station) would give away its location by having a part of its body (feet, legs, arms) or its weapon poke through a wall or floor and be seen by an entity on the other side of the wall or on the floor below. Colliding with an object does not prohibit the VIC from passing through it (for all VICs). In fact, VIC Bravo got stuck in walls on many occasions, so much so that a special function switch was implemented to "unstick" Bravo in these cases. Also, VIC Alpha would occasionally fall from one floor to the floor below if it encountered a hole, however small, in the building structure. This was especially evident near a stairwell in the three-story building used during the exercises.

Another Alpha anecdote is that it is the only VIC in which a soldier can leave his weapon behind. In one exercise the team leader knelt down and laid his weapon down while he performed some task. He then stood up and continued moving up a mountain in the 29 Palms database. At some point he stopped to pick up his weapon, which he could physically see on the floor beside him, but he could not find it around him in the database. The Alpha operators informed him that he had left it about a hundred meters behind him. He continued the exercise without his weapon.

It was interesting to note that the soldiers learned to use Bravo's Land Warrior rifle/IHAS sight system to advantage, especially in the MOUT scenarios. It was common for the team leader to order whoever was on Bravo to move forward and use his rifle display system to look around doorways into rooms that were believed to contain the sniper. Perhaps this tendency to lead with VIC Bravo contributed to its higher casualty rate in the MOUT scenarios.

Finally, communications among the VICs was difficult using the wireless system. It was difficult to get Alpha to be consistently loud enough to be heard by all VICs. Bravo had difficulty hearing communications over the ODT noise. The soldier on Bravo had to stop moving (stop the ODT) in order to hear commands, and it was often difficult to get him to hear that he was being addressed to get him to stop.

5.5 Discussion and Lessons Learned

To summarize, the overall pattern of results is that VIC Bravo was ranked by the soldiers as the best with regard to performing the tasks identified in the questionnaires. This preference held regardless of the data base. For the 29 Palms environment, VICs Soldier Station and Foxtrot were the next preferred systems followed by VIC Alpha. For the MOUT environment, VIC Foxtrot appeared to be the next preferred system. This was followed by VICs Alpha and Soldier Station as the two least preferred systems in this environment. Results for specific tasks included the following:

- For controlling fires and movement, team leaders rated VIC Foxtrot the best, followed closely by VIC Bravo. VICs Alpha and Soldier Station were the least preferred of the systems for these tasks. The pattern of results held for both databases.
- VIC Bravo was clearly viewed by the soldiers as the best when it came to the flexibility of the system; ease of performing the tasks; ability to perform tasks in a tactically sound manner; and ability to perform the tasks in a realistic manner. Again, this finding held across databases. However, while VIC Bravo received high overall rankings across tasks and dimensions, this did not mean soldiers universally liked all features. Features that were viewed as highly desirable were criticized as well. For example, soldiers liked the treadmill approach to moving on VIC Bravo. They liked it because they actually moved, i.e., they had to use their legs to move, turn, and maneuver. Soldiers felt that movement in VIC Bravo was closer to real world movement because different terrains could be simulated. On the other hand, they felt that the treadmill was too slow and it was hard to walk in a straight line. Actual movement was unstable and it was difficult to move as a team and to keep up with others.
- VIC Foxtrot, one of the more preferred systems, was liked by soldiers because the size of objects depicted on the screen was very realistic. They reported that it felt like they were actually moving in the scene. The system also required real world movement in terms of going prone or kneeling. However, once the soldiers got prone, they would slide down the hill while in the 29 Palms data base. Movement, while swift and effortless, was, however, perceived as unrealistic due, in part, to difficulties reported in controlling speed, crawling while using the foot petal, and moving inside of buildings. VIC Foxtrot also provided the ability to approach obstacles, such as building corners or doorways, using the foot pedal, then get off the pedal and walk up to corner or doorway and look around it to see what was behind it. This capability added to the realism of VIC Foxtrot.
- Soldier Station, one of the least preferred systems, also had features which were viewed from both positive and negative perspectives. For example, for engaging targets, soldiers indicated that aiming and shooting were very accurate. Viewing and scanning were very easy using the joystick. On the other hand, soldiers felt that this approach was very unrealistic and they preferred to be standing and holding an actual weapon.
- VIC Alpha, which was ranked very low on the tasks and dimensions mentioned above, received positive feedback from some soldiers who liked the realistic sensation provided by the headset. However, the limited field of view, 45 degrees at any one time, and poor depth perception and peripheral vision made it very difficult to maintain situational awareness.

It is not exactly clear what factors guided soldiers in their rankings. However, one factor may be the apparent realistic nature in which tasks could be performed. Interview responses from one soldier indicated that the overriding factor in his assessment of the VICs was realism. The more realistic the system the better, i.e., use of a real weapon, actual walking, carrying your load bearing equipment (LBE), and having something on your head (helmet or headset like VIC A). The group consensus was that VIC Bravo was the most realistic. The system allowed them to perform tasks with the fewest differences from tactical procedures.

Some additional findings are:

- Observations indicated that the soldiers were not fully trained or fully expert in all functions of each VIC. There was very little time for individual train-up on how to operate controls, etc. Soldiers must be fully proficient with the VIC system to maximize potential advantages offered by these new technologies. The observations also provide some indications of lack of team work, e.g., moving directly to team member's front when bounding, lack of awareness of time-distance factors.
- The databases were perceived as needing improvement. Suggestions included improving the realism of the desert terrain; improving variety and distinctiveness of interiors and exteriors of buildings; incorporation of civilians in the scenarios; and including more obstacles.

In addition to the issues addressed above, other specific limitations were noted. Soldiers were not an intact fire team and for the most part were inexperienced. Some of the observed difficulties were in part due to this inexperience. There was also limited interaction with SAF in the exercises selected. This is primarily due to limitations in current SAF capabilities. The SAF fireteam operated independently and often added a confusion factor when they engaged OPFOR SAF. Enhancements should be made to allow more individual- and team-level interaction between the VICs and the SAF. Also, SAF need improvements to make lethality levels more realistic.

Finally, the technology of some of the VICs, especially VIC Alpha, was unreliable. VIC Alpha was fully operational less than half of the time. System recalibration accounted for most of the down time for this system. VIC Foxtrot was fully operational only forty-seven percent of the time during the 29 Palms scenarios (VIC Foxtrot's weapon was not functional for approximately two days resulting in the total shutdown of the system. Once this problem was corrected, VIC Foxtrot was very reliable). VIC Bravo had some problems with the treadmill during the 29 Palms scenarios, and during the MOUT scenarios, soldiers in VIC Bravo frequently got stuck in walls. Soldier Station was the most reliable system during the 29 Palms exercises and the second most reliable in the MOUT.

6. Implications of Experiment Results

The four VICs that were the object of the engineering and user experiments were consciously selected to represent a reasonable cross-section of technology solutions to the problem of immersing an individual soldier into the virtual environment and allowing him to see, move, and shoot. The results of the experiments prove that there were indeed measurable differences, both quantitatively and qualitatively, among the systems. From an experimental perspective, however, these variables (VICs) represent fixed rather than random samples. The implication of this difference is how far one may extrapolate the results beyond the immediate systems that were studied. With fixed effects variables, the applicability of the results are generally limited to the specific variables or levels of variables studied. With random effects, the variables are considered to have been randomly selected from the entire population of interest and are therefore statistically representative of the entire population. Experimental results can then be generalized over and applied to this population.

Obviously, we would like to extend the implications of the DWN experimental results to areas beyond the present four VICs. There are, we believe, definitive statements that can be made about the results as to how they may and should affect future VICs. The obvious generalization is that no one VIC provided the ultimate solution either in terms of a technology perspective (engineering experiments) or task perspective (USEX). However, each had specific strengths that should be carried forward. The following section discusses the implications of both the engineering and user exercise results for next generation VIC enhancements.

6.1 Next Generation VIC

The current VICs demonstrated both strengths and weaknesses during the DWN engineering experiments and user exercises. Each VIC contained at least one component that showed promise as a candidate solution for some aspect of future DI simulation requirements. These strengths and weaknesses can serve as evolutionary forces shaping the next generation of VICs. The strong aspects of each should survive into the next iteration; the problem areas point to areas of improvement required of the next generation VIC. Technologies that are applicable to DI simulators that can be used to fill these problem areas have recently been reviewed [ref 3].

Since the experimental results have been categorized under visual, locomotion, and weapon aiming tasks, these will be continued for the present discussion. The Army states that the basic requirements for troops are to move, shoot, and communicate. Thus, communication requirements will be addressed as well.

6.1.1 Locomotion

At a gross level, there was a dichotomy between locomotion techniques used by the VICs. VIC Bravo stood alone in attempting to re-create the physical processes involved in walking and running. The rationale for a treadmill or similar device is that it provides task realism for walking or running, providing task exertion and fatigue when climbing hills or traveling long distances. This physical exertion was amply demonstrated during both sets of experiments. Soldiers during the USEX would emerge from Bravo drenched in perspiration from both the physical effort and the emotional stress of battle. Bravo also received overall high marks from the soldiers, especially for both realism and being able to perform tasks in a tactically sound manner.

However, it was also noted that walking on the ODT was not especially natural or comfortable. VSD built the ODT that was used for both sets of experiments as a proof-of-concept device that was not intended for prolonged use. They have plans for an improved ODT that should provide better performance. The stated preference for such a device by the users should justify its incorporation into a second generation VIC.

The other types of locomotion devices obviously fall into the non-treadmill category. There are undoubtedly a number of tasks that can be performed in simulators not equipped with a (costly) treadmill device, particularly within the ACR/RDA domain. VIC Alpha's locomotion solution was not well received, and in many respects is peculiar to their type of motion tracking system. Foxtrot's foot pedal was judged second to Bravo on many tasks, although it could have benefited from an improved control function. Charlie's joystick proved a reliable performer but was not judged as realistic. The optimal approach to non-treadmill locomotion seems yet to be determined, but a modified pedal or perhaps weapon-mounted thumb transducer or mini-joystick may prove satisfactory for most applications. This area needs further research.

One area that needs to be addressed is that tactical locomotion includes a postural component, such as crouched running and low and high crawling. This is not possible on the current ODT, although the enhanced ODT is planned to support these types of movements. For non-treadmill systems, posture changes are triggered using pushbuttons, and locomotion accomplished via the same joystick or pedal. Obviously, DIS (or more accurately High Level Architecture (HLA)) must be able to support a wider set of tactical movement postures.

6.1.2 Visual System

The engineering experiments reinforced what has long been known in the sensor and simulation area - greater resolution and field-of-view is positively correlated with better performance (up to a point). The fact that the VICs' visual systems exhibited a fairly wide range of performance in these areas points to another established fact - high resolution and wide field-of-view are expensive - both in terms of dollars and, for HMDs, size, weight, and complexity.

VIC Alpha's HMD provided an adequate-to-marginal window into the world, but would definitely have benefited from increased field of view and display resolution. There are a number of HMD technologies reviewed in the referenced technology assessment [ref 3] that provide better performance, although none of these are wireless as required by VIC Alpha. This was really the limiting requirement.

VIC Bravo, with its WISE display, offered a visual environment that more closely matched the real world than any of the other systems, in terms of (1) field of view (which was limited only by the human's field of view, which is unusual in VR simulators) and (2) a "geo-stabilized" environment, where the world within which the human moved was visually and spatially fixed in terms of North, East, South, and West. The benefits of this stabilized environment were seen in target range and azimuth estimation performance. However, the lack of good visual resolution diminished the capabilities that Bravo may have otherwise realized. VIC Bravo's WISE also provided an effective environment in which to use and exploit the independent (virtual) LOS of the simulated Land Warrior weapon system.

Finally, VIC Charlie demonstrated that it is a qualitatively different simulator, not really comparable to the other VICs in terms of immersive qualities. While it had many positive performance attributes, such as a high resolution display, it was described basically as a video game (Section 4.5.5.3) and was given the lowest realism ratings.

VIC Foxtrot's visual system provided a relatively large field of view (greater than 90° horizontal) and a high-resolution display. Foxtrot, like Bravo, was reported to provide a good sense of motion to the user. This is a benefit of the expanded FOV.

The lesson for follow-on VICs is to increase FOV and resolution. Newer HMDs are providing better performance in both of these aspects, and costs are becoming more reasonable. Projection systems offer high resolution and can support wide fields of view. A good system can provide excellent fixed-site performance for extended periods of time, yielding a more attractive cost-benefit solution when viewed over the long term.

In addition to display systems, there is a second component to virtual display quality. The virtual environment exists from moment to moment only as it is created by a computer image generator (IG). These IGs have long been the limiting factor in the environmental density or richness (scene resolution). Tactical DI simulation environments require buildings, trees, bushes, curbs, rocks, stumps, brush, sewers, etc., at levels of detail not required from vehicle or flight simulators. The lack of adequate terrain detail was noted by users during the USEX. To achieve these levels of resolution while maintain adequate update rates, IGs need to improve beyond current levels while maintaining or reducing costs. Fortunately, IGs are mirroring the general computer price/ performance trends. Increasingly powerful Image Generators, some PC-based, are becoming increasingly affordable. Future VIC simulators need to constantly upgrade their IG capabilities to maintain performance while increasing the density and realism of the synthetic environment [ref 3].

6.1.3 Weapon Aiming

The general conclusion from the DWN experiments is that current trackers are inadequate to the weapon aiming task. Neither the electromagnetic, acoustic, or optical tracking systems faired well either in accuracy or stability. There were actually three types of aiming used by the VICs: direct weapon aiming, virtual weapon aiming, and a hybrid of the two.

Foxtrot used direct weapon aiming. This method is most sensitive to inaccuracies in weapon tracking performance. The actual weapon sights are used to aim at the target on the projected image. If the system's determination of weapon LOS, as computed through the weapon trackers, doesn't match the user/weapon's visual LOS, then aiming inaccuracy will result. This inaccuracy was observed during the engineering experiments.

VICs Alpha and Charlie both used virtual weapon aiming. Both the target and the aiming reticle or weapon sights are displayed as part of the virtual environment. This method is least susceptible to tracking inaccuracies (tracking as such is not applicable to VIC Charlie), since actual aiming error is identical to the perceived aiming error (unless ballistic algorithms introduce errors not displayed to the user). Regardless of what is being used to compute both target and sight position, their displayed positions are "reality" for the user. When the sight is coincident with the target in the display, the "real" error is zero as well since the display is reality. In fact, there doesn't need to be any external replication of the weapon, as is true in VIC Charlie and in most video games. However, if a weapon surrogate is used, the tracker output must be stable; Alpha's sights often "jumped" off the target during final aiming which increased aiming times and decreased accuracy.

Finally, VIC Bravo, with its simulated Land Warrior weapon system and IHAS, combines both direct and virtual aiming. Initially, the user sees the target projected on the WISE display. He then brings his weapon to bear upon the target as in VIC Foxtrot. However, once the target is within the FOV of the simulated weapon sight sensor (a "video scope"), the aiming is virtual, with the final alignment of the crosshair on the target performed totally within the video. This approach works well as long the weapon tracking error tolerances are less than the field of view of the weapon sighting system. When the user raises the weapon and points it at the target, if the target appears within the sight then final aiming corrections can be made. If the target does not appear within the sight FOV, then the user must "hunt" with the weapon to look for the target. Since most sight sensor's FOV is relatively small, this can become a non-trivial task, especially if the error is initially large. This proved to be the case with Bravo, whose weapon alignment error was significant.

This dual approach offers the potential to allow fast, accurate aiming within the constraints of current tracker performance. Of course, this currently works only with weapons equipped with a sighting sensor, although a similar approach could be used to simulate iron sight aiming with an IHAS-type display. Alternately, tracker improvements such as dual-technology trackers - e.g., inertial combined with acoustic or magnetic - may increase tracker performance to acceptable levels [ref 3]. Both approaches should be pursued.

6.1.4 Communications

As stated during the documentation of USEX results, communications among the VICs was difficult using the wireless microphones. This solution was developed to solve an immediate problem in the quickest and most cost-effective manner. Each VIC had been developed in isolation, so integration with other VICs required some invention and some convention (standardization). Communications fell into the former category.

Beyond voice communications, it was interesting to watch the soldiers gesture to one another, telling them to move "over there" (pointing), "get back" or "down" (waving), and so on. In reality, the soldiers couldn't see each other physically, and their avatars or virtual selves didn't reflect any gestures made by the soldiers (except for Alpha's self avatar). This is a natural means of communication among soldiers (and people in general) who can see each other. Steps should be taken so that future VICs can gesture to each other and, just as importantly, gesture commands to SAF.

VIC Alpha, with its optical motion capture system, provided the only mechanism for capturing and representing gestures and other body postures. Although this information was not capable of being used except for local display of the avatar, it provides a capability that will be required in future VICs for gesture recognition. The major drawback to the motion capture system was a lack of robustness, which affected other aspects of the system such as weapon aiming. As discussed, the system required frequent re-initialization which was at minimum a nuisance to the users. Instrumenting by other means, such as electromagnetic or acoustic sensors on arms and hands, are alternatives that should be explored.

Finally, the Land Warrior system is intended to provide soldiers with the capability for constructing, sending, and viewing digital messages. This form of communication should be supported by future VICs. Integration of the IHAS into VIC Bravo is the first step towards this end.

6.2 Summary

While the DWN experiments did not result in the absolute definition of the optimal VIC, it has provided important information towards defining the discriminating characteristics for VICs that will support specific task requirements. It is most likely that there will be no single best VIC, or DI simulator, but rather there will be a range in fidelity of simulators to meet specific objectives, much as there is currently in weapon, vehicle, and flight simulators.

7. Future Plans

Future DWN plans are driven by the objectives set forth in the previously referenced Requirements Analysis Study. The objectives are stated as follows:

> "The primary objective ... is to identify ... potential enhancements to the DWN systems that will ... support US Army and Marine Corps Advanced Concepts and Requirements/Research, Development and Acquisition (ACR/RDA) objectives as they relate to Individual Combatants (IC) involved in Military Operations in Urban Terrain (MOUT). Within RDA, special emphasis is placed on meeting the simulation needs of the MOUT ACTD. Within ACR, the enhanced DWN system is intended to support concept development, technology evaluation, materiel evaluation, doctrine, tactics, combat techniques, and force structure for IC MOUT applications. A secondary objective is to help identify and assess TEMO requirements for future IC simulators and to identify and assess potential enhancements for the CCTT DI Module."

The follow-on Delivery Order, referred to as DWN Enhancements for Restricted Terrain or DWN ERT, was initiated on September 4, 1997. It is intended to culminate with a set of MOUT experiments in March 1998 at the Land Warrior Test Bed. The DWN ERT efforts will be driven by the objectives just stated, and shaped by the lessons learned from the predecessor DO. Work is planned in the following areas: DI SAF Enhancements for MOUT (7.1), VIC Enhancements (7.2), McKenna MOUT Database Enhancements (7.3), Next Generation VIC Developments (7.4), Dynamic Terrain (7.5), Land Warrior C4I (7.6), and DWN ERT Experiments (7.7).

7.1 DI SAF Enhancements for MOUT

In its current form, DI SAF provides an adequate simulation for open terrain (e.g. using the Range 400 terrain database), but does not provide a suitable capability for MOUT scenarios. The biggest lack in DI SAF performance is its treatment of buildings. In the current implementation, buildings are simply obstacles to the DI SAF entities. They cannot be entered, seen through, or shot through. The behaviors to support operations in and around buildings are also lacking. In addition, DI SAF currently does not model some individual soldier weapon systems that are required to blow mouseholes in walls (e.g., the AT8 weapon system), or for clearing buildings once inside (e.g. hand grenades or stun grenades).

In order to provide the necessary enhancements to DI SAF we plan to build on the Multiple Elevation Surfaces (MES) work done by the Computer Generated Forces Terrain Database

(CGFTB) project [ref 2]. MES models buildings as structures containing apertures and enclosures. An enclosure is used to model a room, and an aperture is used to model doors and windows that are part of a room. MES relies on a topology for a building that identifies apertures with enclosures, and enclosures with sub-enclosures. The main extensions that will be required will be the modeling of dynamic apertures, specifically mouseholes and breached doors/windows.

MES provides the necessary data structures, but not the MOUT behaviors - the behaviors which model the movements and actions that the SAF take in and around the buildings. We plan to develop the necessary behaviors by first developing the necessary MOUT CISs, or Combat Instruction Sets. These CISs will be developed via the same approach that was used successfully on the CCTT program for developing vehicle-oriented behaviors. The CISs will include clear traceability to US doctrinal and tactical references. In addition, these CISs will be verified and validated by contractor subject matter experts, which will lead to improved fidelity and a greater level of user acceptance.

We also plan to support dynamic terrain, specifically the creation of mouseholes in walls and the breaching of doors and windows. An AT8 weapon model will be developed to create mouseholes, and the SAW model will be modified to breach doors and windows. The MES software will be modified to support dynamic apertures.

7.2 VIC Simulator Enhancements

VICs Alpha, Bravo and Charlie (BAYONET) will be modified to support the MOUT experiments as defined below.

a. VIC Alpha will be modified to work with the DWN virtual radios and to simulate IHAS imagery in the HMD. VIC Alpha will also be modified to improve the overall robustness of the simulator.
b. VIC Bravo will be enhanced with improved weapon tracking such that the soldier will be able to use the IHAS and the weapon in a coordinated, natural fashion regardless of soldier compass heading. In addition, an SGI Infinite Reality will be leased for use during the experiments such that an adequate visual update rate is achieved.
c. VIC Charlie: Two FlyBoxes will be procured to replace the two FlyBoxes that were borrowed for the DWN experiments.
d. A site license will be procured for DI-Guy software, since it was determined to be the best human animation software currently available. This site license will cover up to 10 systems, which can be a mix of PCs, Real3D Pros, and SGI workstations. The licenses will not time out, and they will float between different machines, as long as no more than 10 are active at one time.

The DWN Government partners responsible for Soldier Station and TTES have decided not to participate with their systems in the follow-on effort, although they will continue to support the planning and development effort.

7.3 McKenna MOUT Database Enhancements

A number of database modifications are planned to the McKenna MOUT database to enhance its utility for DWN MOUT simulation. They include the following:

a. Add the interior structures to Building F, and ensure that the geometry matches the geometry inherent in the MES data structures for Building F. At least one breachable door and window will be added to Building F.
b. Update the database to match the construction currently underway at the MOUT site, including colors, textures, new doorways, and introduction of rubble.
c. Eliminate the interiors from Buildings L, G and B so that the update rate for the various visual systems employed in DWN will be improved. Different versions of the McKenna MOUT database will be maintained, with and without the building interiors.
d. Improve the texture maps on the ground and on the floors and stairwells of the buildings to improve spatial cueing for the VIC soldiers. The use of microtexture is expected to improve spatial cueing as well as reduce the tendency for the buildings to appear to "float" above the ground (because of the low resolution imagery used for ground texture).

This work will be preceded by a data capturing trip to the McKenna MOUT site, and will include database reviews with the government at each of the TIMs. Video tape and still pictures will be collected from McKenna. All database modeling work will be done in the ADST II OSF in Orlando using ADST II MultiGen software tools.

7.4 Next Generation VIC

7.4.1 VIC Delta

VIC Delta is defined as the Soldier Visualization Station (SVS) developed by RBD for AE4. This system will be a residual at the LWTB after AE4. For DWN ERT, VIC Delta will be modified to support dynamic terrain and to support LW C4I. These modifications are described in paragraphs 7.5 and 7.6, respectively. VIC Delta will also be integrated with a Real3D Pro IG to maximize its update rate in the dense MOUT environment and provide the potential for increased visual system resolution. The SVS as it will be configured for AE4 is briefly described below.

The SVS is a PC-based man-in-the-loop DIS system geared toward individual combatants. It provides two simultaneous channels of computer generated imagery: one for the regular IC view of the synthetic environment, and one for presentation via the Land Warrior IHAS display. A surrogate Land Warrior rifle is instrumented and connected to the SVS system. Navigation is achieved via a thumb activated joystick located on the grip of the rifle. Two motion trackers provide position and orientation information - one located on the surrogate rifle and one located on the IC helmet. Spatialized battlefield audio is presented to the participant via speakers. The SVS supports display of the regular IC view of the synthetic environment via a rear screen projection system.

While SVS was developed concurrently with the execution of the DWN experiments and thus is not directly a product of DWN lessons learned, it was developed by a DWN team member and does incorporate much of what was learned in the preparation and execution of DWN. It enhances and extends BAYONET-type performance on a lower cost PC platform. SVS consists of the following:

Hardware components:

a. Two Pentium personal computers
b. Two external, self-powered speakers
c. One Land Warrior surrogate rifle instrumented with functioning triggers, buttons and thumb activated joystick
d. One motion tracking system
e. One video projection system capable of delivering a 640x480 resolution image
f. One projection screen with a minimum 6'x 6' dimensions capable of rear projection

Software capabilities:

a. Generation of a three-dimensional computer graphics, simulated soldier's view into the virtual battlefield presented at a 640x480 image resolution
b. Generation of a 3-D simulated rifle view presented as a 640x480 resolution image
c. Capability for the soldier to move, interact and operate in the virtual battlefield, including aiming, lasing and firing the LW mockup rifle
d. Computation and presentation of spatialized audio
e. Tracking of the rifle and soldier's position and posture
f. Networked transmission of the soldier's position, posture and state using DIS 2.0.4 protocols
g. Software linkages to the LW C4I system (see paragraph 7.6)

7.4.2 VIC Echo

VIC Echo is planned to have functionality similar to VIC Delta but with two different display modes: (1) a curved screen (dome segment) with higher resolution projectors and wider field of view as compared to VIC Delta, and (2) a head mounted display with improved field of view and resolution as compared to VIC Alpha. It will be possible to reconfigure VIC Echo to support either display mode. Alternately, two configurations may be developed - VIC Echo with the dome segment display and VIC Golf with the HMD. This latter configuration would require the acquisition of an additional Real3D Pro for use with an additional SVS. VIC Golf may be integrated with the ODT asset available at the LWTB. Modifications to the DWN ERT contract are ongoing to support the development of VIC Golf.

VIC Echo is defined as a VIC Delta system with modifications to provide a wide FOV display on a 150 degree by 40 degree dome segment and high resolution Barco projectors. It also requires acquisition of 2 Real3D Pro IGs to drive the Barco projectors, and a Head Mounted Display. Figure 7.4.2-1 illustrates the planned configuration.

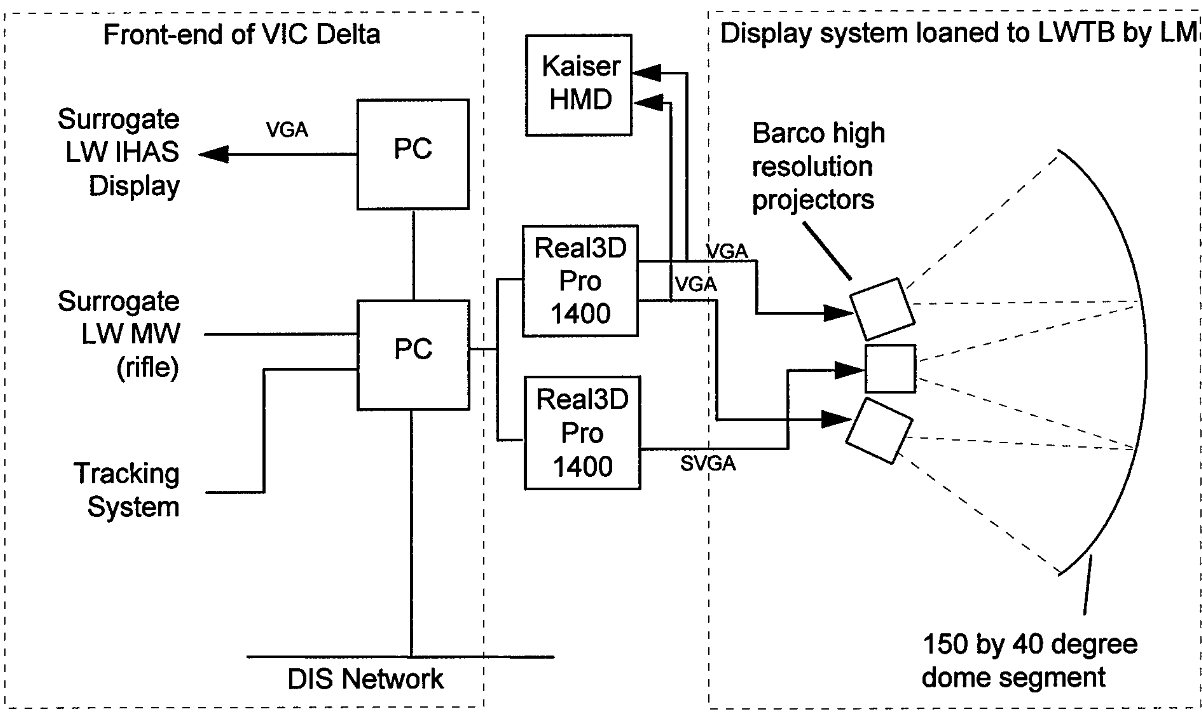


Figure 7.4.2-1: VIC Echo Block Diagram

The dome segment display system will provide a capability that has not been tested to date on any DWN system: wide field of view on a curved surface with high resolution and high update rate. We believe that this will provide a level of immersion not available on lower performance systems, and provide a benchmark against which other VICs can be measured. Similarly, the Kaiser HMD will provide higher resolution, wider FOV and a higher update rate than provided by previous HMDs.

7.5 Dynamic Terrain

We plan to implement two types of dynamic terrain: mouseholes and breaching of doors and windows. We plan to utilize the Army Research Lab (ARL) approach to dynamic terrain, in which the mousehole is created at the impact point by modifying the polygons that comprise the surface where the impact occurred. The surface polygons are read from the OpenFlight database, new polygons are created to match the shape and size of the old surface but with a hole at the impact point, then the new polygons are written back into the OpenFlight database. No new PDUs are required to implement DT in DWN; all participants just need to agree on the size of the hole to be created by a given weapon, and to respond appropriately when the detonation PDU is received indicating that a hole is to be blown. We propose to utilize the AT8 to create the mouseholes.

Each VIC will be modified with the ARL algorithm, which simply creates a hole of a pre-determined size at a point on the surface of a wall, ceiling, or floor, as specified by the Detonation PDU. The DI SAF will also respond to this Detonation PDU, and create a hole of the proper size and location in the MES data structures.

Breaching a door or window will result in the removal of the door/window from the simulation. As with mouseholes, it will be the responsibility of each simulator to listen to the Detonation PDU, and if it impacts a door or window, the feature is removed from its database. VICs and SAF will be able to breach doors/windows, and to detect that a door/window has been breached. The SAW will be declared capable of breaching doors or windows along with the AT8.

7.6 Land Warrior C4I Simulation

We plan to develop a software simulation of the Land Warrior C4I system with the use of COTS hardware and without the use of tactical software. With the help of the government we plan to obtain sample screens and other relevant data necessary to simulate the required LW C4I displays. We also propose to utilize LMSG subject matter experts to help design a PC based software simulation of the LW C4I capability.

For this first instantiation we plan to build four (4) LW C4I simulation sets - two to run on standard PC monitors co-located with two BAYONET stations and two to run on the simulated IHAS of VIC Delta and VIC Echo. Each simulation will run on a PC that is networked to the DIS network. The DIS network is used as a virtual Variable Message Format (VMF) network; i.e., VMF data is packaged into DIS Data PDUs and transmitted over the DIS network. Appliqué will interface to the LW C4I simulation via a Sun workstation connected to the DIS network. Figure 7.6-1 illustrates the LW C4I networking configuration.

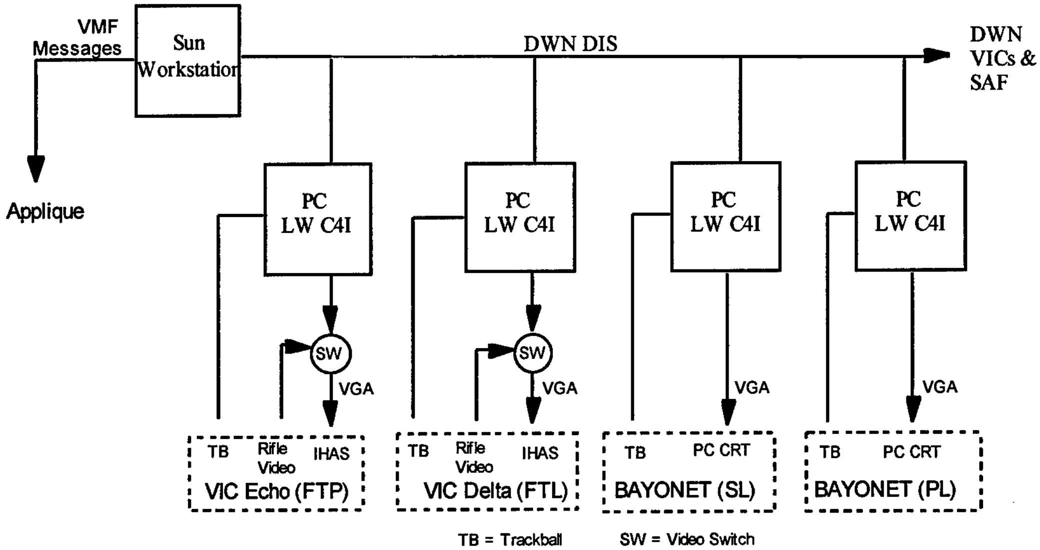


Figure 7.6-1: Land Warrior C4I Simulation Block Diagram

For this initial implementation we propose to support three types of text screens: position reports (friendly), SPOT reports (enemy) and free text. The free text mode will support several canned messages, such as "room clear". SPOT reports can include enemy locations which may be input automatically based on a laser range finder function performed by the host VIC.

7.7 Experiment Execution

The DWN ERT experiment phase is planned for the last two weeks of March, 1998 at the LWTB at Fort Benning, Georgia. We propose to define and collect engineering performance data similar to that collected during the DWN engineering experiments, with the emphasis on subsystem characterization metrics, e.g., visual system performance, lags, tracking accuracy and repeatability, etc. Performance-type data (aiming, shooting, movement) will be integrated into test scenarios similar to those developed for the DWN USEX. Performance data in the form of logged PDU data and subjective assessments will be collected with the help of ARI as during the prior DWN experiments.

8. References

1. Jones, Traci, "Individual Combatant Simulation Technology Transfer Plan", November, 1995.
2. Evans, Alan, Stanzione, Tom, et. al., "Multiple Elevation Structures in the Improved Computer Generated Forces Terrain Database", 1996.
3. Lockheed Martin, "Requirements Analysis for Dismounted Warrior Network Enhancements for Restricted Terrain", ADST-II-MISC-DWN-9700240A, July 14, 1997.
4. Pace, D. K. "Preliminary Guidelines for Distributed Simulation Analysis and Engineering (A&E) Applications", January, 1997.

5. Kennedy, R.S., Lane, N.E., Berbaum, K.S., & Lillienthal, M.G. "A simulator sickness questionnaire (SSQ): A new method for quantifying simulator sickness." International Journal of Aviation Psychology, 3(3), 203-220, 1993.
6. Kennedy, R.S., Lane, N.E., Lilienthal, M.G., Berbaum, K.S., & Hettinger, L.J. "Profile analysis of simulator sickness symptoms: Application to virtual environment systems." Presence, 1(2), 295-301, 1992.
7. Witmer, B. G., & Singer, M.S. "Measuring presence in virtual environments." (ARI Technical Report TR 1014). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 1994.
8. Johnson, J. "Analysis of Image Forming Systems," Proceedings of the Image Intensifier Symposium, US Army Engineering Research Development Laboratories, Fort Belvoir, Virginia, October 1958.
9. Best, R.D., "Tradeoffs in the Configuration of Computer Image Generation Systems," Proceedings of the 11th Interservice/Industry Conference, 1989.
10. Lampton, D.R., et. al., "The Virtual Environment Performance Assessment Battery (VEPAB)," Presence 3(2), 145-157, 1994.

9. Attachments

Appendix A: Engineering Experiment Plan

Appendix B: Engineering Experiment Questionnaire Forms

Appendix C: Engineering Experiment Questionnaire Data

Appendix D: User Exercise Plan

Appendix E: User Exercise Questionnaire/Data Collection Forms

Appendix F: User Exercise Questionnaire Data

Appendix G: Acronyms

Appendix H: Bibliography of DWN-Related Papers

Appendix A: Engineering Experiment Plan

ADVANCED DISTRIBUTED SIMULATION TECHNOLOGY II (ADST II)

DISMOUNTED WARRIOR NETWORK

Engineering Experiments Plan

15 April 1997

BY: Lockheed Martin Corporation
Information Systems Company
P.O. Box 780217
Orlando, Florida 32878-0217

TABLE OF CONTENTS

1. Introduction

This document defines the current plans for the execution of the engineering experiments phase of the ADST II delivery order Dismounted Warrior Network (DWN) (DO #0020). The engineering experiment design effort is specified in the DWN Statement of Work paragraph 3.1.1.5, with support of the conduct of these experiments specified in paragraph 3.1.3.1 of the work statement. This document is not a CDRL item but is a necessary part of the planning process.

The major thrust of the DWN effort is to develop a set of requirements for dismounted infantry (DI) simulation to support both the Training, Exercises, and Military Operations (TEMO) and the Advanced Concepts and Requirements/Research, Development, and Acquisition (ACR/RDA) domains. Through a process of task requirements definition and functional fidelity analyses, this analytic effort is to culminate in a DI simulation requirements document.

The engineering and follow-on user experiments are intended to supplement this analytic effort by exercising important or "high-driver" DI tasks within state-of-the-art DI-simulation insertion technologies. The results of these empirical investigations can be compared with the criticality and fidelity results of the analyses.

2. Purpose

The DWN engineering experiments are intended to compare and contrast the ability of the key features of different Virtual Individual Combatant (VIC) technologies to support DI task performance in a virtual environment. The intent of comparing these different technologies over different tasks is to document the capabilities of each in order to be later matched against functional fidelity requirements flowing from the fidelity analysis portion of DWN. The result is the beginnings of a catalog that match existing technologies and capabilities against simulation requirements, and the identification of areas where future technology development is required.

3. Integration with Task Analysis

The experiment planning process has maintained continual communication with the task analysis effort to ensure that task parameters identified by the analysis are captured and reflected in the experiment plans to the maximum extent possible. Monthly coordination meetings have been held since the initiation of the engineering experiment phase of DWN. Important tasks from the defined task lists have been used to help identify discriminating measures for comparing VIC component performance, and task analysis data has been used to develop scenario segments for the experiments.

4. Technology Evaluation Options

Preliminary technology analyses conducted prior to the award of the DWN contract help to define the VICs that would ultimately participate in the DWN experiments. The VICs were selected to represent a cross section of current-technology capability within a variety of functional areas important to DIS-based DI simulation. These functional areas and the capabilities found within the VICs participating in these experiments are listed in Table 4-1 below.

Table 4-1. Technology Evaluation Options

- Locomotion
  - Human joystick
  - Bi-directional treadmill
  - Omni-directional treadmill
  - Joystick
- Motion Capture
  - Video: • whole body tracking • rifle pointing
  - Magnetic sensors: • upper body tracking • rifle pointing
  - Acoustic sensors: • rifle pointing
- Communicate
  - Digital radio
  - Gesture/Voice control of SAF *
- Shoot
  - Weapon performance
  - Physical representation
- Semi-Automated Forces
  - Realistic behavior, individual and collective, open terrain
  - MOUT behaviors*
- DIS Technologies
  - Interoperability Issues
  - Network Issues
- Human Animation
  - Physical based (JACKML)
  - Appearance based (DI-GUY)
  - Biomechanics based (DSS)
- Visual Presentation
  - HMDs - wireless
  - IHAS
  - WISE, CRTs
- Aural Cues
  - Directional sound

*Not currently funded

The specific component capabilities of the four VICs to be used in the experiments are presented in the following Table 4-2 and are briefly described in the following sections.

Table 4-2. VIC Component Comparison Matrix

	Subsystem			
Function	VIC Alpha	VIC Bravo	VIC Charlie	VIC Foxtrot
Locomotion	Human Joystick	ODT	Joystick	Foot Pedal + Head LOS
Visual Display	HMD (wireless, low resolution)	WISE	Monitors	Projection Screen (1)
Body Motion Capture	Video-based tracking	Electro-magnetic (E-M)	N/A	E-M
Weapon Tracking	Video	E-M	N/A	Acoustic
Weapon Aiming	In video thru HMD	In video thru IHAS	Crosshairs in video	Rifle sight
Directional Sound	Yes	Yes	Yes/stereo	Yes/stereo
DI SAF*	Yes	Yes	Yes	Yes
Human Animation	DSS-unique	DI-Guy	JackML	DI-Guy
Communication*	Digital Radio	Digital Radio	Digital Radio	Digital Radio

* No difference so no comparison possible

4.1 VIC Alpha

VIC Alpha, which consists of the Veda, Inc. Dismounted Soldier System (DSS), is summarized below:

- Video based full body motion tracking (Biomechanics)
  - Free movement in a restricted space ("human joystick")
- SGI RE2 Image Generator
- Wireless Helmet Mounted Display
- Weapon Simulation (GFE from NAWCTSD)
- Omni-directional Sound
- DIS PDUs with human animation enhancements

4.2 VIC Bravo

VIC Bravo is comprised of the integration of NPSNET, the Omni-Directional Treadmill (ODT), and the Land Warrior Rifle and Integrated Helmet Assembly Subsystem (IHAS). These subsystems are in turn made up of the following:

- NPSNET
  - Magnetic based upper body motion tracking
  - SGI RE2 Image Generator
  - Channel Walk-In-Synthetic-Environment (WISE)
  - Human animation (Jack-ML and DI Guy)
  - DIS Compliant
- ODT (Omni-directional Treadmill)
  - Developed by Virtual Space Devices
  - Supports 360° directional locomotion
- Land Warrior Rifle + IHAS
  - From AUSA, plus COTS IHAS device
  - Will NOT include LW C3I message traffic

4.3 VIC Charlie

TRAC WSMR's Soldier Station was to be the VIC Charlie system. Soldier Station, as configured for the DWN experiments, consists of:

- Visualization component only; uses subset of NPSNET plus JackML
- SGI Maximum Impact (utilizes polygonal MultiGen database)
- Desktop CRT display + touchscreen

- Joystick movement control via flybox
- Directional Sound
- DIS Compliant
- Does NOT include Janus component
- Environmental functions utilize gridded data base which raises potential correlation problems with visualization functions

After the bulk of the planning effort had been completed, Soldier Station had to withdraw from the engineering experiments. Thus, VIC Charlie will consist of a system with a human-computer interface similar to Soldier station - namely NPSNET software integrated with a flybox for VIC control.

4.4 VIC Foxtrot

VIC Foxtrot (VICs Delta and Echo were not exercised by STRICOM due to funding limitations) consists of NAWC TSD's Team Tactical Engagement Simulator (TTES). TTES, developed for USMC by NAWC TSD, is made up of:

- SGI RE3 Image Generator
- Large screen display
- Movement control via foot pedal
- Electro-magnetic based head tracking; acoustic-based rifle tracking
- DIS Compliant
- The TTES visualization system will be provided as GFE

4.5 Support Capabilities

Supporting the VIC network for the DWN experiments will be a DI SAF station under development for DWN by SAIC, a ModSAF station to provide target entities, and an Exercise Support Station. This latter station will use the *Simulyzer* software to collect DIS PDU data and perform real-time system monitoring during the experiments.

5. Engineering Experiments

5.1 General Requirements

The engineering experiments will be run using VICs Alpha, Bravo, Charlie, and Foxtrot as the manned subsystems under test, with ModSAF and DI SAF workstations providing target and other support entities as required. All subsystems and workstations will be networked together using DIS 2.0.4 communication protocols. *Simulyzer* data logging and analysis software located on the Exercise Support Station will be used for data collection (PDU logging) and summarization. *Simulyzer* has the capability to output ASCII data files, which will be loaded into Excel software on a PC for further analysis.

In addition to *Simulyzer* data collection, the following data collection/logging capabilities will be required:

- Video tape recording of the four VICs (including audio), possibly with common time stamp (time code generator)
- Input header information for data files including:
  - Subject identifier for each VIC
  - Date/time
  - Test conditions
  - Run/trial number
- Measure system parameters (identified below for each functional test area) during system integration
- Administer questionnaires including:
  - Immersive Tendencies Questionnaire (administered once at the beginning of the experiments
  - Presence Questionnaire (administered after the last use of each system)
  - Simulator Sickness Questionnaire (administered before and after each session)
  - Task Performance Difficulty Rating Scale
  - Task Learning Difficulty Rating Scale

It is also required that experimental trials can be initiated, monitored, and terminated (if required) from either the ModSAF or Exercise Support Station terminal. This control will be exercised over the DIS radios by verbally commanding the system operators at the other workstations and VICs to start, stop, etc.

One question that must be resolved is the ability of ModSAF and DI SAF to support repeatable (identical) trials. It may not be possible to run all four stations simultaneously on a given experimental condition, so it will be necessary to run identical trials at different times. This requires that in those instances in which SAF moving targets are an element that the target path be identical or as close as identical as possible during each run.

Finally, for at least the target identification tasks, a variety of recognizable targets are required. The list of models to be supported for the DWN experiments include the following:

- M1A1/A2
- M2A3
- AH-64
- HIND
- HMMWV
-
- BMP
- DI (both friendly and enemy)

Subjects will be shown how these models look in the databases to be used during the experiments - specifically, the 29 Palms and McKenna MOUT databases.

The following sections provide descriptions of the experimental tasks, the data collection requirements, performance measures, and database requirements for each of the functional test areas: locomotion, visual system, weapon aiming, body motion capture, human figure animation, and a composite including move, see, hear, and shoot.

5.2 Locomotion Experiments

The basic purpose of the locomotion experiments is to determine how well the VIC mobility component allows navigation through the virtual environment. This will be assessed by requiring the subjects to navigate through an obstacle-strewn section of the database.

5.2.1 Tasks

The basic task for the locomotion experiments is for individual participants to negotiate multiple courses outside of and through building interiors in the McKenna MOUT database.

The courses will not be difficult to learn (if fact, it may provide no choices as to direction), but it will require frequent changes in direction, changes in movement speed, going up and down stairs, and movement through confined areas, such as going through doors.

Design considerations for these experiments include:

- Six repetitions of this task will be performed over the course of a week
- One base course will be used for collection of proficiency measures data. Six (6) practices courses will be used after the base course to allow additional practice on moving and navigating through the MOUT site.

5.2.2 Data Requirements

Prior to the experiments, system parameters including the following will be measured and recorded:

- Controller sensitivity (output per unit input), deadbands, hysteresis

- Maximum output (movement rates)
- System lag (control input through visual system)

Data to be logged for the locomotion/obstacle avoidance tasks includes:

- Simulation time (seconds)
- DI position and orientation in database (1 foot resolution)
- Collision events (with terrain features/walls)

Subjective data from post session debriefs and questionnaires listed in Section 5.1 will also be collected. All subjects will be videotaped to observe their performance during the tasks.

5.2.3 Performance Measures.

The data collected will support the assessment of the following measures:

- Plot of DI position vs time
- Course or course segment completion time
- Number of collisions
- Change in proficiency over time

5.3 Visual System Experiments

The vision experiments will be conducted to assess how well the VIC visual system component allows the detection and identification of objects in the virtual environment. This will be assessed by requiring the subjects to locate and identify static and moving objects. Although the theoretical range for detection and identification for each system can and will be computed using the Johnson criteria, the following tasks will be performed to empirically determine or verify these thresholds

5.3.1 Tasks

Task 1.Target Detection

In order to reduce the number of trials required for visual tasks during the experiment period, the detection tasks originally envisioned to be conducted in the same manner as the identification task described as Task 2 below will be conducted prior to or at least separately from the other experimental tasks. These detection experiments will be conducted as psychophysical measurements using an increasing/decreasing stimulus intensity (size) method for determining the detection threshold for each system. For half the trials (n=10), a target such as a tank will begin beyond visual range (BVR) (0% detection criterion empirically determined prior to testing using the theoretical limit as a starting point) and gradually move toward the stationary observer. The observer will signal when he can detect the object and where (as a confirmation check). For the other half of the trials (n= 10), the target will begin within visual range of the subject (100% detection criterion again empirically determined) and gradually move away from the observer. The observer will signal when he can no longer detect the object.

Both tank (M1A2 model) and DI targets will be used for this task. As noted above, 5 trials will be begun with the tank beginning at a BVR distance identified for this model, and 5 trials will begin with the DI beginning at a BVR distance identified for this model. For these trials, the models will move toward the observer. For the remaining trials, both the DI and tank models will begin at predetermined ranges near but not exceeding the BVR distances identified for the two models, and will move away from the observer. BVR distances for incoming targets will be established using the range identified for the best performing VIC, and the near-BVR distance for the outgoing targets will be determined using the range obtained from the VIC with the shortest (theoretical) detection range. All targets will begin within the initial FOV of the VICs, defined as the narrowest FOV of the VICs (45°).

For these detection tests, it will be important to determine how the different graphics systems handle the display of near pixel-size objects, as this could influence the results obtained. Models will be limited to the initial, highest detail level-of-detail (LOD) model; no range-based LOD transitions to lower detailed models will take place.

Task 2. Target Identification

Fixed viewing position tasks require the stationary observer (subject) to locate, identify, and estimate the distance, direction, and speed of motion of an object. This is summarized in the following Table 5-1:

Table 5-1. Visual Task 2 Summary

	Stationary Object	Moving Object
Identify Object	X	X
Estimate Distance to Object	X	X
Estimate Direction and Speed of Moving Object		X

All objects will be placed in the initial field of view of the participant (within ± 45° of line of sight). For the identification tasks, multiple objects having the same approximate size and color will be required (tank, truck, soldier, etc.). These objects will be drawn from the available model list presented in Section 5.1. The moving objects will move at a constant speed and direction relative to the observer, but different speeds and orientations will be used for different targets. Trials will be conducted in the 29 Palms database.

There will be 36 trials developed for presentation of the stimuli for this task: 3 object classes (tanks (M1A2, T-72), non-tank vehicles (M2A3, BMP), infantry (Red, Blue)) x 6 distances (see Table 5-2 below) x 2 states (moving/stationary). Initial target orientation will present a flank or flank oblique view to the observer.

Table 5-2. Distances for Task 2 (in meters).

Tanks/Vehicles	DI
50	25
100	50
200	75
300	100
400	200
500	300

Task 3.270-degree Search

Individual participants in a fixed position will attempt to detect DI-only targets and estimate the azimuth (relative to their initial orientation) to them. Backgrounds are anticipated to be the same as Task 2. Targets will be presented anywhere within the forward 270 degree field of regard. Both stationary and moving targets will be included. This will be done in both of the two different environments, i.e., open and built-up areas.

A total of 32 trials will be required for presentation of the stimuli for this task: 1 object class (infantry) x 4 distances (50, 100, 150, 250 meters) x 2 states (moving (2 kph) and stationary) x 4 azimuths (230°, 315°, 80°, 130°).

Thus, the total number of trials for the vision Tasks 2 and 3 will be 68. Given 6 vision experimental sessions (see Section 6.3.2), this will require ~ 12 trials per session.

Task 4. DI Animation Detection

During the second Technical Interchange Meeting (TIM), the question was raised about how close (hence how visually detailed) a DI model had to be to the observer to allow discrimination of features such as limbs, and whether these limbs were moving (as in walking or running). Task 4 will be conducted in an attempt to answer this question for these systems. DI models will begin from locations at three predetermined distances (50, 100, and 200 meters) and will move at different orientations relative to the observer at a fixed rate. Two models will be used: a static standing model and an animated figure. The observer will indicate when he is able to determine whether it is a fixed or animated model. DI targets will begin from five (5) different azimuth locations in the visual field in order to present different viewing aspects of the models. See Figure 5-1 for a representation of the models movement relative to the observer.

5.3.2 Data Requirements

Prior to the experiments, system parameters including the following will be measured and recorded:

- Resolution (acuity measured via system display), field of view, color registration
- Update rates, subject viewing distance from display

- System lag (control input through visual system)

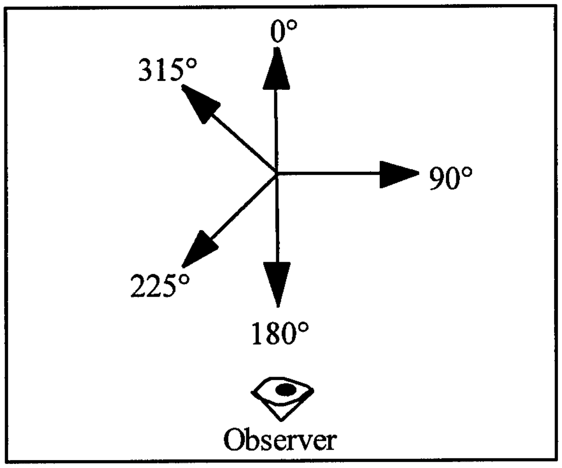


Figure 5-1. Azimuth Locations and Movements Relative to Observer

Data to be logged for the visual system tasks includes:

- Simulation time (seconds)
- DI position in database (fixed position)
- Target position, range, and orientation from the subject; line-of-sight (LOS)
- Target detection and identification events (trigger pull/button press)

Subjective data from post session debriefs and questionnaires listed in Section 5.1 will also be collected. Data logging sheets will be used to manually record voice responses to target identification ("M1A2", "T-72", "AH-64", etc.) and where he thinks he has detected a target, i.e., range and bearing.

5.3.3 Performance Measures.

Visual system performance measures include:

- Target detection time and range
- Target identification time and range
- Target identification accuracy
- Accuracy of distance estimates
- Accuracy of azimuth estimates

5.4 Weapon Aiming Experiments

The weapon aiming experiments will be conducted to assess how well the VIC weapon tracking and visual system components allow the acquisition and engagement of objects in the virtual environment. This will be assessed by requiring the subjects to locate, track, and shoot at static and moving objects.

5.4.1 Tasks

Task 1. Participants use their individual weapons to engage fixed and moving bull's eye targets from a prone, kneeling, and standing posture.

In general, the settings for the vision tasks (Section 5.3.1) will be appropriate. Targets should be engaged from the kneeling, standing, and prone positions. All targets will consist of a special "bull's eye" target that will be developed and added to the databases to aid in assessing shooting accuracy (See Figure 5-2). This target will appear in the initial field of view.

The Task 1 session with the bull's-eye target will consist of 15 trials: 3 postures (prone, kneeling, standing) x 5 motion states (static + moving at 2 speeds (2, 6 kph) x 2 directions (L→R, R→L)) x 1 distance (200 meters). Each subject will be required to fire 3 shots in each condition, returning to a ready (non-aiming) condition between each shot. Thus, 45 data points will be collected for each subject at each VIC.

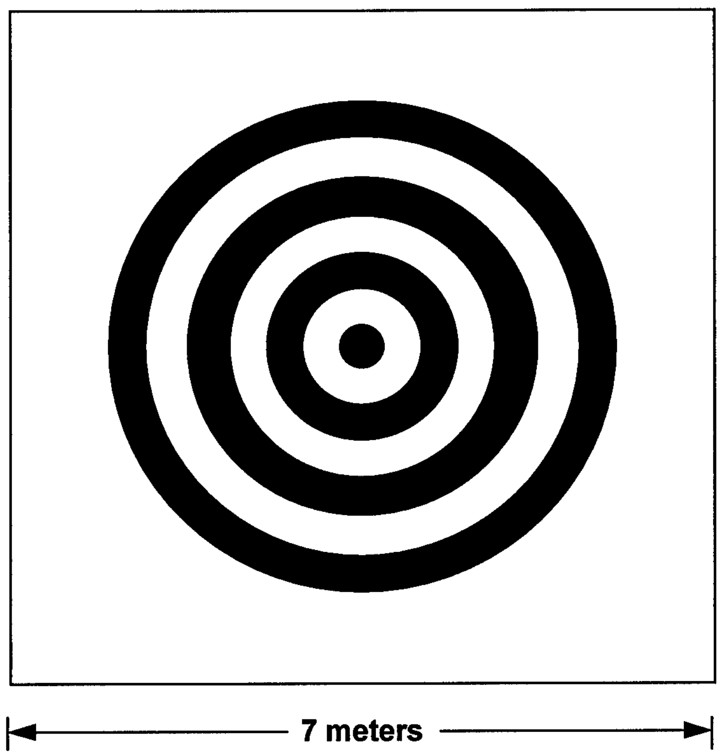


Figure 5-2. Propose Bull's Eye Target

Task 2. Subjects will search over 270° field of regard for the bull's eye target and will engage when located.

Under this set of conditions, standing participants will be required to engage targets (bull's eye) appearing anywhere within the forward 270 degree field of regard. These sessions will consist of 50 trials: 1 posture (standing) x 5 motion states (static + moving at 2 speeds (2, 5 kph) x 2 directions (L→R, R→L)) x 2 distances (100, 200 meters) x 5 azimuths (270°, 315°, 355°, 30°, 93°).

5.4.2 Data Requirements

Prior to the experiments, system parameters including the following will be measured and recorded:

- Tracking system resolution
- Repeatability (reliability)
- Update rates, system lag (control input through visual system)

Data to be logged for the weapon aiming tasks includes:

- Simulation time (seconds)
- DI position in database (fixed position)
- Target position, range, and orientation from the subject; LOS
- Weapon firing events (trigger pull/button press)
- Target hit/miss results (where on target hit; miss distance in target plane)

Subjective data from post session debriefs and questionnaires listed in Section 5.1 will also be collected.

5.4.3 Performance Measures.

Weapon aiming system performance measures include:

- Time to engage, number/percent of targets successfully engaged, miss distance
- Accuracy against different types of targets
- Engagement time against different types of targets

5.5 Integrated See, Hear, Move and Shoot Experiments

These experiments will be conducted at the end of the subjects' experimental session on each VIC to assess how well the overall VIC subsystem components allow the subject to move, acquire, and engage objects in the virtual environment. This will be assessed by requiring the subjects to move, locate, and engage static objects in a more complicated scenario approaching the level of complexity anticipated in the user experiments. Each subject will participate individually, which will require these tests to be run serially.

5.5.1 Tasks

Task 1. Navigate through a built-up area, attempting to locate and engage an enemy sniper while not shooting friendlies or neutrals.

The subject will be required to move through the urban area of the MOUT database, using buildings to cover his movement from a sniper located on the roof of a building. The subject will have to move, look and listen for cues to determine the location of the sniper, who will be firing at other entities and who will fire at the subject if LOS is obtained. The subject will encounter non-hostile forces and will have to identify them as such. Once the sniper is located, the subject will attempt to engage him with his weapon.

5.5.2 Data Requirements

Data to be logged for the composite search/engage task includes:

- Simulation time (seconds)
- DI position in database
- Target position, range, and orientation from the subject; LOS
- Weapon firing events (trigger pull/button press)
- Target hit/miss results on subject and on target(s) (enemy and friendly)

Subjective data from post session debriefs and questionnaires listed in Section 5.1 will also be collected. All subjects will be videotaped to observe their performance during the tasks.

5.5.3 Performance Measures.

- Composite search/engage system performance measures include:
- Time to locate and engage enemy target
- Number of targets successfully engaged (friendly and enemy)
- Subject 'kills' by sniper

5.6 Body Motion Capture Assessments

These assessments of how well the motion capture components of VICs Alpha, Bravo, and Foxtrot perform are engineering measurements of the visual, electromagnetic, and possibly acoustic tracking system employed by several of the VICs.

5.6.1 Tasks

There are no man-in-the-loop task requirements for these measurements.

5.6.2 Data Requirements

Separate from the experiments, system parameters including the following will be measured and recorded:

- Tracking system accuracy (real world vs sensed/displayed positions) and resolution
- Repeatability (reliability)

- Update rates, system lag

No DIS data logging is required.

5.6.3 Performance Measures.

Body motion capture system performance measures include:

- Ability to support capture and display of required postures and gestures
  - Body coverage (head, upper body, arms, hands, lower body, etc.)
  - Resolution

5.7 Human Animation Fidelity Assessments

These assessments of how well the human movement animation component of the VIC performs are subjective estimates of "naturalness" and objective attempts to identify tasks and gestures performed by the subjects as represented by their animated "avatars".

5.7.1 Tasks

Task 1. Human motion.

This will involve VIC Alpha and perhaps VICs Bravo, Charlie, and Foxtrot. A trained "standard human" will perform a set of action sequences. These will be captured by the motion capture equipment and recorded by video cameras. The VICs will then display these actions as made by their avatars. The human animation of his body which result are recorded, if possible from a variety of viewing angles and distances. The videotapes will be shown to judges (perhaps the soldiers, although this is not necessary), who will be asked to compare the videotaped segments in terms of "realism" and similarity.

Task 2. Action Identification.

Judges will view the animation from Task 1 and attempt to identify the action being performed. Viewing distance may be varied.

5.7.2 Data Requirements

No DIS data logging is required.

5.7.3 Performance Measures.

Subjective and objective performance measures include:

- Ratings of similarity of human and avatar action
- Ratings of avatar "naturalism"
- Action identification accuracy

6. Experimental Design

Due to the limited availability of subject matter expert (SME) subjects, a repeated measures design will be employed. Thus, all subjects will experience all conditions on all VICs. All analyses conducted will be appropriate to this design, and will consider the limited sample on which the data will be collected.

6.1 Subjects

Eight (8) active-duty US Army Infantry soldiers have been requested from Ft. Benning, Georgia. These soldiers will be made available for the entire three-week engineering experiment period. They will be randomly paired into four groups, and each group will be presented with the same conditions over time. Within each group, soldiers will alternate sessions on the VIC in order to minimize fatigue effects. Each group will experience all four VICs during the experiments.

All restrictions and safety consideration concerning the use of human subjects and the use of military personnel on (potentially) non-safety certified equipment will be addressed prior to allowing the subjects to use any of the equipment.

6.2 Counterbalancing

Since all subjects will experience all four VICs, the order of presentation of the VICs between groups of subjects should be balanced to the extent possible. This counterbalancing scheme for the four groups and the four VICs is presented in Table 6-1 below. Participant numbers (1-8) are shown in the cells, with the "first shift" participant numbers to the left of the comma and the "second shift" participant numbers to the right. Each pair of participants uses each VIC for one three-day sequence. Pairs are re-constituted every three days. Each VIC is the first VIC used for two participants, the second VIC used for two participants, etc.

Table 6-1. Group/VIC Counterbalancing

	Dates			
VIC	22-24 April	28-30 April	1-3 May	5-7 May
A	1,5	2,6	3,7	4,8
B	2,7	1,8	4,5	3,6
C	3,8	4,7	1,6	2,5
F	4,6	3,5	2,8	1,7

6.3 Schedule

The engineering experiments are scheduled to take place over a three week period from April 21 - May 9, 1997. This provides 15 working days with 2 weekends. Given the four VICs in the experiment, each group can spend three or four days on each VIC, depending on how aggressive a schedule is attempted. Assuming one day for briefing and subject history/information collection and at least one half-day for debrief, it is felt that the more conservative allocation of three days per group per VIC should be planned. This should be adequate to provide sufficient exposure to observe learning effects and complete all defined trials, while providing adequate leeway to accommodate unanticipated system down-time and make-up sessions. Thus, the experimental schedule will be as shown in Table 6-2. This schedule assumes an eight hour work day, since experience indicates that work days usually grow longer rather than shorter, and to plan for more invites the potential for overtaxing support personnel as well as the subjects.

The schedule also shows that a shorter experimental session work week is planned for the first week. This will allow Friday the 25th of April, plus the following weekend, to correct any system deficiencies noted during the first session, to allow make-up due to problems encountered, and/or conduct extra-session testing, such as Visual System Tasks 1 and 4. However, the major purpose for this schedule is to allow all three-day experimental sessions to be conducted contiguously, without a weekend breaking up the sessions and confounding the data for these sessions.

The first day will involve administrative duties, project briefing, overview of the experiments, and detailed procedures on operation of the four VICs. The subjects will tour the experiment area and see the VICs but will not receive any hands-on demonstration. The remainder of the first day will be taken up with filling out personal history and other pre-experiment questionnaires.

Following the 12 test days, there will be one full day for session make-ups. Of course, weekends will also be available for system maintenance and session make-ups as required. The last day will be used for post-experiment debrief and completion of questionnaires.

Table 6-2. Overall Experiment Schedule

<table>
<tr><th colspan="10">April</th><th colspan="9">May</th></tr>
<tr><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>Briefing</td><td colspan="3">Tests</td><td colspan="3"></td><td colspan="6">Tests</td><td></td><td colspan="3">Tests</td><td>Make-up</td><td>Debrief</td></tr>
</table>

6.3.1 Training

Subjects will be briefed on VIC operation and will receive equipment familiarization prior to the initial experimental test session. Operations instruction material will be provided for review and study. However, no hands-on training will be provided at this time. Prior to his first-time operation of a VIC, each subject will receive 15 - 30 minutes of hands-on familiarization time. Familiarization time will be determined for each VIC prior to the tests and will be standardized for all subjects.

6.3.2 Test Sessions

The constraints imposed by number of VICs (4), number of subjects (8), number of experimental conditions (3 plus See, Move, and Shoot), and number of trials per condition (variable), help define the number of sessions required for each condition over the test period (12 days). Assuming one session lasts a maximum of approximately 30 minutes (to minimize fatigue), each subject will participate in six sessions per day. The following Table 6-3 presents a notional allocation of the total three days' sessions to the experimental conditions for a single subject.

Table 6-3. Three-Day Training Session Schedule (Single Subject)

	Day 1	Day 2	Day 3
	Training Session	n/a	n/a
Session 1	Locomotion	Locomotion	Locomotion
Session 2	Visual	Visual	Visual
Session 3	Weapon Aiming	Weapon Aiming	Locomotion
Session 4	Locomotion	Locomotion	Visual
Session 5	Visual	Visual	See, move, shoot integrated tests
Session 6	Weapon Aiming	Weapon Aiming	

6.3.3 Data Analysis

Data collected for each of the tasks as described in Section 5 will be logged and summarized using the Simulyzer data logger and Excel software. Analysis of variance procedures appropriate to the experimental design and subject size will be conducted to determine whether differences exist among the measures of performance for the test sessions. ARI will be primarily responsible for analysis of questionnaire data collected during the experiment, LMIS will be primarily responsible for the analysis of PDU data.

Engineering Experiment Plan Attachment 1

Subject Instructions

Locomotion Trials

Base Course

You will start at one of two locations in the McKenna MOUT database. Your task is simply to walk from this location along a defined route, trying to finish as quickly as possible without running into anything or straying from the route. You should have/will see a plan of this route before you start. The course includes both outside and inside building portions. The operator at your VIC will provide guidance to help you stay on course if you need it. The route is circular, so your goal is to return to your starting position. If you complete this route well within your session time, you will be placed at a new starting location and given another practice route to complete.

Do you have any questions?

Target Identification

At the beginning of this session you will be placed at a specific location and orientation within the 29 Palms desert database. I'd like you to stay in this location for the entire session. You will be shown 12 targets, one at a time, at various distances and angles from you. All targets will appear within a 90° cone around your initial line of sight. Some targets will be moving, others will not. Your task will be to locate the target as soon as possible. When you have located it, fire the weapon (pointed down) at your VIC so we can record the time that you saw it. After firing the weapon, verbally tell your VIC's operator what you think the target is (M1A2, T-72, Bradley, BMP, DI friendly, DI enemy), how far away it is (in meters), whether it is moving or not and if so, how fast, and finally what direction it is from you relative to North - 0°. Your VIC operator will record your answers on a data sheet.

In between targets I ask you to look down so you won't be able to see targets before we are ready. I will give you a "READY", "GO", signal when you are to begin to look for the target. I will also give you a "TRIAL OVER" signal when you can stop looking for targets and relax.

It is possible that you may not be able to see all the targets at all VICs. We will end a trial (target presentation) after a period of time if no targets are detected.

Do you have any questions?

Target Search

These sessions are similar to the target identification sessions except that only DI targets (red and blue) will be presented, and they can appear anywhere within about 270° of your initial line of sight. At the beginning of this session you will be placed at a specific location and orientation within the 29 Palms desert database. I'd like you to stay in this location for the entire session. You will be shown 11 DI targets, one at a time, at various distances and angles from you. Some targets will be moving, others will not. Your task will be to locate the target as soon as possible. When you have located it, fire the weapon (pointed down) at your VIC so we can record the time that you saw it. After firing the weapon, verbally tell your VIC's operator what you think the target is (DI friendly or DI enemy), how far away it is (in meters), whether it is moving or not and if so, how fast, and finally what direction it is from you relative to North - 0°. Your VIC operator will record your answers on a data sheet.

In between targets I ask you to look down so you won't be able to see targets before we are ready. I will give you a "READY", "GO", signal when you are to begin to look for the target. I will also give you a "TRIAL OVER" signal when you can stop looking for targets and relax.

It is possible that you may not be able to see all the targets at all VICs. We will end a trial (target presentation) after a period of time if no targets are detected.

Do you have any questions?

Weapon Aiming Task - Posture

At the beginning of this session you will be placed at a specific location and orientation within the 29 Palms desert database. I'd like you to stay in this location for the entire session. You will be shown 15 bull's eye targets, one at a time, at 200 meters distance and at various angles from you, but within most VIC's initial field of view. Some targets will be moving, others will not. Your task will be to locate the target as soon as possible. When you have located it, engage it with the weapon at your VIC, trying to hit the center circle. Please fire only one shot. After firing the weapon, return your weapon to the ready (non-aiming) position, then re-engage the target. Repeat this one more time until you have fired three times at the target. Please return your weapon to a ready position in between shots.

Prior to each trial, I will give you a posture to assume - either standing, kneeling, or lying prone. In VICs Bravo and Charlie, this posture change is simulated; in Alpha and Foxtrot, you will need to actually assume the requested posture. You will stay in this posture while you fire your three shots and the "TRIAL OVER" signal is given. Then the next posture will be given.

In between targets I ask you to look down so you won't be able to see targets before we are ready. I will give you a "READY", "GO", signal when you are to begin to look for the target. I will also give you a "TRIAL OVER" signal when you can stop looking for targets and relax.

Do you have any questions?

Weapon Aiming Task - Target Search

At the beginning of this session you will be placed at a specific location and orientation within the 29 Palms desert database. I'd like you to stay in this location for the entire session. You will be shown 17 bull's eye targets, one at a time, at 100 or 200 meters distance and at various angles from you anywhere within 270° of your initial line of sight. Some targets will be moving, others will not. Your task will be to locate the target as soon as possible. When you have located it, engage it with the weapon at your VIC, trying to hit the center circle. Please fire only one shot. All targets will be engaged from the standing position.

In between targets I ask you to look down so you won't be able to see targets before we are ready. I will give you a "READY", "GO", signal when you are to begin to look for the target. I will also give you a "TRIAL OVER" signal when you can stop looking for targets and relax.

Do you have any questions?

Vision Task - Target Detection

At the beginning of this session you will be placed at a specific location and orientation (facing East) within the 29 Palms desert database. I'd like you to stay in this location for the entire session. The object of this session is to test the limits of being able to see objects. For 1/2 of the trials, a single target (either DI or tank) will appear out in the distance in front of you (within approximately 45°) and begin moving directly away from you. When the object finally disappears from view, I'd like you to pull the trigger to indicate this to the data logger. You may relax after this until the next trial.

For the other 1/2 of the trials, a target will be place out further than you can see it, and will begin moving toward you. When you can finally see the target (detect it), I'd like you to pull the trigger to indicate this to the data logger. You may relax after this until the next trial.

All four of you will be given the same trials at the same time, and we will wait for everyone to fire their weapon before we end the trial. There are 20 trials in all. These may take some time to complete, so I'd like you to get as comfortable as possible and to try to relax after you have responded and between trials.

Do you have any questions?

Appendix B: Engineering Experiment Questionnaire Forms

Dismounted Warrior Network
Engineering Experiments
Biographical Information Questionnaire

Date____________
Participant No.______

Please fill in the blank or circle the appropriate response.

1. What is your age? _____ years

2. MOS _________

3. Rank ________

3. Time in service Years _____ Months _____

4. What is your current duty position?

5. What Army training courses, other than basic training, have you completed (Infantry, AIT, BNOC, etc.)?

6. Have you ever experienced motion or car sickness? yes no
(motsick) 1 0

7. How susceptible to motion or car sickness do you feel you are?
(motsscpt)

0	1	2	3	4	5	6	7
not very		mildly susceptible				highly susceptible	

8. Do you have a good sense of direction? yes no
(dirsnse) 1 0

9. How many hours per week do you use computers? _____ hours per week
(compuse)

10. My level of confidence in using computers is
(compcon)

1	2	3	4	5
low		average		high

11. I enjoy playing video games (home or arcade).
(vid_joy)

1	2	3	4	5
disagree		unsure		agree

12. I am _____ at playing video games.
(vid_con)

1	2	3	4	5
bad		average		good

13. How many hours per week do you play video games? _____ hours per week
(vidplay)

14. How many times in the last year have you experienced a virtual reality game or entertainment? (vr_exp)

0 1 2 3 4 5 6 7 8 9 10 11 12+

15. Do you have a history of epilepsy or seizures? yes no
(epilepsy) 1 0

16. Do you have normal or corrected to normal 20/20 vision? yes no
(normvis) 1 0

17. Are you color blind? yes no
(colrblnd) 1 0

18. Have you had any previous experience with simulators? yes no
If yes, please describe briefly.

Date_________________
Participant No._______

IMMERSIVE TENDENCIES QUESTIONNAIRE
(Witmer & Singer, Version 3.0, Nov. 1994)

Indicate your preferred answer by marking an "X" in the appropriate box of the seven point scale. Please consider the entire scale when making your responses, as the intermediate levels may apply. For example, if your response is once or twice, the second box from the left should be marked. If your response is many times but not extremely often, then the sixth (or second box from the right) should be marked.

1. Do you easily become deeply involved in movies or TV dramas?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

2. Do you ever become so involved in a television program or book that people have problems getting your attention?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

3. How mentally alert do you feel at the present time?

|_______|_______|_______|_______|_______|_______|_______|
NOT ALERT MODERATELY ALERT FULLY ALERT

4. Do you ever become so involved in a movie that you are not aware of things happening around you?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

5. How frequently do you find yourself closely identifying with the characters in a story line?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

6. Do you ever become so involved in a video game that it is as if you are inside the game rather than moving a joystick and watching the screen?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

7. What kind of books do you read most frequently? (CIRCLE ONE ITEM ONLY!)

Spy novels Fantasies Science fiction Biographies

Adventure novels	Romance novels	Historical novels	Autobiographies
Westerns	Mysteries	Other fiction	Other non-fiction

8. How physically fit do you feel today?

|_______|_______|_______|_______|_______|_______|_______|

NOT FIT — MODERATELY FIT — EXTREMELY FIT

9. How good are you at blocking out external distractions when you are involved in something?

|_______|_______|_______|_______|_______|_______|_______|

NOT VERY GOOD — SOMEWHAT GOOD — VERY GOOD

10. When watching sports, do you ever become so involved in the game that you react as if you were one of the players?

|_______|_______|_______|_______|_______|_______|_______|

NEVER — OCCASIONALLY — OFTEN

11. Do you ever become so involved in a daydream that you are not aware of things happening around you?

|_______|_______|_______|_______|_______|_______|_______|

NEVER — OCCASIONALLY — OFTEN

12. Do you ever have dreams that are so real that you feel disoriented when you awake?

|_______|_______|_______|_______|_______|_______|_______|

NEVER — OCCASIONALLY — OFTEN

13. When playing sports, do you become so involved in the game that you lose track of time?

|_______|_______|_______|_______|_______|_______|_______|

NEVER — OCCASIONALLY — OFTEN

14. How well do you concentrate on enjoyable activities?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL — MODERATELY WELL — VERY WELL

15. How often do you play arcade or video games? (OFTEN should be taken to mean every day or every two days, on average.)

|_______|_______|_______|_______|_______|_______|_______|

NEVER — OCCASIONALLY — OFTEN

16. Have you ever gotten excited during a chase or fight scene on TV or in the movies?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

17. Have you ever gotten scared by something happening on a TV show or in a movie?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

18. Have you ever remained apprehensive or fearful long after watching a scary movie?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

19. Do you ever become so involved in doing something that you lose all track of time?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

20. On average, how many books do you read for enjoyment in a month?

|_______|_______|_______|_______|_______|_______|_______|
NONE ONE TWO THREE FOUR FIVE MORE

21. Do you ever get involved in projects or tasks, to the exclusion of other activities?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

22. How easily can you switch attention from the activity in which you are currently involved to a new and completely different activity?

|_______|_______|_______|_______|_______|_______|_______|
NOT SO EASILY FAIRLY EASILY QUITE EASILY

23. How often do you try new restaurants or new foods when presented with the opportunity?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY FREQUENTLY

24. How frequently do you volunteer to serve on committees, planning groups, or other civic or social groups?

|_______|_______|_______|_______|_______|_______|_______|
NEVER SOMETIMES FREQUENTLY

25. How often do you try new things or seek out new experiences?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

26. Given the opportunity, would you travel to a country with a different culture and a different language?

|_______|_______|_______|_______|_______|_______|_______|
NEVER MAYBE ABSOLUTELY

27. Do you go on carnival rides or participate in other leisure activities (horse back riding, bungee jumping, snow skiing, water sports) for the excitement of thrills that they provide?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

28. How well do you concentrate on disagreeable tasks?

|_______|_______|_______|_______|_______|_______|_______|
NOT AT ALL MODERATELY WELL VERY WELL

29. How often do you play games on computers?

|_______|_______|_______|_______|_______|_______|_______|
NOT AT ALL OCCASIONALLY FREQUENTLY

30. How many different video, computer, or arcade games have you become reasonably good at playing?

|_______|_______|_______|_______|_______|_______|_______|
NONE ONE TWO THREE FOUR FIVE SIX OR MORE

31. Have you ever felt completely caught up in an experience, aware of everything going on and completely open to all of it?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY FREQUENTLY

32. Have you ever felt completely focused on something, so wrapped up in that one activity that nothing could distract you?

|_______|_______|_______|_______|_______|_______|_______|
NOT AT ALL OCCASIONALLY FREQUENTLY

33. How frequently do you get emotionally involved (angry, sad, or happy) in news stories that you see, read, or hear?

|_______|_______|_______|_______|_______|_______|_______|
NEVER OCCASIONALLY OFTEN

34. Are you easily disturbed when involved in an activity or working on a task?

|________|________|________|________|________|________|________|

NEVER OCCASIONALLY OFTEN

Date_______________
Participant Number______

Dismounted Warrior Network
Comfort Questionnaire

1. Are you in your usual state of fitness: YES NO

   If not, what is the nature of your illness (flu, cold, etc.).

2. Please indicate all medication you have used in the past 24 hours:

   (a) NONE

   (b) Sedatives or tranquilizers

   (c) Aspirin, Tylenol, other analgesics

   (d) Anti-histamines

   (e) Decongestants

   (f) other (specify):

3. How many hours sleep did you get last night? ___ (Hours)

   Was this amount sufficient? YES NO

4. Did you notice any delayed or after effects after your last DWN session? YES NO

   If so, please describe them.

Date____________
Time____________
Session No.________

Participant No.__________
VIC_____________

Dismounted Warrior Network
Engineering Experiments
Simulator Sickness Questionnaire

Instructions: Please indicate the severity of symptoms that apply to you right now by circling the appropriate word.

1. General discomfort	None	Slight	Moderate	Severe
2. Fatigue	None	Slight	Moderate	Severe
3. Headache	None	Slight	Moderate	Severe
4. Eye Strain	None	Slight	Moderate	Severe
5. Difficulty focusing	None	Slight	Moderate	Severe
6. Salivation increased	None	Slight	Moderate	Severe
7. Sweating	None	Slight	Moderate	Severe
8. Nausea	None	Slight	Moderate	Severe
9. Difficulty concentrating	None	Slight	Moderate	Severe
10. "Fullness of the Head"	None	Slight	Moderate	Severe
11. Blurred Vision	None	Slight	Moderate	Severe
12. a. Dizziness with eyes open	None	Slight	Moderate	Severe
b. Dizziness with eyes closed	None	Slight	Moderate	Severe
13. Vertigo	None	Slight	Moderate	Severe
14. *Stomach awareness	None	Slight	Moderate	Severe
15. Burping	None	Slight	Moderate	Severe

16. Other (describe): ____

____

* Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

Date_____________
Participant No.______
VIC______________

Dismounted Warrior Network
Engineering Experiments
Task Difficulty Questionnaire

Instructions: This questionnaire contains a list of tasks that you performed using the VIC to which you were assigned for the last three days. For each task, place a mark on the line that indicates how difficult it was to perform that task.

1. Detect people or vehicles

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

2. Identify people or vehicles

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

3. Estimate distances to people or vehicles

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

4. Search for targets

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

5. Move in a straight line

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

6. Move without bumping into objects

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

7. Maintain balance while moving

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

8. Change direction while moving

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

9. Identify Landmarks

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

10. Maintain orientation while moving inside buildings

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

11. Maintain orientation while moving out of doors

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

12. Engage stationary targets

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

13. Engage moving targets

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

14. Move tactically

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

15. Detect targets while moving

Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult

Date______________
Participant No.____
VIC_______________

PRESENCE QUESTIONNAIRE
(Witmer & Singer, Vs. 3.0, Nov. 1994)

Characterize your experience in the environment, by marking an "X" in the appropriate box of the 7-point scale, in accordance with the question content and descriptive labels. Please consider the entire scale when making your responses, as the intermediate levels may apply. Answer the questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer.

WITH REGARD TO THE VIC YOU USED MOST RECENTLY

1. How much were you able to control events?

|______|______|______|______|______|______|______|

NOT AT ALL — SOMEWHAT — COMPLETELY

2. How responsive was the environment to actions that you initiated (or performed)?

|______|______|______|______|______|______|______|

NOT RESPONSIVE — MODERATELY RESPONSIVE — COMPLETELY RESPONSIVE

3. How natural did your interactions with the environment seem?

|______|______|______|______|______|______|______|

EXTREMELY ARTIFICIAL — BORDERLINE — COMPLETELY NATURAL

4. How much did the visual aspects of the environment involve you?

|______|______|______|______|______|______|______|

NOT AT ALL — SOMEWHAT — COMPLETELY

5. How much did the auditory aspects of the environment involve you?

|______|______|______|______|______|______|______|

NOT AT ALL — SOMEWHAT — COMPLETELY

6. How natural was the mechanism which controlled movement through the environment?

|______|______|______|______|______|______|______|

EXTREMELY ARTIFICIAL — BORDERLINE — COMPLETELY NATURAL

7. How compelling was your sense of objects moving through space?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL — MODERATELY COMPELLING — VERY COMPELLING

8. How much did your experiences in the virtual environment seem consistent with your real world experiences?

|_______|_______|_______|_______|_______|_______|_______|

NOT CONSISTENT — MODERATELY CONSISTENT — VERY CONSISTENT

9. Were you able to anticipate what would happen next in response to the actions that you performed?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL — SOMEWHAT — COMPLETELY

10. How completely were you able to actively survey or search the environment using vision?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL — SOMEWHAT — COMPLETELY

11. How well could you identify sounds?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL — SOMEWHAT — COMPLETELY

12. How well could you localize sounds?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL — SOMEWHAT — COMPLETELY

13. How well could you actively survey or search the virtual environment using touch?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL — SOMEWHAT — COMPLETELY

14. How compelling was your sense of moving around inside the virtual environment?

|_______|_______|_______|_______|_______|_______|_______|

NOT COMPELLING — MODERATELY COMPELLING — VERY COMPELLING

15. How closely were you able to examine objects?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL — PRETTY CLOSELY — VERY CLOSELY

16. How well could you examine objects from multiple viewpoints?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL SOMEWHAT EXTENSIVELY

17. How well could you move or manipulate objects in the virtual environment?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL SOMEWHAT EXTENSIVELY

18. How involved were you in the virtual environment experience?

|_______|_______|_______|_______|_______|_______|_______|

NOT INVOLVED MILDLY INVOLVED COMPLETELY ENGROSSED

19. How much delay did you experience between your actions and expected outcomes?

|_______|_______|_______|_______|_______|_______|_______|

NO DELAYS MODERATE DELAYS LONG DELAYS

20. How quickly did you adjust to the virtual environment experience?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL SLOWLY LESS THAN ONE MINUTE

21. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

|_______|_______|_______|_______|_______|_______|_______|

NOT PROFICIENT REASONABLY PROFICIENT VERY PROFICIENT

22. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL INTERFERED SOMEWHAT PREVENTED TASK PER-FORMANCE

23. How much did the control devices interfere with the performance of assigned tasks or with other activities?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL INTERFERED SOMEWHAT INTERFERED GREATLY

24. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

|_______|_______|_______|_______|_______|_______|_______|

NOT AT ALL SOMEWHAT COMPLETELY

25. How completely were your senses engaged in this experience?

|___|___|___|___|___|___|___|

NOT ENGAGED — MILDLY ENGAGED — COMPLETELY ENGAGED

26. To what extent did events occurring outside the virtual environment distract from your experience in the virtual environment?

|___|___|___|___|___|___|___|

NOT AT ALL — MODERATELY — VERY MUCH

27. Overall, how much did you focus on using the display and control devices instead of the virtual experience and experimental tasks?

|___|___|___|___|___|___|___|

NOT AT ALL — SOMEWHAT — VERY MUCH

28. Were you involved in the experimental task to the extent that you lost track of time?

|___|___|___|___|___|___|___|

NOT AT ALL — SOMEWHAT — COMPLETELY

29. How easy was it to identify objects through physical interaction; like touching an object, walking over a surface, or bumping into a wall or object?

|___|___|___|___|___|___|___|

IMPOSSIBLE — MODERATELY DIFFICULT — VERY EASY

30. Were there moments during the virtual environment experience when you felt completely focused on the task or environment?

|___|___|___|___|___|___|___|

NONE — OCCASIONALLY — FREQUENTLY

31. How easily did you adjust to the control devices used to interact with the virtual environment?

|___|___|___|___|___|___|___|

DIFFICULT — MODERATE — EASILY

32. Was the information provided through different senses in the virtual environment (e.g., vision, hearing, touch) consistent?

|___|___|___|___|___|___|___|

NOT CONSISTENT — SOMEWHAT CONSISTENT — VERY CONSISTENT

Dismounted Warrior Network
Engineering Experiments
Post Difficulty Questionnaire

Instructions: This questionnaire contains a list of tasks that you performed using each VIC. For each task, please rank the different VICs in order of how easy it was to perform the task.. Place a "1" in front of the easiest VIC, a "2" in front of the next easiest VIC, a "3" in front of the third easiest VIC, and a "4" in front of the most difficult VIC. If you found two or more VICs to be equally easy, assign them both the same number.

1. Detect people or vehicles

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

2. Identify people or vehicles

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

3. Estimate distances to people or vehicles

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

4. Search for targets

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

5. Move in a straight line

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

6. Move without bumping into objects

VIC Alpha
______________ VIC Bravo
______________ VIC Charlie
______________ VIC Foxtrot
____

7. Maintain balance while moving

VIC Alpha
______________ VIC Bravo
______________ VIC Charlie
______________ VIC Foxtrot
____

8. Change direction while moving

VIC Alpha
______________ VIC Bravo
______________ VIC Charlie
______________ VIC Foxtrot
____

9. Identify Landmarks

VIC Alpha
______________ VIC Bravo
______________ VIC Charlie
______________ VIC Foxtrot
____

10. Maintain orientation while moving inside buildings

VIC Alpha
______________ VIC Bravo
______________ VIC Charlie
______________ VIC Foxtrot
____

11. Maintain orientation while moving out of doors

VIC Alpha
______________ VIC Bravo
______________ VIC Charlie
______________ VIC Foxtrot
____

12. Engage stationary targets

VIC Alpha
______________ VIC Bravo
______________ VIC Charlie
______________ VIC Foxtrot
____

13. Engage moving targets

______	VIC Alpha
______	VIC Bravo
______	VIC Charlie
______	VIC Foxtrot

14. Move tactically

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

15. Detect targets while moving

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

Dismounted Warrior Network
Engineering Experiments
Post Realism Questionnaire

Instructions: This questionnaire contains a list of tasks that you performed using each VIC. For each task, please rank the different VICs in order of how realistic your performance the task was, that is, how similar the way you performed the task was to how you would perform it in the real world, and how much it felt to you as if you were performing it in the real world. Place a "1" in front of the most realistic VIC, a "2" in front of the next most realistic VIC, a "3" in front of the third most realistic VIC, and a "4" in front of the least realistic VIC. If you found two or more VICs to be equally realistic, assign them both the same number.

1. Detect people or vehicles

____________ VIC Alpha
____________ VIC Bravo
____________ VIC Charlie
____________ VIC Foxtrot

2. Identify people or vehicles

____________ VIC Alpha
____________ VIC Bravo
____________ VIC Charlie
____________ VIC Foxtrot

3. Estimate distances to people or vehicles

____________ VIC Alpha
____________ VIC Bravo
____________ VIC Charlie
____________ VIC Foxtrot

4. Search for targets

____________ VIC Alpha
____________ VIC Bravo
____________ VIC Charlie
____________ VIC Foxtrot

5. Move in a straight line

____________ VIC Alpha
____________ VIC Bravo
____________ VIC Charlie
____________ VIC Foxtrot

6. Move without bumping into objects

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

7. Maintain balance while moving

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

8. Change direction while moving

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

9. Identify Landmarks

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

10. Maintain orientation while moving inside buildings

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

11. Maintain orientation while moving out of doors

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

12. Engage stationary targets

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

13. Engage moving targets

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

14. Move tactically

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

15. Detect targets while moving

_______________ VIC Alpha
_______________ VIC Bravo
_______________ VIC Charlie
_______________ VIC Foxtrot

Appendix C: Engineering Experiment Questionnaire Data

Results of the Administration of the Immersive Tendencies Questionnaire

1. Do you easily become deeply involved in movies or TV dramas?

|_______|_______|_______|_______|__X____|_______|_______|

NEVER OCCASIONALLY OFTEN

2. Do you ever become so involved in a television program or book that people have problems getting your attention?

|_______|_____X_|_______|_______|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

3. How mentally alert do you feel at the present time?

|_______|_______|_______|_______|_______|____X_|_______|

NOT ALERT MODERATELY ALERT FULLY ALERT

4. Do you ever become so involved in a movie that you are not aware of things happening around you?

|_______|_______|X_______|_______|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

5. How frequently do you find yourself closely identifying with the characters in a story line?

|_______|___X___|_______|_______|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

6. Do you ever become so involved in a video game that it is as if you are inside the game rather than moving a joystick and watching the screen?

|_______|______X|_______|_______|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

7. Not scored numerically.

8. How physically fit do you feel today?

|_______|_______|_______|_______|_______|___X___|_______|

NOT FIT MODERATELY FIT EXTREMELY FIT

9. How good are you at blocking out external distractions when you are involved in something?

|_______|_______|_______|_______|_______|__X___|_______|

NOT VERY GOOD SOMEWHAT GOOD VERY GOOD

10. When watching sports, do you ever become so involved in the game that you react as if you were one of the players?

|_______|_______|_______|______X|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

11. Do you ever become so involved in a daydream that you are not aware of things happening around you?

|_______|____X__|_______|_______|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

12. Do you ever have dreams that are so real that you feel disoriented when you awake?

|_______|_______|_______|X______|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

13. When playing sports, do you become so involved in the game that you lose track of time?

|_______|_______|_______|_______|X______|_______|_______|

NEVER OCCASIONALLY OFTEN

14. How well do you concentrate on enjoyable activities?

|_______|_______|_______|_______|_______|____X__|_______|

NOT AT ALL MODERATELY WELL VERY WELL

15. How often do you play arcade or video games? (OFTEN should be taken to mean every day or every two days, on average.)

|_______|_______|_______|_______|__X____|_______|_______|

NEVER OCCASIONALLY OFTEN

16. Have you ever gotten excited during a chase or fight scene on TV or in the movies?

|_______|_______|_______|___X___|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

17. Have you ever gotten scared by something happening on a TV show or in a movie?

|_______|_______|______X|_______|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

18. Have you ever remained apprehensive or fearful long after watching a scary movie?

|________|X________|________|________|________|________|________|

NEVER OCCASIONALLY OFTEN

19. Do you ever become so involved in doing something that you lose all track of time?

|________|________|________|________X|________|________|________|

NEVER OCCASIONALLY OFTEN

20. On average, how many books do you read for enjoyment in a month?

|________|_____X__|________|________|________|________|________|

NONE ONE TWO THREE FOUR FIVE MORE

21. Do you ever get involved in projects or tasks, to the exclusion of other activities?

|________|_______X|________|________|________|________|________|

NEVER OCCASIONALLY OFTEN

22. How easily can you switch attention from the activity in which you are currently involved to a new and completely different activity?

|________|________|________|________|___X____|________|________|

NOT SO EASILY FAIRLY EASILY QUITE EASILY

23. How often do you try new restaurants or new foods when presented with the opportunity?

|________|________|________|________|________|___X____|________|

NEVER OCCASIONALLY FREQUENTLY

24. How frequently do you volunteer to serve on committees, planning groups, or other civic or social groups?

|________|________|____X___|________|________|________|________|

NEVER SOMETIMES FREQUENTLY

25. How often do you try new things or seek out new experiences?

|________|________|________|________|______X_|________|________|

NEVER OCCASIONALLY OFTEN

26. Given the opportunity, would you travel to a country with a different culture and a different language?

|________|________|________|________|________|_______X|________|

NEVER MAYBE ABSOLUTELY

27. Do you go on carnival rides or participate in other leisure activities (horse back riding, bungee jumping, snow skiing, water sports) for the excitement of thrills that they provide?

|_______|_______|_______|_______|_______|__X____|_______|

NEVER OCCASIONALLY OFTEN

28. How well do you concentrate on disagreeable tasks?

|_______|_______|_______|______X|_______|_______|_______|

NOT AT ALL MODERATELY WELL VERY WELL

29. How often do you play games on computers?

|_______|_______|_______|_______|__X____|_______|_______|

NOT AT ALL OCCASIONALLY FREQUENTLY

30. How many different video, computer, or arcade games have you become reasonably good at playing?

|_______|_______|_______|_______|__X____|_______|_______|

NONE ONE TWO THREE FOUR FIVE SIX OR MORE

31. Have you ever felt completely caught up in an experience, aware of everything going on and completely open to all of it?

|_______|_______|____X__|_______|_______|_______|_______|

NEVER OCCASIONALLY FREQUENTLY

32. Have you ever felt completely focused on something, so wrapped up in that one activity that nothing could distract you?

|_______|_______|_______|____X__|_______|_______|_______|

NOT AT ALL OCCASIONALLY FREQUENTLY

33. How frequently do you get emotionally involved (angry, sad, or happy) in news stories that you see, read, or hear?

|_______|_______|______X|_______|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

34. Are you easily disturbed when involved in an activity or working on a task?

|_______|_______|_X______|_______|_______|_______|_______|

NEVER OCCASIONALLY OFTEN

Presence Questionnaire Results

The locations of the upper-case letters on the scales designates the approximate mean score given to that VIC. Items which showed a statistically significant differnece among the VICs are shown in bold.

1. How much were you able to control events?

|_______|_______|___B___|_______|___A_FC|_______|_______|

NOT AT ALL SOMEWHAT COMPLETELY

2. How responsive was the environment to actions that you initiated (or performed)?

|_______|_______|_______F_|_______|C_____A|___B___|_______|

NOT RESPONSIVE MODERATELY RESPONSIVE COMPLETELY RESPONSIVE

3. How natural did your interactions with the environment seem?

|_______|_______|_______F_|_____C_|___A___|_B_____|_______|

EXTREMELY ARTIFICIAL BORDERLINE COMPLETELY NATURAL

4. How much did the visual aspects of the environment involve you?

|_______|_______|_____FB__|_______|_____C__|_A_____|_______|

NOT AT ALL SOMEWHAT COMPLETELY

5. How much did the auditory aspects of the environment involve you?

|_______|_______|_______|_____C_|__BA_F__|_______|_______|

NOT AT ALL SOMEWHAT COMPLETELY

6. How natural was the mechanism which controlled movement through the environment?

|_______|_______|___C___|___A____|__FB___|_______|_______|

EXTREMELY ARTIFICIAL BORDERLINE COMPLETELY NATURAL

7. How compelling was your sense of objects moving through space?

|_______|_______|_______|___C____|__A___B_|F_______|_______|

NOT AT ALL MODERATELY COMPELLING VERY COMPELLING

8. How much did your experiences in the virtual environment seem consistent with your real world experiences?

|_______|_______|_______|__CA__B|F_______|_______|_______|

NOT CONSISTENT | MODERATELY CONSISTENT | VERY CONSISTENT

9. Were you able to anticipate what would happen next in response to the actions that you performed?

|_______|_______|_______|__B__A__|FC_______|_______|_______|

NOT AT ALL | SOMEWHAT | COMPLETELY

10. How completely were you able to actively survey or search the environment using vision?

|_______|_______|_______F_|_______|_______B|AC_______|_______|

NOT AT ALL | SOMEWHAT | COMPLETELY

11. How well could you identify sounds?

|_______|_______|_______F|_______|_______|__ABC__|_______|

NOT AT ALL | SOMEWHAT | COMPLETELY

12. How well could you localize sounds?

|_______|_______|_______|_______C|_______AB|__F_______|_______|

NOT AT ALL | SOMEWHAT | COMPLETELY

13. How well could you actively survey or search the virtual environment using touch? (p=.006)

|_____C__|__A_____|__B_____|_______F|_______|_______|_______|

NOT AT ALL | SOMEWHAT | COMPLETELY

14. How compelling was your sense of moving around inside the virtual environment? (p=.067)

|_______|_______|_______|___C___|___A___B|__F_______|_______|

NOT COMPELLING | MODERATELY COMPELLING | VERY COMPELLING

15. How closely were you able to examine objects?

|_______|_______|_______|_______|__C__AB_|F_______|_______|

NOT AT ALL | PRETTY CLOSELY | VERY CLOSELY

16. How well could you examine objects from multiple viewpoints?

|_______|_______|_______|___C___|___F__B|A_______|_______|

NOT AT ALL | SOMEWHAT | EXTENSIVELY

17. How well could you move or manipulate objects in the virtual environment?

|________|______B__|___F____|_A______|_C______|________|________|

NOT AT ALL SOMEWHAT EXTENSIVELY

18. How involved were you in the virtual environment experience?

|________|________|________|________|___C____|___FB_A_|________|

NOT INVOLVED MILDLY INVOLVED COMPLETELY ENGROSSED

19. How much delay did you experience between your actions and expected outcomes?

|________|__B___F_|AC______|________|________|________|________|

NO DELAYS MODERATE DELAYS LONG DELAYS

20. How quickly did you adjust to the virtual environment experience? (p=.025)

|________|________|________|________|________|B__A___C|F_______|

NOT AT ALL SLOWLY LESS THAN 1 MINUTE

21. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

|________|________|________|________|______C_|__B_A___|__F____|

NOT PROFICIENT REASONABLY PROFICIENT VERY PROFICIENT

22. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities? (p=.004)

|__CF____|_B______|A_______|________|________|________|________|

NOT AT ALL INTERFERED SOMEWHAT PREVENTED TASK PERFORMANCE

23. How much did the control devices interfere with the performance of assigned tasks or with other activities?

|________|F__C_AB_|________|________|________|________|________|

NOT AT ALL INTERFERED SOMEWHAT INTERFERED GREATLY

24. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

|_______|_______|_______|_______|____AF_|_B_C____|_______|

NOT AT ALL SOMEWHAT COMPLETELY

25. How completely were your senses engaged in this experience?

|_______|_______|_______|_______|____A_C|__FB____|_______|

NOT ENGAGED MILDLY ENGAGED COMPLETELY ENGAGED

26. To what extent did events occurring outside the virtual environment distract from your experience in the virtual environment?

|__FC___|_BA_____|_______|_______|_______|_______|_______|

NOT AT ALL MODERATELY VERY MUCH

27. Overall, how much did you focus on using the display and control devices instead of the virtual experience and experimental tasks?

|_______|_______|__B____|_C____A_|F_______|_______|_______|

NOT AT ALL SOMEWHAT VERY MUCH

28. Were you involved in the experimental task to the extent that you lost track of time?

|_______|_______|_______|B__C_FA_|_______|_______|_______|

NOT AT ALL SOMEWHAT COMPLETELY

29. How easy was it to identify objects through physical interaction; like touching an object, walking over a surface, or bumping into a wall or object? (p=.079)

|_______|_______|_C__A____|_______B|_______|_F_____|_______|

IMPOSSIBLE MODERATELY DIFFICULT VERY EASY

30. Were there moments during the virtual environment experience when you felt completely focused on the task or environment?

|_______|_______|______A_|_______|_______C|B_F_____|_______|

NONE OCCASIONALLY FREQUENTLY

31. How easily did you adjust to the control devices used to interact with the virtual environment?

|_______|_______|_______|_______|___C____|BA___F_|_______|

DIFFICULT MODERATE EASILY

32. Was the information provided through different senses in the virtual environment (e.g., vision, hearing, touch) consistent?

|_______|_______|_______|_______|__C____B|_AF_____|_______|

NOT CONSISTENT	SOMEWHAT CONSISTENT	VERY CONSISTENT

Appendix D: User Experiment Plan

(Note: The following User Experiment Plan is the last version created. It contains errors in dates of execution and some TBDs. It was determined not to be cost-effective to revise the plan after the fact so it is presented as-is.)

Dismounted Warrior Network User Experiment Plan

Date of Plan:	4/8/97
Exercise Dates:	5/19/97 -6/7/97
Version:	Revision C

1. PURPOSE

a. Goals: DWN USEX will evaluate the capability of the DWN systems and the overall system of systems to enable the execution of individual and collective tasks and missions within a virtual environment. DWN USEX will exercise selected BLUFOR DI-SAF Units and OPFOR MODSAF Units with virtual individual combatants (VICs) which have been integrated into two squad level scenarios. DWN USEX uses the system components of four (VICs), a DI-SAF, a ModSAF, and Exercise Support equipment including a Stealth and PVD.

b. Objectives:

(1) Focus on user needs;

(2) Evaluate at the system and system of systems level;

(3) Assess the ability of the systems to enable individual and collective task/small unit mission level performance.

2. CONCEPT

DWN USEX will consist of:

a. Training for the soldiers, to include familiarization and preoperations checks of the VIC's;

b. A squad level training exercise wherein the soldiers conduct an attack across broken terrain at 29 Palms, CA;

c. A squad level training exercise wherein the soldiers conduct a squad attack and building clearance at MeKenna Range, Ft. Benning Ga;

d. Data collection and after action reviews.

For the training exercise the VIC's will be part of a squad, and given missions to conduct tactical operation. The DWN USEX scenarios will be based on a tailored dismounted Mechanized Infantry Squad performing selected individual and collective tasks (Annex A). The training force will be organized for combat with a mixed force of DI-SAF and VIC elements. One fire team will be manned by DI-SAF generated entities. This will always be the First Fire team (Alpha). Its organization will match that of the Second Fire team (Bravo), composed of VICs. Both fire teams will consist of a team leader, one SAW gunner, and two riflemen.

The scenarios are:

a. Squad Attack Exercise -- The Squad attack will consist of a tailored dismounted Mech Infantry Squad moving from an occupied Assault Position to attack and seize two Squad size objectives at 29 Palms, CA. The Squad will consolidate and reorganize on the final objective and prepare a Hasty Defense to repel a counter-attack.

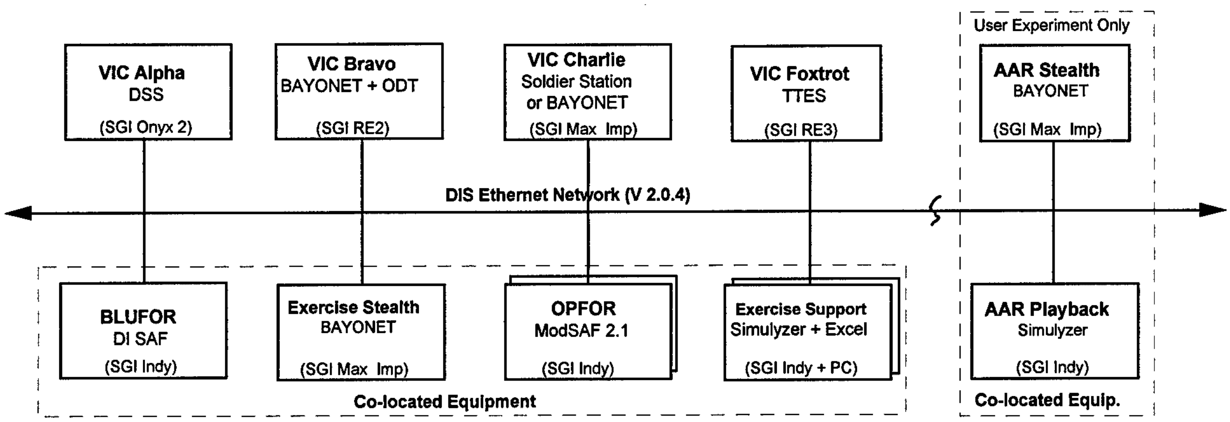
b. Squad MOUT Exercise -- The Squad MOUT attack will consist of a tailored dismounted Mech Infantry Squad moving from an occupied Assault Position to attack and clear two buildings at McKenna Range at Ft. Benning GA. The Squad will consolidate and reorganize in the final building and prepare a Hasty Defense to repel a counter-attack.

After Action Reviews (AAR) will be conducted at the conclusion of each session. One of the Battlemasters will guide the AAR while the other Battlemaster continues to oversee the exercise being conducted. Separate resources are available to permit this to happen simultaneously.

Human Factors engineers will administer the data collection instruments, conduct structured interviews and analyze the results to assess task trainability (Annexes D and E).

3. APPROACH

a. System Configuration - per the following block diagram:



Notes:
(1) DIS Compatible virtual radios supplied with each system for operator coordination, but connected together on a separate ethernet network ("admin net");
(2) Separate wireless radio net between soldiers using the four VIC's and the Exercise Stealth ("tactical net");
(3) Second ModSAF and second Simulyzer provided as back-up and to provide additional PVD for use Exercise Director and Battlemaster

b. Personnel Requirements - per the following table:

Personnel Requirement	VIC Alpha (DSS)	VIC Bravo (NPSNET + ODT)	VIC Charlie* (Soldier Station or BAYONET)	VIC Foxtrot (TTES)	Co-located equipment: Exercise Stealth (BAYONET)	Co-located equipment: BLUFOR (DI SAF)	Co-located equipment: OPFOR (ModSAF)	Co-located equipment: Exercise Logger (Simulyzer)	Co-located equip.: AAR Stealth* (BAYONET)	Co-located equip.: AAR Playback (Simulyzer)
Experiment Application	Eng & User	Eng & User	Eng (BAYONET) User (s)	Eng & User	Eng & User		Eng & User	Eng & User	User	User
Operator	Veda	RBD	LMIS/TRAC (Eng/User)	NAWCTSD	LMIS	SAIC	LMSG	LMIS	LMSG	LMSG
Data Collector	ARI	ARI	ARI	ARI	n/a	n/a	n/a	n/a	n/a	n/a
Maintainer	Veda	RBD	LMIS/TRAC (Eng/User)	NAWCTSD	LMIS	SAIC	LMSG	LMIS	LMIS	LMIS
Soldier Participant	2	2	2	2	1 [Sqd Ldr]	n/a	n/a	n/a	n/a	n/a
Experiment Coordination	n/a	n/a	n/a	n/a	LMSG - Battlemaster # 1 (User Exp), LMIS - Exercise Director (Eng & User Exp)				LMSG - Battlemaster # 2 (User Exp)	

(*) Note: BAYONET is used for VIC Charlie during the Engineering Experiments and used for the AAR Stealth during the User Experiments

c. Procedures, Design and Schedule

The user exercises are less structured exercises than the engineering experiments. They are intended to test the operational capabilities of the VICs within the context of a squad level mission segment or scenario. Thus, there is no experimental design as such in terms of conditions, trials, presentation order, etc. However, experimental procedures will be developed to insure the soldiers are adequately trained on the VICs, that the exercise sessions are conducted in an efficient and orderly manner, that the soldiers are debriefed on their performance, and that the data collection requirements are met.

1. Train Soldiers

The initial four days of the user exercise session has been allocated to training on the operation of the VICs within the scenario-driven context. Current information is that the same soldiers who participated in the engineering experiments will be taking part in the user exercises as well. While this will minimize the training requirements in terms of operating the VICs' interfaces, the soldiers will have had limited experience in using the VICs as a total integrated system. They will also have had no experience in coordinating activities with the other VICs or the DI SAF. It is envisioned that the four training days will include briefings on planned activities followed by training in small unit operations within the context of isolated scenario segments. Two soldiers will receive training for all three roles (leader, SAW gunner, rifleman) on one VIC per day, with complete soldier rotation among all four of the VICs within the four day training period.

2. Conduct Exercises

The four days after Memorial Day will be used to conduct the exercise and perform data collection. The eight soldiers will be assigned in pairs to each of the four VICs, and will operate the assigned VIC for the entire day. Each soldier will experience three to four exercise sessions per day, with each session lasting approximately one half hour. A session will involve a coordinated effort among the participants presented in the Personnel Table presenting a one-half hour portion of the overall scenarios described in Annexes B and C. Prior to the exercises, the scenarios will be modified so that each session will begin and end with a coherent " chunk" or segment of the overall scenario. After each session, the four soldiers will be given an after action review (AAR) while the other four soldiers are participating in their sessions. This AAR is described in Section C.3. Again, the soldiers will be rotated through the four VICs over the four days of data collection.

The week after the data collection period will be used for the make-up of data collection sessions as required and to practice for the demonstration sessions. Two days of this period will be used for demonstrations of the VICs, DI SAF, and data collection capabilities.

3. Conduct AAR

AAR's will be conducted simultaneous with the Exercise scenarios. One Battlemaster will support AAR's while the other Battlemaster supports the Exercises using dedicated resources. Soldiers will therefore rotate between AAR's and Exercises. A dedicated Stealth and logger/playback (Simulyzer) will be used to support the AAR sessions. Once the log file has been transferred to the AAR playback device, the DIS network will be disconnected from the AAR equipment and the log file played back using Simulyzer and the Stealth. A stand-alone version of NPSNET running on a Maximum Impact will serve as the Stealth.

4. Collect Data

Data collection will involve logging the same PDU data as was recorded during the engineering experiments - entity state, fire, detonation, and collision PDUs. This data will be summarized and reported as the following measures of performance/effectiveness (MOP/MOE):

TBD

Questionnaires and subjective rating information will also be collected during the debrief sessions. See Annexes D and E.

5. Schedule

a. VIC Training: 19-22 May 97

b. System Modifications: 23 May 97 (Soldiers day off)

c. Memorial Weekend: 24-26 May 97

d. Conduct USEX Scenarios: 27-30 May 97

e. Makeup plus practice for Demonstration sessions: 2-3 June 97

f. Demonstrations: 4-5 June 97

g. Make-up: 6 June 97 (if needed)

d. System Capabilities - per the following tables:

System Capabilities - Part 1:

Capability	**VIC Alpha** (DSS)	**VIC Bravo** (BAYONET + O	**VIC Charlie** (Soldier Station	**VIC Charlie** (BAYONET)	**VIC Foxtrot** (TTES)	**BLUFOR** (DI-SAF)	**OPFOR** (ModSAF)
DIS 2.0.4 PDU's: Entity State, Collision, Fire, Impact; constant collision rate <= 1 PDU/	Yes (collision PDU in work)	Yes (collision PDU in work)	Yes (collision PDU in work)	Yes (collision PDU in work)	Yes (collision PDU in work)	yes	yes
Remote Entity Postures Supported	Stand, Walk, R Kneel, Prone, Crawl	Stand, Walk, R Kneel, Prone, Crawl	Stand, Walk, R Kneel, Prone, Crawl	Stand, Walk, R Kneel, Prone, Crawl	Stand, Walk, R Kneel, Prone, Crawl	Stand, Walk, R Kneel, Prone, Crawl	Stand, Walk, R Prone
Impacts/Detonations	DI die, probabilistic determination, xyz impact loc	DI die, probabilistic determination, xyz impact loc	DI die, DI woun probabilistic determination xyz impact loc	DI die, probabilistic determination, xyz impact loc	DI die, DI woun probabilistic determination xyz impact loc	DI die, probabilistic determination	DI die, probabilistic determination
Number of entities supported	at least 9 articulated IC' plus at least 8 vehicles	at least 9 articulated IC' plus at least 8 vehicles	at least 9 articulated IC' plus at least 8 vehicles	at least 9 articulated IC' plus at least 8 vehicles	at least 9 articulated IC' plus at least 8 vehicles	at least 9 articulated IC' plus at least 8 vehicles	at least 9 articulated IC' plus at least 8 vehicles
Visual system capacity	2 ch Onyx 2, 2 R10000 CPUs 128 MB memo	4 channel RE2, CPUs, 256 M memory	1 ch Maximu Impact, 1 R100 CPU, 128 MB memory	1 ch Maximu Impact, 1 R100 CPU, 128 MB memory	1 ch RE3, 4 R10000 CPUs 256 MB memo	n/a	n/a
Databases: 29 Palms, AUSA MO (now available via LM FTP site)	yes	yes	yes	yes	yes	yes	yes
Moving Models: M1A2, M2A3, 64, HMMWV, T72, BMP, HIND, Enemy (now available via LM F site)	yes	yes	yes	yes	yes	yes	yes

System Capabilities - Part 2:

Capability	VIC Alpha (DSS)	VIC Bravo (BAYONET + ODT)	VIC Charlie (Soldier Station)	VIC Charlie (BAYONET)	VIC Foxtrot (TTES)	BLUFOR (DI-SAF)	OPFOR (ModSAF)
Database Correlation Issues	none	none	Janus gridded database for environment interactions	none	none	none	none
Animation Capabilities/Limitations (NOTE: not used for DWN)	Biomechanics DI Model; 14 body angles	DI Guy and JackML; 14 body angles supported in JackML	JackML; 14 body angles supported in JackML	JackML; 14 body angles supported in JackML	DI Guy	n/a	n/a
Local Entity Gestures (NOTE: not used for DWN)	no	no for DI-Guy; JackML can do 27+ arm and hand signals	yes (42 different gestures)	JackML can do 27+ arm and hand signals	no	no	no
3D Display characteristics (color, resolution, FOV)	Wireless HMD 420 by 230 NTSC Color 45 deg FOV 360 deg FOR	WISE 640 by 480 Color 270 deg FOV 360 deg FOR	CRT 1280 by 1024 Color 10 to 60 deg FOV 360 deg FOR	CRT 1280 by 1024 Color 45 deg FOV 360 deg FOR	8' x 10' screen 1280 by 1024 Color Variable FOV 360 deg FOR	none	none
Aural cues - mono/stereo, omni-directional	omni-directional, speakers (Soundstorm3d)	omni-directional, speakers (Soundstorm)	stereo, speakers	omni-directional, speakers	stereo, headset; need to mix with voice comms	none	none
Weapon type(s), aiming capability, lasing capability (NOTE: we will use only M-16 and SAW weapons)	M16, AT4, SAW planned, lasing (range), LOS vector	M16, SAW, lasing (range, heading, elevation), LOS vector	M16, SAW, AT4, others, LOS checks, ballistics model	M16, SAW, lasing (range, heading, elevation), LOS vector	M16, SAW, LOS checks, ballistics model	M16, LOS checks, ballistics model	M16, LOS checks, ballistics model
Physical and Graphical Weapon Representations Available	M16	M16	M16, SAW, AT4, others	M16	M16	n/a	n/a
Mobility Capabilities and Limitations (Inside buildings? Up stairways?)	Collide with walls, objects, walk thru doors, climb stairs	Collide with walls, objects, walk thru doors, climb stairs	Collide with walls, objects, respond to surface type (cannot go inside buildings[*])	Collide with walls, objects, walk thru doors, climb stairs	Collide with walls, objects, walk thru doors, climb stairs	Collide with walls, objects	Collide with walls, objects

[*] However, Soldier Station does permit an entity to be placed at the window or door of a building, with the ability to see and shoot outside the portal

System Capabilities - Part 3:

Capability	VIC Alpha (DSS)	VIC Bravo (BAYONET + ODT)	VIC Charlie (Soldier Station)	VIC Charlie (BAYONET)	VIC Foxtrot (TTES)	BLUFOR (DI-SAF)	OPFOR (ModSAF)
SAF Behaviors Supported (see note below)	n/a	n/a	n/a	n/a	n/a	squad level & below (entities will be represented individually)	fireteam & below (entities will be represented as a group)
Night vision capabilities (thermal, NVG, LLLTV, etc.)	none	none	basic thermal, basic NVG	none	none	none	none
Weather effects supported (haze, wind, etc.)	Time of Day, Fog	Time of Day, Fog	Time of Day, Wind	Time of Day, Fog	Time of Day, Fog	Time of Day	Time of Day
Battlefield effects (explosions, fire, smoke, etc.)	Explosions, fire,smoke, missile exhaust	Explosions, fire, smoke, missile exhaust, dust trails	Explosions, smoke	Explosions, fire, smoke, missile exhaust, dust trails	Explosions, fire, smoke	Explosions, fire, smoke (stealth representation)	Explosions, fire, smoke (PVD representation)
Dynamic Terrain (craters, mines, holes, etc.)	Crater overlay in work	Crater overlay	Crater overlay	Crater overlay	no	no	no
Indirect Fire Casualty Effects	yes	yes	yes	yes	yes	yes	yes
Local Entity Controls	Resurrect, Invincible modes	Resurrect, Invincible modes	Resurrect mode	Resurrect, Invincible modes	Resurrect, Invincible modes	Invincible mode	Invincible mode
DI SAF Behaviors:							
Converted behaviors: IC Halt, IC Occupy Position, IC March, IC Move, IC Road March (Fireteam), React to Fire and Infantry Attack							
New behaviors: Conduct Fire and Movement, React to Ambush, Break Contact, Mount/Dismount							

Annex A - Individual and Collective Tasks

1. Squad Attack Exercise, 29 Palms, CA

Occupy Assault Position

Move Dismounted

React to Contact

Move Under Direct Fire

Squad Attack

Employ Fire Support (Suppressive Fire)

Consolidate and Reorganize

Conduct Hasty Defense

2. Squad MOUT Exercise, Ft. Benning GA.

Occupy Assault Position

Move Dismounted

Recon Objective (VICs only)

Move Under Direct Fire

Enter and Clear Building (VICs only)

Consolidate and Reorganize

Conduct Hasty Defense

Annex B - Squad Attack Exercise, 29 Palms

Concept of Operation

On command a dismounted mechanized squad attacks across broken terrain to seize a series of squad objectives. Enemy forces in the area consist of a squad size OPFOR element. Mortars are in support. The exercise is constructed in three events. The events can be done either sequentially or nonsequentially. Refer to the illustration.

¥ **EVENT 1:**

  ¥ 2nd SQUAD, Ist PLATOON FROM ASSAULT POSITION 1 MOVES BY BOUNDING OVERWATCH/FIRE AND MOVEMENT TO SEIZE OBJ 1. CONSOLIDATES AND REORGANIZES ON OBJ 1 AND PREPARES TO ATTACK OBJ 2. MORTARS IN SUPPORT.

¥ **EVENT 2:**

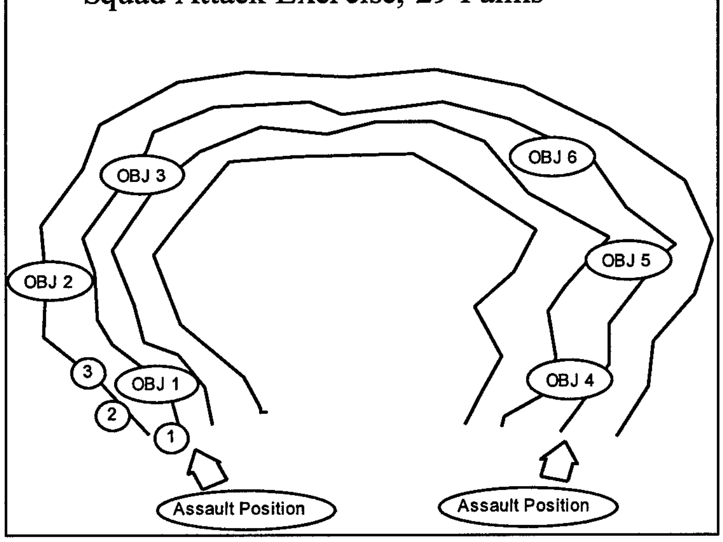
  ¥ OBJ 1 TO OBJ 2: AFTER SEIZURE OF OBJ 1, 2ND SQUAD CONTINUES THE ATTACK BY BOUNDING OVERWATCH/FIRE AND MOVEMENT THE ATTACK TO SEIZE OBJ 2. MORTARS IN SUPPORT.

¥ **EVENT 3:**

  ¥ DEFEND: ON OBJ 2, 2ND SQUAD PREPARES HASTY BATTLE POSITION FACING NORTH. PREPARE FOR COUNTER ATTACK. MORTARS IN SUPPORT.

NOTE: During training (week 1), a variation of this exercise will be practiced: the squad will start from Assault Position 2, and attack objectives 4 and 5.

Squad Attack Exercise, 29 Palms



SCENARIO SCRIPT - SQUAD ATTACK EXERCISE, 29 PALMS
EVENT I

	VIC A	VIC B	VIC C	VIC F	DI SAF	OPFOR SAF	Facilitator
Occupy Assault Position	Fire Team (FT) Leader, Fire Team Bravo, 2nd squad. Assault Position Activities, Occupy left portion of Assault Position **(#1)**, prone position	Saw Gunner; Fire Team Bravo, 2nd squad Assault Position Activities, Occupy left portion of Assault Position **(#1)**, prone position	Rifleman; Fire Team Bravo, 2nd squad Assault Position Activities, Occupy left portion of Assault Position **(#1)**, prone position	Rifleman; Fire Team Bravo, 2nd squad Assault Position Activities, Occupy left portion of Assault Position **(#1)**, prone position	Fire Team Alpha (FT) Assault Position Activities, Occupy right portion of Assault Position **(#1)**, prone position	In defensive positions Obj 1 & 2. 2 machine gun teams, one on Obj 1 and one on Obj 2. All enemy forces are prone in defilade.	Squad Leader Deliver Platoon / squad FRAGO/attack order. Command & Control 2nd Squad DI SAF
Assault Position to Obj 1	FT Bravo Move Bounding Over Watch, squad column, FT in wedge. Trail FT. Employs fire support (mortars) on Obj 1.	FT Bravo Move Bounding Over Watch, squad column, FT in wedge. Trail FT.	FT Bravo Move Bounding Over Watch, squad column, FT in wedge. Trail FT.	FT Bravo Move Bounding Over Watch, squad column, FT in wedge. Trail FT.	FT Alpha, 2nd squad lead. Move Bounding Over Watch, squad column, FT in wedge. Supports by fire assault on Obj 1.	N/C	Direct Squad

	VIC A	VIC B	VIC C	VIC F	DI SAF	OPFOR SAF	Facilitator
Obj 1	FT Bravo Move to left of FT Alpha and seize left portion of Obj 1 **(#2)**. Consolidate & Reorganize. Occupy hasty defense facing north, left FT. Assume prone position.	FT Bravo Move to left of FT Alpha and seize left portion of Obj 1 **(#2)**. Consolidate & Reorganize. Occupy hasty defense facing north, left FT. Assume prone position.	FT Bravo Move to left of FT Alpha and seize left portion of Obj 1 **(#2)**. Consolidate & Reorganize. Occupy hasty defense facing north, left FT. Assume prone position.	FT Bravo Move to left of FT Alpha and seize left portion of Obj 1 **(#2)**. Consolidate & Reorganize. Occupy hasty defense facing north, left FT. Assume prone position.	Seize right portion of Obj 1 **(#2)**. Consolidate & Reorganize. Occupy hasty defense facing north, right FT. Assume prone position.	N/C	N/C

SCENARIO SCRIPT - SQUAD ATTACK EXERCISE, 29 PALMS

EVENT II

	VIC A	VIC B	VIC C	VIC F	DI SAF	OPFOR SAF	Facilitator
Obj 1 to Obj 2	FT Bravo moves 1st by bounding overwatch, in wedge, towards Obj 2 **(#3)**, lead FT. Support by fire assault of Obj 2.	FT Bravo moves 1st by bounding overwatch, in wedge, towards Obj 2 **(#3)**, lead FT. Support by fire assault of Obj 2.	FT Bravo moves 1st by bounding overwatch, in wedge, towards Obj 2 **(#3)**, lead FT. Support by fire assault of Obj 2.	FT Bravo moves 1st by bounding overwatch, in wedge, towards Obj 2 **(#3)**, lead FT. Support by fire assault of Obj 2.	FT Alpha moves 2nd by bounding overwatch, in wedge, towards Obj 2 **(#3)**, trail FT.	N/C	N/C
Obj 2	Seize left portion of Obj 2 **(#3)**, Consolidate & Reorganize, Prepare and occupy hasty defense facing north, left FT. Assume prone position.	Seize left portion of Obj 2 **(#3)**, Consolidate & Reorganize, Prepare and occupy hasty defense facing north, left FT. Assume prone position.	Seize left portion of Obj 2 **(#3)**, Consolidate & Reorganize, Prepare and occupy hasty defense facing north, left FT. Assume prone position.	Seize left portion of Obj 2 **(#3)**, Consolidate & Reorganize, Prepare and occupy hasty defense facing north, left FT. Assume prone position.	Seize right portion of Obj 2 **(#3)**, Consolidate & Reorganize, Prepare and occupy hasty defense facing north, right FT. Assume prone position. Employs fire support (mortars) on Obj 2.		

SCENARIO SCRIPT - SQUAD ATTACK EXERCISE, 29 PALMS
EVENT III

	VIC A	VIC B	VIC C	VIC F	DI SAF	OPFOR SAF	Platoon/Squad Leader (Facilitator)
Defend Obj 2	FT Bravo on line defend Obj 2 **(#3)** (left FT in 2nd squad line) prone position. Orient to the North. Employs fire support (mortars) in defense of Obj 2.	FT Bravo on line defend Obj 2 **(#3)** (left FT in 2nd squad line) prone position. Orient to the North.	FT Bravo on line defend Obj 2 **(#3)** (left FT in 2nd squad line) prone position. Orient to the North.	FT Bravo on line defend Obj 2 **(#3)** (left FT in 2nd squad line) prone position. Orient to the North.	1. FT Alpha on line defend Obj 2 **(#3)** (right FT in 2nd squad line), prone position, Orient to the North.	Counterattack role, squad line, six OPFOR DI SAF assault Obj 2 from north to south.	N/C

Annex C - SQUAD MOUT EXERCISE, MCKENNA RANGE

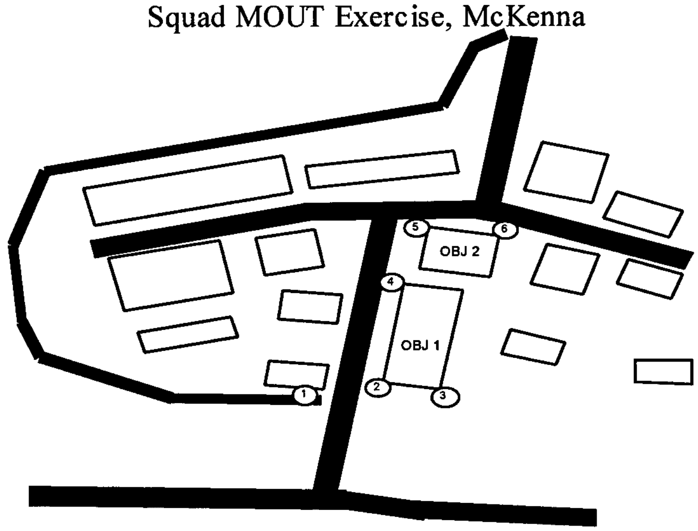
Concept of Operation

On command a dismounted mechanized platoon attacks a built up area and clears a series of buildings. Enemy forces in the area consist of small two - three man elements. The exercise is constructed in two events. The events can be done either sequentially or nonsequentially. Refer to the illustration.

- **EVENT I:**
  - ASSAULT POSITION TO OBJ 1: 2nd SQUAD, 1st PLATOON MOVES IN BOUNDING OVERWATCH IN SQUAD COLUMN, FIRE TEAMS IN WEDGE TO BUILDING #1 (OBJ 1). 2ND SQUAD ENTERS, CLEARS AND SEIZES OBJ 1.
- **EVENT 2:**
  - OBJ 1 TO OBJ 2: 2ND SQUAD MOVES BY BOUNDING OVERWATCH TO ENTER, CLEAR AND SEIZE BUILDING #2 (OBJ 2). ON OBJ 2, 2ND SQUAD PREPARES HASTY BATTLE POSITION FACING (NORTH). PREPARE FOR COUNTER ATTACK. MORTARS IN SUPPORT.
- **EVENT 3:**
  - DEFEND: ON OBJ 2, 2ND SQUAD PREPARES HASTY BATTLE POSITION FACING NORTH. PREPARE FOR COUNTER ATTACK. MORTARS IN SUPPORT.

NOTE: During training (week 1), a variation of this exercise will be practiced: ***TBD***

Squad MOUT Exercise, McKenna



SCENARIO SCRIPT MOUT, MCKENNA RANGE, EVENT I

	VIC A	VIC B	VIC C	VIC F	DI SAF	OPFOR SAF	Facilitator
Occupy Assault Position	Fire Team Leader, Fire Team Bravo, 2nd squad. Assault Position Activities, Occupy left portion of Assault Position **(#1)**, kneeling position	Saw Gunner; Fire Team Bravo, 2nd squad Assault Position Activities, Occupy left portion of Assault Position **(#1)**, kneeling position	Rifleman; Fire Team Bravo, Join FT Alpha at south side of Obj 1 and continue mission with FT Alpha	Rifleman; Fire Team Bravo, 2nd squad Assault Position Activities, Occupy left portion of Assault Position **(#1)**, kneeling position	Fire Team Alpha Assault Position Activities, Occupy right portion of Assault Position **(#1)**, kneeling position	In defensive position; 2 OPFOR DI in Obj1 & 2. Six more OPFOR DI, in zone beyond Obj 2. The six OPFOR DI are located near corners of buildings	Squad Leader Deliver Platoon / squad FRAGO/attack order. Command & Control 2nd Squad DI SAF
Assault Position to Obj 1	Squad bounding overwatch, FT Bravo (- VIC C) lead. FT Bravo will bound to south east corner of Obj 1, **(#3),** then in file move up east side of building to courtyard. Enter building from east side (courtyard), clear bottom floor first then top floor of the south end of	Squad bounding overwatch, FT Bravo (- VIC C) lead. FT Bravo will bound to south east corner of Obj 1, **(#3),** then in file move up east side of building to courtyard. Enter building from east side (courtyard), clear bottom floor first then top floor of the south end of	N/C	Squad bounding overwatch, FT Bravo (- VIC C) lead. FT Bravo will bound to south east corner of Obj 1, **(#3),** then in file move up east side of building to courtyard. Enter building from east side (courtyard), clear bottom floor first then top floor of the south end of	FT Alpha, 2nd squad (+ VIC C) cover FT Bravo entering Obj 1. Then in file move by bounding overwatch to south west **(#2)** and south east corner **(#3)** of Obj 1. Support by fire FT Bravo. Be prepared to move toward Obj 2 on west side of Obj 1	N/C	Direct Squad

	VIC A	VIC B	VIC C	VIC F	DI SAF	OPFOR SAF	Facilitator
	the building. After clearance of the top floor, return to the bottom floor, cross courtyard and clear top then bottom floor of north side of building.	the building. After clearance of the top floor, return to the bottom floor, cross courtyard and clear top then bottom floor of north side of building.		the building. After clearance of the top floor, return to the bottom floor, cross courtyard and clear top then bottom floor of north side of building.			

SCENARIO SCRIPT MOUT, MCKENNA RANGE, EVENT II

	VIC A	VIC B	VIC C	VIC F	DI SAF	OPFOR SAF	Facilitator
OBJ 1 to OBJ 2	FT Bravo (-VIC c), by bounds enters building (Obj 2) on the south side door, clears Obj 2, top floor first then middle floor, finally bottom floor. Do not proceed beyond LOA.	FT Bravo (-VIC c) by bounds enters building (Obj j2) on the south side door, clears Obj 2, top floor first then middle floor, finally bottom floor. Do not proceed beyond LOA.	Remain a member of FT Alpha.	FT Bravo (-VIC c) by bounds enters building (Obj 2) on the south side door, clears Obj 2, top floor first then middle floor, finally bottom floor. Do not proceed beyond LOA	FT Alpha, (plus VIC C) 2nd squad, cover FT Bravo entering Obj 2. From the northwest corner **(#4)** of Obj 1, on order, move in file towards northwest corner **(#5)** of Obj 2. Move up west side of Obj 2. Do not proceed past limit of advance.	N/C	N/C

SCENARIO SCRIPT MOUT, MCKENNA RANGE, EVENT III

	VIC A	VIC B	VIC C	VIC F	DI SAF	OPFOR SAF	Facilitator
Defend Obj 2	FT Bravo (-VIC c) Defend Obj 2 from interior . Orient to the North. Employs fire support (mortars) in defense of Obj 2.	FT Bravo (-VIC c) Defend Obj 2 from interior . Orient to the North. Employs fire support (mortars) in defense of Obj 2.	Remain a member of FT Alpha	FT Bravo (-VIC c) Defend Obj 2 from interior . Orient to the North. Employs fire support (mortars) in defense of Obj 2.	FT Alpha, (plus VIC C) 2nd squad, Defend Obj 2 from exterior **(#5 & 6)**. Orient to the North.	Counterattack role, squad line, six OPFOR DI SAF assault Obj 2 from north to south.	N/C

Dismounted Warrior Network
User Exercises Schedule

1. **General.** The following schedule of events which will take place during the Dismounted Warrior Network User Exercises (DWN USEX) are designed to train soldiers on use of the various Virtual Individual Combatant Simulators (VICS), conduct tactical exercises in a virtual battle simulation, and demonstrate VICS capabilities. Each soldier will experience each VIC.

2. **Training 27 - 30 May.** Tuesday morning the 27th of May will be devoted to in brief of all personnel and equipment preparation. The training runs will be allotted 60 minutes (10 min. TL brief, 5 min. to mount VICS, 15 min. to execute scenario, 5 min. to dismount VICS and 25 min. AAR & ARI interviews). Daily schedule in enclosure 1.

3. **Exercises 2 - 5 and 9, 10 June.** The exercise runs will be allotted 60 minutes (10 min. TL brief, 5 min. to mount VICS, 15 min. to execute scenario, 5 min. to dismount VICS and 25 min. AAR & ARI interviews). Daily schedule at enclosure 2.

4. **Demonstrations 11 - 13 June.** Specific time utilization will generally follow the training timeline but will be flexible to meet visitors schedule. Daily schedule at enclosure 2.

5. **Scenarios.** There are eighteen basic scenarios planned to support DWN USEX, three for training on 29 Palms, three for exercises on 29 Palms, four for training on McKenna MOUT and eight for exercises on McKenna MOUT. Scenarios to support excursions and demonstrations will be selected from those planned and/or developed during the course of the exercises. Scenarios are at enclosure 3. Details of the DISAF scenarios, both Blue and Red, are at enclosure 4. Graphic outlines for 29 Palms and McKenna MOUT are at enclosure 5 and 6 respectively.

USEX Training Schedule

	Time	VIC	Soldier	Position	Notes
27	0830				In-Brief All Personnel &
May					Equipment Prep
Tues					
	0930				In-Brief All Personnel &
					Equipment Prep
	1030				In-Brief All Personnel &
					Equipment Prep
					In-Brief All Personnel &
					Equipment Prep
	1300	A	1	TL	
	Penny	B	3	SG	
		C	5	R1	
		F	7	R2	
	1400	A	2	SG	
	Penny	B	4	R1	
		C	6	R2	
		F	8	TL	
	1500	A	1	R1	
	Nickel	B	3	R2	
		C	5	TL	
		F	7	SG	
	1600	A	2	R2	
	Nickel	B	4	TL	
		C	6	SG	
		F	8	R1	

Legend - TL = Team Leader R1 = Rifleman 1

SG = Saw Gunner R2 = Rifleman 2

Date	Time	VIC	Soldier	Position	Notes
28	0830	A	3	TL	
May	Dime	B	5	SG	
Wed		C	7	R1	
		F	1	R2	
	0930	A	4	SG	
	Dime	B	6	R1	
		C	8	R2	
		F	2	TL	
	1030	A	3	R1	
	Penny	B	5	R2	
		C	7	TL	
		F	1	SG	
	1300	A	4	R2	
	Penny	B	6	TL	
		C	8	SG	
		F	2	R1	
	1400	A	5	TL	
	Nickel	B	7	SG	
		C	1	R1	
		F	3	R2	
	1500	A	6	SG	
	Nickel	B	8	R1	
		C	2	R2	
		F	4	TL	
	1600	A	7	R1	
	Dime	B	1	R2	
		C	3	TL	
		F	5	SG	

Legend - TL = Team Leader R1 = Rifleman 1
SG = Saw Gunner R2 = Rifleman 2

Date	Time	VIC	Soldier	Position	Notes
29 May	0830	A	8	R2	
Thur	Dime	B	2	TL	
		C	4	SG	
		F	6	R1	
	0930				Transition from 29 Palms to McKenna
					MOUT (Soldiers and Equipment)
	1030	A	7	R2	
	Chevy	B	1	TL	
		C	3	SG	
		F	5	R1	
	1300	A	8	R1	
	Chevy	B	2	R2	
		C	4	TL	
		F	6	SG	
	1400	A	7	SG	
	Dodge	B	1	R1	
		C	3	R2	
		F	5	TL	
	1500	A	8	TL	
	Dodge	B	2	SG	
		C	4	R1	
		F	6	R2	
	1600	A	5	R2	
	Ford	B	7	TL	
		C	1	SG	
		F	3	R1	

Legend - TL = Team Leader R1 = Rifleman 1

SG = Saw Gunner R2 = Rifleman 2

Date	Time	VIC	Soldier	Position	Notes
30 May	0830	A	6	R1	
Fri	Ford	B	8	R2	
		C	2	TL	
		F	4	SG	
	0930	A	5	SG	
	Jeep	B	7	R1	
		C	1	R2	
		F	3	TL	
	1030	A	6	TL	
	Jeep	B	8	SG	
		C	2	R1	
		F	4	R2	
	1300	A	3	R2	
	Chevy	B	5	TL	
		C	7	SG	
		F	1	R1	
	1400	A	4	R1	
	Chevy	B	6	R2	
		C	8	TL	
		F	2	SG	
	1500	A	1	SG	
	Dodge	B	3	R1	
		C	5	R2	
		F	7	TL	
	1600	A	2	TL	
	Dodge	B	4	SG	
		C	6	R1	

		F	8	R2	

Legend - TL = Team Leader R1 = Rifleman 1
SG = Saw Gunner R2 = Rifleman 2

USEX Data Collection Exercise Schedule

Date	**TimeV ign.**	**VIC**	**Soldier**	**Position**	**Notes**
2 Jun Mon	0830 Red	A	1	TL	
		B	3	R2	
		C	5	R1	
		F	7	SG	
	0930 Red	A	2	TL	
		B	4	R2	
		C	6	R1	
		F	8	SG	
	1030 White	A	1	TL	
		B	3	R2	
		C	5	SG	
		F	7	R1	
	1300 White	A	2	TL	
		B	4	R2	
		C	6	SG	
		F	8	R1	
	1400 Blue	A	5	R1	
		B	7	R2	
		C	1	TL	
		F	3	SG	
	1500 Blue	A	6	R1	
		B	8	R2	
		C	2	TL	

		F	4	SG	

Legend - TL = Team Leader R1 = Rifleman 1

SG = Saw Gunner R2 = Rifleman 2

Date	Time Vign.	VIC	Soldier	Position	Notes
3 Jun Tues	0830 Red	A	5	R2	
		B	7	SG	
		C	1	TL	
		F	3	R1	
	0930 Red	A	6	R2	
		B	8	SG	
		C	2	TL	
		F	4	R1	
	1030 White	A	3	R2	
		B	5	SG	
		C	7	R1	
		F	1	TL	
	1300 White	A	4	R2	
		B	6	SG	
		C	8	R1	
		F	2	TL	
	1400 Blue	A	3	SG	
		B	5	R1	
		C	7	R2	
		F	1	TL	
	1500 Blue	A	4	SG	
		B	6	R1	
		C	8	R2	
		F	2	TL	

Legend - TL = Team Leader R1 = Rifleman 1
SG = Saw Gunner R2 = Rifleman 2

Date	Time Vign.	VIC	Soldier	Position	Notes
4 Jun	0830	A	7	SG	
Wed	Red	B	1	TL	
		C	3	R1	
		F	5	R2	
	0930	A	8	SG	
	Red	B	2	TL	
		C	4	R1	
		F	6	R2	
	1030	A	7	SG	
	White	B	1	TL	
		C	3	R2	
		F	5	R1	
	1300	A	8	SG	
	White	B	2	TL	
		C	4	R2	
		F	6	R1	
	1400	A	1	TL	
	Green	B	3	SG	
		C	5	R1	
		F	7	R2	
	1500	A	2	TL	
	Green	B	4	SG	
		C	6	R1	
		F	8	R2	

Legend - TL = Team Leader R1 = Rifleman 1
SG = Saw Gunner R2 = Rifleman 2

	Time	VIC	Soldier	Position	Notes
5 Jun	0830	A	1	TL	
Thur	Yellow	B	3	R1	
		C	5	R2	
		F	7	SG	
	0930	A	2	TL	
	Yellow	B	4	R1	
		C	6	R2	
		F	8	SG	
	1030	A	5	R1	
	Brown	B	7	SG	
		C	1	R2	
		F	1	TL	
	1300	A	6	R1	
	Brown	B	8	SG	
		C	4	R2	
		F	2	TL	
	1400	A	5	SG	
	Black	B	7	R1	
		C	3	R2	
		F	1	TL	
	1500	A	6	SG	
	Black	B	8	R1	
		C	4	R2	
		F	2	TL	

Legend - TL = Team Leader R1 = Rifleman 1
SG = Saw Gunner R2 = Rifleman 2

Date	Time	VIC	Soldier	Position	Notes
6 Jun					Post Training Holiday
Fri					Maintenance Activities
					Final IIM Meeting 2868A

Date	Time	VIC	Soldier	Position	Notes
9 Jun	0830	A	3	R1	
Mon	Gold	B	5	R2	
		C	7	SG	
		F	1	TL	
	0930	A	4	R1	
	Gold	B	6	R2	
		C	8	SG	
		F	2	TL	
	1030	A	3	R2	
	Copper	B	5	R1	
		C	7	SG	
		F	1	TL	
	1300	A	4	R2	
	Copper	B	6	R1	
		C	8	SG	
		F	2	TL	
	1400	A	7	R1	
	Grey	B	1	TL	
		C	3	R2	
		F	5	SG	
	1500	A	8	R1	
	Grey	B	2	TL	
		C	4	R2	
		F	6	SG	

Legend - TL = Team Leader R1 = Rifleman 1
SG = Saw Gunner R2 = Rifleman 2

Date	Time	VIC	Soldier	Position	Notes
10 Jun	0830	A	7	R2	
Tues	Orange	B	1	TL	
		C	3	SG	
		F	5	R1	
	0930	A	8	R2	
	Orange	B	2	TL	
		C	4	SG	
		F	6	R1	
	1030	A			ARI Interview
		B			
		C			
		F			
	1300	A			MOUT “On Site” Review / AAR
		B			
		C			
		F			
	1400	A			MOUT “On Site” Review / AAR
		B			
		C			
		F			
	1500	A			MOUT “On Site” Review / AAR
		B			
		C			
		F			

Legend - TL = Team Leader R1 = Rifleman 1
SG = Saw Gunner R2 = Rifleman 2

Date	Time	VIC	Soldier	Position	Notes
11 Jun Wed	0830	A			Demonstration Rehearsal &
		B			Video Filming
		C			
		F			
	0930	A			Demonstration Rehearsal &
		B			Video Filming
		C			
		F			
	1030	A			Demonstration Rehearsal &
		B			Video Filming
		C			
		F			
	1300	A			Demonstration Rehearsal &
		B			Video Filming
		C			
		F			
	1400	A			Demonstration Rehearsal &
		B			Video Filming
		C			
		F			
	1500	A			Demonstration Rehearsal &
		B			Video Filming
		C			
		F			

Date	Time	VIC	Soldier	Position	Notes
12 Jun	0830				Demonstration Inf Cdr Conf
Thur					
	0930				Demonstration Inf Cdr Conf
	1030				Demonstration Inf Cdr Conf
	1300				Demonstration Inf Cdr Conf
	1400				Demonstration Inf Cdr Conf
	1500				Demonstration Inf Cdr Conf
13 Jun	0830				Demonstration Inf Cdr Conf
Fri					
	0930				Demonstration Inf Cdr Conf

USEX Vignette Definitions

29 Palms Training

Scen. Name	Blue Mission	Blue Start Location (XY)	Red Mission	Red Composition	Red Start Location (XY)	Map
Penny	Atk 1 > 2 749m	A - 3258-4462 B - 3260-4460 C - 3258-4458 F - 3256-4460 SAF - 3271-4451	Def 2	3 R (1 Bay - 2 DISaf)	DISaf - 3100-4601 Bayonet - 3109-4603	1 A
Nickel	Atk 2 > 3 837m	A - 3089-4589 B - 3091-4587 C - 3089-4585 F - 3087-4587 SAF - 3093-4580	Def 3	3 R (1 Bay - 2 DISaf)	DISaf - 2998-4813 Bayonet - 3004-4818	2A
Dime	Def 3 862m	A - 3017-4795 B - 3019-4793 C - 3017-4791 F - 3015-4793 SAF BP3 - 2996-4822	Atk 4 > 3	2 Squads (DISaf)	DISaf 1 - 2740-4963 DISaf 2 - 2735-4943	3D

MOUT Training

Scen. Name	Blue Mission	Blue Start Location (XY)	Red Mission	Red Composition	Red Start Location (XY)	Map
Chevy	Atk 1 > C 128m	A - 16519-16512 B - 16521-16510 C - 16519-16508 F - 16517-16510 SAF - 16519-16490	Def C	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16542-16628 Rifleman - Bldg C	C - 1
Dodge	Atk 2 > C 129m	A - 16459-16592 B - 16461-16590 C - 16459-16588 F - 16457-16590 SAF - 16439-16590	Def C	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16542-16628 Rifleman - Bldg C	C - 2
Ford	Atk 3 > C 130m	A - 16559-16682 B - 16561-16680 C - 16559-16678 F - 16557-16680 SAF - 16559-16700	Def C	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16534-16624 Rifleman - Bldg C	C - 3
Jeep	Atk 4 > C 130m	A - 16589-16612 B - 16591-16610 C - 16589-16608 F - 16587-16610 SAF - 16609-16610	Def C	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16544-16632 Rifleman - Bldg C	C - 4

29 Palms Exercises

Scen. Name	Blue Mission	Blue Start Location (XY)	Red Mission	Red Composition	Red Start Location (XY)	Map
Red	Atk 5 > 6 757m	A - 2379-4706 B - 2381-4704 C - 2379-4702 F - 2377-4704 SAF - 2379-4684	Def 6	3 R (1 Bay - 2 DISaf)	DISaf - 2375-4957 Bayonet - 2382-4956	5 A
White	Atk 6 > 7 863m	A - 2346-4959 B - 2348-4957 C - 2346-4955 F - 2344-4957 SAF - 2346-4935	Def 7	3 R (1 Bay - 2 DISaf)	DISaf - 2499-5224 Bayonet - 2504-5224	6A
Blue	Def 7 935m	A - 2526-5230 B - 2528-5228 C - 2526-5226 F - 2524-5228 SAF BP7 - 2533-5264	Atk 8 > 7	2 Squads (DISaf)	DISaf 1 - 2603-5702 DISaf 2 - 2641-5701	7D

MOUT Exercises

Sign. Name	Blue Mission	Blue Start Location (XY)	Red Mission	Red Composition	Red Start Location (XY)	Map
Green	Atk 1 > A 128m	A - 16519-16512 B - 16521-16510 C - 16519-16508 F - 16517-16510 SAF - 16519-16490	Def A	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16543-16592 Rifleman - Bldg A	A - 1
Yellow	Atk 2 > A 129m	A - 16459-16592 B - 16461-16590 C - 16459-16588 F - 16457-16590 SAF - 16439-16590	Def A	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16530-16594 Rifleman - Bldg A	A - 2
Brown	Atk 3 > A 130m	A - 16559-16682 B - 16561-16680 C - 16559-16678 F - 16557-16680 SAF - 16559-16700	Def A	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16546-16585 Rifleman - Bldg A	A - 3
Black	Atk 4 > A 130m	A - 16589-16612 B - 16591-16610 C - 16589-16608 F - 16587-16610 SAF - 16609-16610	Def A	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16542-16592 Rifleman - Bldg A	A - 4
Gold	Atk 1 > B 128m	A - 16519-16512 B - 16521-16510 C - 16519-16508 F - 16517-16510 SAF - 16519-16490	Def B	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16533-16615 Rifleman - Bldg B	B - 1
Copper	Atk 2 > B 129m	A - 16459-16592 B - 16461-16590 C - 16459-16588 F - 16457-16590 SAF - 16439-16590	Def B	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16533-16615 Rifleman - Bldg B	B - 2
Gray	Atk 3 > B 130m	A - 16559-16682 B - 16561-16680 C - 16559-16678 F - 16557-16680 SAF - 16559-16700	Def B	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16555-16609 Rifleman - Bldg B	B - 3
Orange	Atk 4 > B 130m	A - 16589-16612 B - 16591-16610 C - 16589-16608 F - 16587-16610 SAF - 16609-16610	Def B	2 R (DISaf) 1 R (1 Bay)	Fire Tm - 16555-16609 Rifleman - Bldg B	B - 4

Appendix E: User Experiment Questionnaire/Data Collection Forms

VIC EVALUATION PROTOCOL

Evaluation Dimensions:

- Perform in VIC, Ease of Performing, Effectiveness of Executing Tasks, Similarity to Real World, Tactically Sound, Overall Assessment of Technology Potential.

VIC Capability Assessment Questionnaire (VIC-CAQ).

- Completed after soldier finishes his first non-leader session on each VIC.
- Completed after soldier finishes his team leader session on each VIC.

VIC Evaluation Questionnaire (VIC-EQ).

- Completed after soldier executes all positions for a VIC.

VIC Comparison Questionnaire (VIC-Compare)

- Completed after the fourth day.

If time allows, the VIC-Compare will be followed by a structured interview to determine the reasons for soldiers' rankings of the VICs and to address other questions. Due to time constraints, it may not be possible to conduct the structured interview following the VIC-Compare. These interviews may be completed the following week.

VIC-Observations (VIC-Observe)

- Soldier actions, reactions, and performance in each VIC will be observed.

AARs: Observe the AARs.

Other Evaluation Techniques

- Soldiers validate actions, leader decisions, etc. at McKenna after completion of all VIC exercises

Training Phase

- 27 - 30 May. VIC-CAQ, VIC-EQ, and VIC-Compare piloted if appropriate. Observation sheets refined. USEX evaluation phase may begin on 30 May.

USEX Phase

- 2-3 June USEX-29 Palms.
- 4-5 June and 9-10 USEX-MOUT
- Dates tentative. Pending revised experimental plan.

VIC Capability Assessment Questionnaire

Name: ______________ Date: ______________ Time: ______

Position: Tm Ldr SAW Rifleman 1 Rifleman 2

VIC: A (Sensor) B (Tread) C (Computer) F(Foot)

Scenario: MOUT 29 Palms

Using the scale below, rate how difficult it was for you to perform the following tasks.

1 = No opportunity to perform 2 = Unable to perform
3 = Could perform easily 4 = Could perform with difficulty

Movement

1. _____ Move around and inside of buildings.
2. _____ Enter door, window, hole.
3. _____ Move over open, flat terrain.
4. _____ Move over hills and cross compartments.
5. _____ Move tactically

Orientation (of Self and Others)

6. _____ Move through a building knowing which rooms were cleared.
7. _____ Determine where team members are around and inside of buildings.
8. _____ Determine own movement direction.
9. _____ Maintain position relative to other personnel.
10. _____ Determine where team members are in open, flat terrain.
11. _____ Determine where team members are over hills and cross compartments.

Communication

12. _____ Identify hand and arm signals.

Visual Recognition (Person, Target, Object)

13. _____ Estimate distance to other personnel.
14. _____ Locate your fire team members.
15. _____ Determine activity (e.g., firing, kneeling, running) of your team or enemy.
16. _____ Identify specific fire team members.
17. _____ Identify assigned sectors.
18. _____ Identify dead space.
19. _____ Detect enemy soldiers.

Weapon Engagement

20. _____ Aim your weapon.
21. _____ Fire your weapon.

22. _____ Detect enemy fire.
23. _____ Fire from tactical positions

VIC Evaluation Questionnaire

Name: ______________ Date: ____________ Time: __________
VIC: A (Sensor) B (Tread) C (Computer) F (Foot)

Rate the following dimensions, from 1 to 5, based on your overall assessment of the capabilities of the VIC you were just assigned to. For questions 1-3 use the following scale:

1 = Very effective 2 = Generally effective 3 = Somewhat effective
4 = Generally ineffective 5 = Very ineffective

1. _____ How effective was this VIC for engaging targets?

2. _____ How effective was this VIC for simulating movement?

3. _____ How effective was this VIC for identifying objects, people, etc.?

For questions 4-7 use the following scale:
1 = Yes, very similar 2 = Somewhat similar 3 = No very dissimilar

4. _____ Does this VIC allow you to move over open, flat terrain in a manner similar to how you would move in the real world ?

5. _____ Does this VIC allow you to move over hills and cross compartments in a manner similar to how you would move in the real world ?

6. _____ Does this VIC allow you to move around and inside of buildings in a manner similar to how you would move in the real world ?

7. _____ Does this VIC allow you to fire your weapon in a manner similar to how you would do it in the real world?

8. _____ Does this VIC allow you to fire and move as a team member in a manner similar to how you would fire and move in the real world?

For questions 9-10, check the response which best applies

9. Could you engage targets as quickly on this VIC as on a real weapon?

_____ Quicker than a real weapon
_____ Slower than a real weapon
_____ About the same as a real weapon

10. Could you recognize people, objects, and targets as quickly on this VIC as you could in the real world?

_____ Quicker than in the real world
_____ Slower than the real world

_____ About the same as in the real world

VIC Comparison Questionnaire

Name: ________________ Date: ____________ Time: ______

1. Rank order the VICs, from 1 to 4, based on how MANY ELEMENTS OR ASPECTS of the following tasks and skills can be performed.

I = Best (More elements or aspects can be performed with this VIC than with any other)
4 = Worst (Fewer elements or aspects can be performed with this VIC than with any other)

	VIC A	VIC B	VIC C	VIC F
Move as an individual				
Move as member of a fire team				
Maintain situational awareness: Of your location, your fire team's location, the enemy situation, etc.				
Communicate				
Recognize people, targets, and objects				
Engage targets as an individual				
Engage targets as a member of a fire team				
Control fires (as a team leader)				
Control movement (as a team leader)				

2. Rank order the VICs, from 1 to 4, based on how EASY it is to perform the following tasks and skills.

1 = Best (Can be performed most easily)
4 = Worst (Hardest to perform)

	VIC A	VIC B	VIC C	VIC F
Move as an individual				
Move as member of a fire team				
Maintain situational awareness: Of your location, your fire team's location, the enemy situation, etc.				
Communicate				
Recognize people, targets, and objects				
Engage targets as an individual				
Engage targets as member of a fire team				
Control fires (as a team leader)				
Control movement (as a team leader)				

3. Rank order the VICs, from 1 to 4, based on how well each allows you to perform the following tasks or skills in a TACTICALLY SOUND manner.

I = Best (No differences or the fewest differences from tactical procedures)
4 = Worst (Performance differs the most from tactical procedures)

	VIC A	VIC B	VIC C	VIC F
Move as an individual				
Move as member of a fire team				
Maintain situational awareness: Of your location, your fire team's location, the enemy situation, etc.				
Communicate				
Recognize people, targets, and objects				
Engage targets as an individual				
Engage targets as member of a fire team				
Control fires (as a team leader)				
Control movement (as a team leader)				

4. Rank order the VICs, from 1 to 4, based on how well each allows you to perform the following tasks and skills LIKE YOU WOULD PERFORM THE TASKS IN THE REAL WORLD.

I = Best (Most similar to real-world performance)
4 = Worst (Least similar to real-world performance)

	VIC A	VIC B	VIC C	VIC F
Move as an individual				
Move as member of a fire team				
Maintain situational awareness: Of your location, your fire team's location, the enemy situation, etc.				
Communicate				
Use of visual displays				
Recognize people, targets, and objects				
Engage targets as an individual				
Engage targets as member of a fire team				
Control fires (as a team leader)				
Control movement (as a team leader)				

5. Rank order the VICs, from 1 to 4, based on how effective each VIC would be at simulating the following positions.

I = Best (Most effective for this position)
4 = Worst (Least effective for this position)

	VIC A	VIC B	VIC C	VIC F
Team leader				
SAW gunner				

Rifleman				
Squad leader				
Platoon leader				

VIC Observation

Name: ______________ Date: __________ Time: _____ to_____

Position:	Tm Ldr	SAW	Rifleman 1	Rifleman 2
VIC:	A (Sensor)	B (Tread)	C (Computer)	F (Foot)
Scenario:	MOUT	29 Palms		

Session #____

Circle which positions were used to move?:

Walk Run Crawl

Circle which positions were used in firing:

Stand unsupported Kneel Prone Other ________________

Speed of Movement:

Scanning:

Enemy Contact:

Did you see the enemy? _____Yes _____No

Did you see the enemy firing? _____Yes _____No

Did you fire at the enemy? _____Yes _____No

Were you killed? _____Yes _____No

What position were you in when you were killed?

_____Standing _____Kneeling _____Prone

If not killed, what was your final position?

_____Standing _____Kneeling _____Prone

Appendix F: User Experiment Questionnaire Data

VIC Capability Questionnaire Data

Task Difficulty Ratings by VIC for "Move over open, flat terrain"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	85.7	87.5	100.0	100.0
Could perform with difficulty	14.3	12.5	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Move over hills and cross compartments"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	12.5	0
Unable to perform	0	0	0	0
Could perform easily	100.0	75.0	87.5	100.0
Could perform with difficulty	0	25.0	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Move tactically"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	12.5	0
Unable to perform	14.3	0	0	0
Could perform easily	57.1	62.5	75.0	83.3
Could perform with difficulty	28.6	37.5	12.5	16.7

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Determine own movement direction"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	16.7
Could perform easily	71.4	62.5	100.0	83.3
Could perform with difficulty	28.6	37.5	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Maintain position relative to other personnel" - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	71.4	62.5	87.5	66.7
Could perform with difficulty	28.6	37.5	12.5	33.3

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Determine where team members are in open, flat terrain"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	12.5	0	16.7
Could perform easily	85.7	75.5	100.0	83.3
Could perform with difficulty	14.3	12.5	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Determine where team members are over hills and cross compartments"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	25.0	0	16.7
Could perform easily	71.4	62.5	87.5	66.7
Could perform with difficulty	28.6	12.5	12.5	16.7

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Estimate distance to other personnel"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	28.6	12.5	0	16.7
Could perform easily	42.9	62.5	50.0	33.3
Could perform with difficulty	28.6	25.0	50.0	50.0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Locate your fire team members"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	16.7
Could perform easily	85.7	75.0	100.0	83.3
Could perform with difficulty	14.3	25.0	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Determine activity of your team or enemy" - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	14.3	0	0	0
Could perform easily	71.4	50.0	75.0	66.7
Could perform with difficulty	14.3	50.0	25.0	33.3

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Identify specific fire team members"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	16.7
Could perform easily	100.0	100.0	100.0	83.3
Could perform with difficulty	0	0	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Identify assigned sectors"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	28.6	12.5	25.0	33.3
Unable to perform	0	12.5	0	16.7
Could perform easily	42.9	37.5	25.0	50.0
Could perform with difficulty	28.6	37.5	50.0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Identify dead space"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	28.6	12.5	12.5	16.7
Unable to perform	0	12.5	25.0	0
Could perform easily	28.6	37.5	25.0	0
Could perform with difficulty	42.9	37.5	37.5	83.3

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Detect enemy soldiers"- 29 Palm (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	16.7
Unable to perform	14.3	25.0	25.0	16.7
Could perform easily	0	25.0	25.0	0
Could perform with difficulty	85.7	50.0	50.0	66.7

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Aim your weapon"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	16.7
Could perform easily	57.1	87.5	87.5	83.3
Could perform with difficulty	42.9	12.5	12.5	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Fire your weapon"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	16.7
Unable to perform	0	0	0	16.7
Could perform easily	100.0	100.0	100.0	66.7
Could perform with difficulty	0	0	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Detect enemy fire"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	14.3	0	12.5	16.7
Unable to perform	28.6	62.5	12.5	50.0
Could perform easily	28.6	12.5	25.0	33.3
Could perform with difficulty	28.6	25.0	50.0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Fire from tactical positions"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	28.6	0	0	16.7
Unable to perform	0	0	0	33.3
Could perform easily	57.1	75.0	87.5	16.7
Could perform with difficulty	14.3	25.0	12.5	33.3

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Task Difficulty Ratings by VIC for "Move around and inside of buildings"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	20.0	0
Unable to perform	0	16.7	60.0	0
Could perform easily	83.3	50.0	0	100.0
Could perform with difficulty	16.7	33.3	20.0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Enter door, window, hole"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	20.0	0
Unable to perform	0	33.3	60.0	0
Could perform easily	83.3	66.7	0	100.0
Could perform with difficulty	16.7	0	20.0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Move tactically"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	66.7	83.3	80.0	100.0
Could perform with difficulty	33.3	16.7	20.0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Move through a building knowing which rooms were cleared"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	33.3	20.0	0
Unable to perform	0	0	40.0	0
Could perform easily	50.0	66.7	0	80.0
Could perform with difficulty	50.0	0	40.0	20.0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Determine where team members are around and inside of buildings"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	40.0	0
Could perform easily	83.3	83.3	0	100.0
Could perform with difficulty	16.7	16.7	60.0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Determine own movement direction"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	100.0	83.3	100.0	100.0
Could perform with difficulty	0	16.7	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Maintain position relative to other personnel" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	83.3	83.3	100.0	100.0
Could perform with difficulty	16.7	16.7	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Estimate distance to other personnel" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	20.0
Could perform easily	66.7	83.3	80.0	60.0
Could perform with difficulty	33.3	16.7	20.0	20.0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Locate your fire team members" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	83.3	100.0	100.0	100.0
Could perform with difficulty	16.7	0	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for “Determine activity of your team or enemy” - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	20.0	0
Could perform easily	83.3	83.3	80.0	80.0
Could perform with difficulty	16.7	16.7	0	20.0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for “Identify specific fire team members” - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	83.3	100.0	80.0	100.0
Could perform with difficulty	16.7	0	20.0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for “Identify assigned sectors” - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	16.7	0	40.0	20.0
Unable to perform	16.7	16.7	0	20.0
Could perform easily	50.0	83.3	60.0	60.0
Could perform. with difficulty	16.7	0	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Identify dead space" MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	33.3	16.7	40.0	20.0
Unable to perform	16.7	16.7	0	0
Could perform easily	50.0	66.7	20.0	60.0
Could perform with difficulty	0	0	40.0	20.0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Detect enemy soldiers" MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	20.0	0
Unable to perform	16.7	0	20.0	0
Could perform easily	50.0	66.7	0	100.0
Could perform with difficulty	33.3	33.3	60.0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Aim your weapon" MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	20.0	0
Unable to perform	0	0	20.0	0
Could perform easily	66.7	66.7	40.0	100.0
Could perform with difficulty	33.3	33.3	20.0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Fire your weapon" MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	16.7	0	40.0	0
Unable to perform	0	0	0	20.0
Could perform easily	83.3	100.0	60.0	60.0
Could perform with difficulty	0	0	0	20.0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Detect enemy fire" MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	16.7	0	40.0	20.0
Unable to perform	50.0	33.3	20.0	20.0
Could perform easily	16.7	50.0	40.0	60.0
Could perform with difficulty	16.7	16.7	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Task Difficulty Ratings by VIC for "Fire from tactical positions" MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	50.0	0	20.0	0
Unable to perform	0	0	0	0
Could perform easily	50.0	83.3	60.0	60.0
Could perform with difficulty	0	16.7	20.0	40.0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

VIC Evaluation Questionnaire Data

Effectiveness Ratings by VIC for Engaging Targets - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	0	37.5	37.5	20
Generally effective	57.1	62.5	62.5	40
Somewhat effective	42.9	0	0	0
Generally ineffective	0	0	0	20
Very ineffective	0	0	0	20

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 5 for VIC F.

Effectiveness Ratings by VIC for Simulating Movement - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	0	12.5	37.5	33.3
Generally effective	42.9	75.0	50.0	33.3
Somewhat effective	28.6	12.5	0	33.3
Generally ineffective	28.6	0	12.5	0
Very ineffective	0	0	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Effectiveness Ratings by VIC for Identifying Objects, People, etc. - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	0	37.5	37.5	50.0
Generally effective	71.4	62.5	50.0	16.7
Somewhat effective	28.6	0	12.5	16.7
Generally ineffective	0	0	0	0
Very ineffective	0	0	0	16.7

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Similarity of Moving over Open, Flat Terrain in VIC to Real World Performance 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	0	28.6	28.6	16.7
Somewhat similar	57.1	71.4	57.1	66.7
Very Dissimilar	42.9	0	14.3	16.7

Note. n = 7 for VICs A, B, and C; n = 6 for VIC F.

Similarity of Moving over Hills and Cross Compartments in VIC to Real World Performance 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	0	14.3	28.6	16.7
Somewhat similar	57.1	85.7	57.1	66.7
Very Dissimilar	42.9	0	14.3	16.7

Note. n = 7 for VICs A, B, and C; n = 6 for VIC F.

Similarity of Firing Weapon in VIC to Real World Performance
- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	28.6	0	14.3	83.3
Somewhat similar	28.6	71.4	42.9	0
Very Dissimilar	42.9	28.6	42.9	16.7

Note. n = 7 for VICs A, B, and C; n = 6 for VIC F.

Similarity of Firing and Moving as a Team Member in VIC to Real World Performance 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	14.3	28.6	28.6	16.7
Somewhat similar	42.9	71.4	71.4	66.7
Very Dissimilar	42.9	0	0	16.7

Note. n = 7 for VICs A, B, and C; n = 6 for VIC F.

Quickness of Engaging Targets in VIC Compared to Using a Real Weapon - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Quicker than a real weapon	0	28.6	25.0	0
Slower than a real weapon	100.0	57.1	62.5	16.7
About the same as a real weapon	0	14.3	12.5	83.3

Note. n = 7 for VICs A and B; n = 8 for VIC C; n = 6 for VIC F.

Quickness in Recognizing People, Objects, and Targets in VIC Compared to Real World 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Quicker than in the real world	0	14.3	0	0
Slower than the real world	85.7	57.1	37.5	50.0
About the same as in the real world	14.3	28.6	62.5	50.0

Note. n = 7 for VICs A and B; n = 8 for VIC C; n = 6 for VIC F.

Effectiveness Ratings by VIC for Engaging Targets - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	16.7	16.7	60.0	40.0
Generally effective	50.0	33.3	40.0	40.0
Somewhat effective	33.3	33.3	0	20.0
Generally ineffective	0	16.7	0	0
Very ineffective	0	0	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Effectiveness Ratings by VIC for Simulating Movement - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	16.7	16.7	0	20.0
Generally effective	33.3	66.7	60.0	20.0
Somewhat effective	50.0	0	40.0	60.0
Generally ineffective	0	0	0	0
Very ineffective	0	16.7	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Effectiveness Ratings by VIC for Identifying Objects, People, etc. - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	33.3	50.0	40.0	80.0
Generally effective	66.7	33.3	40.0	20.0
Somewhat effective	0	0	0	0
Generally ineffective	0	16.7	20.0	0
Very ineffective	0	0	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Similarity of Moving Around and Inside of Buildings in VIC to Real World Performance MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	16.7	16.7	0	20.0
Somewhat similar	50.0	66.7	33.3	80.0
Very Dissimilar	33.3	16.7	66.7	0

Note. n = 6 for VICs A and B; n = 3 for VIC C; and n = 5 for VIC F.

Similarity of Firing Weapon in VIC to Real World Performance - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	33.3	16.7	0	80.0
Somewhat	33.3	50.0	25.0	20.0

	VIC A	VIC B	VIC C	VIC F
similar				
Very Dissimilar	33.3	33.3	75.0	0

Note. n = 6 for VICs A and B; n = 4 for VIC C; n = 5 for VIC F.

Similarity of Firing and Moving as a Team Member in VIC to Real World Performance - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	16.7	50.0	0	40.0
Somewhat similar	66.7	50.0	75.0	60.0
Very Dissimilar	16.7	0	25.0	0

Note. n = 6 for VICs A and B; n = 4 for VIC C; n = 5 for VIC F.

Quickness of Engaging Targets in VIC Compared to Using a Real Weapon - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Quicker than a real weapon	16.7	0	20.0	0
Slower than a real weapon	66.7	66.7	80.0	20.0
About the same as a real weapon	16.7	33.3	0	80.0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Quickness in Recognizing People, Objects, and Targets in VIC Compared to Real World - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Quicker than in the real world	16.7	16.7	0	0
Slower than the real world	50.0	16.7	80.0	20.0
About the same as in the real world	33.3	66.7	20.0	80.0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

VIC Comparison Questionnaire Data

Means and Standard Deviations Collapsed Across Dimension by Task (29 Palms)

	VIC											
	VIC A			*VIC B*			*VIC C*			*VIC F*		
Comparison Task	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Move as an individual.	3.125	.907	32	1.969	1.121	32	2.375	1.100	32	2.531	1.077	32
Move as a member of a fire team.	3.125	.942	32	2.125	1.157	32	2.438	1.014	32	2.313	1.148	32
Maintain situational awareness.	3.281	.888	32	1.563	.759	32	2.844	1.019	32	2.313	1.030	32
Recognize people, targets, and objects.	3.281	.888	32	1.938	1.134	32	2.313	.896	32	2.469	1.135	32
Engage targets as an individual.	3.281	.924	32	1.563	.669	32	2.594	.946	32	2.563	1.190	32
Engage targets as a member of a fire team.	3.250	.880	32	1.656	.827	32	2.438	.948	32	2.656	1.208	32

Note. Total number of subjects in sample = 8. n=32 derived from collapsing across four dimensions.

Means and Standard Deviations Collapsed Across Dimension by Task (MOUT)

	VIC											
	VIC A			*VIC B*			*VIC C*			*VIC F*		
Comparison Task	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Move as an individual.	2.906	.818	32	2.063	1.162	32	2.656	1.181	32	2.375	1.157	32
Move as a member of a fire team.	2.844	.767	32	1.969	1.150	32	2.781	1.157	32	2.406	1.188	32
Maintain situational awareness.	2.938	.948	32	1.500	.803	32	3.125	.942	32	2.438	1.045	32
Recognize people, targets, and objects.	2.844	1.019	32	1.844	1.019	32	2.969	.861	32	2.344	1.234	32
Engage targets as an individual.	2.781	1.008	32	1.938	1.076	32	2.781	.941	32	2.500	1.270	32
Engage targets as a member of a fire team.	2.875	1.100	32	1.813	.965	32	2.719	.958	32	2.500	1.244	32

Note. Total number of subjects in sample = 8. n=32 derived from collapsing across four dimensions.

Means and Standard Deviations Collapsed Across Task By Dimension (29 Palms)

	VIC *VIC A*			*VIC B*			*VIC C*			*VIC F*		
DIMENSIONS	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Elements/Aspects Performed	3.417	.846	48	1.750	.934	48	2.479	.945	48	2..54	1.082	48
Ease of Performance	3.396	.676	48	2.000	1.130	48	2.229	1.036	48	2.375	1.064	48
Tactically Sound Performance	3.354	.758	48	1.729	.893	48	2.229	.928	48	2.688	1.188	48
Realistic Performance	2.729	1.086	48	1.729	.939	48	3.063	.836	48	2.479	1.167	48

Note. Total number of subjects in sample = 8. n=48 derived from collapsing across six tasks.

Means and Standard Deviations Collapsed Across Task By Dimension (MOUT)

	VIC *VIC A*			*VIC B*			*VIC C*			*VIC F*		
DIMENSIONS	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Elements/Aspects Performed	2.792	1.051	48	1.688	.993	48	2.958	.824	48	2.521	1.185	48
Ease of Performance	2.917	.964	48	2.063	1.137	48	2.688	1.055	48	2.333	1.155	48
Tactically Sound Performance	3.021	.863	48	1.833	1.018	48	2.708	1.051	48	2.438	1.201	48
Realistic Performance	2.729	.869	48	1.833	.996	48	3.000	1.092	48	2.417	1.200	48

Note. Total number of subjects in sample = 8. n=48 derived from collapsing across six tasks.

Leader Ratings -- Means and Standard Deviations Collapsed Across Dimension By Task (29 Palms)

	VIC *VIC A*			*VIC B*			*VIC C*			*VIC F*		
Comparison Task	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Control fire.	3.375	.518	8	2.125	.991	8	3.250	.886	8	1.250	.463	8
Control movement.	3.125	.991	8	1.875	.991	8	3.250	.707	8	1.750	1.035	8

Note. Total number of subjects in sample = 2. n=8 derived from collapsing across four dimensions.

Leader Ratings -- Means and Standard Deviations Collapsed Across Dimension By Task (MOUT)

	VIC											
	VIC A			***VIC B***			***VIC C***			***VIC F***		
Comparison Task	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Control fire.	3.375	.518	8	1.875	.991	8	3.250	.886	8	1.500	.756	8
Control movement.	3.375	.518	8	1.875	.991	8	3.250	.886	8	1.500	.756	8

Note. Total number of subjects in sample = 2. n=8 derived from collapsing across four dimensions.

Leader Ratings -- Means and Standard Deviations Collapsed Across Task By Dimension (29 Palms)

	VIC											
	VIC A			***VIC B***			***VIC C***			***VIC F***		
DIMENSIONS	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Elements/Aspects Performed	2.750	1.258	4	2.250	.500	4	3.250	.957	4	1.750	1.500	4
Ease of Performance	3.000	.000	4	3.000	1.155	4	3.000	1.155	4	1.000	.000	4
Tactically Sound Performance	4.000	.000	4	1.250	.500	4	3.000	.000	4	1.750	.500	4
Realistic Performance	3.250	.500	4	1.500	.577	4	3.750	.500	4	1.500	.577	4

Note. Total number of subjects in sample =2. n=4 derived from collapsing across two tasks.

Leader Ratings -- Means and Standard Deviations Collapsed Across Task By Dimension (MOUT)

	VIC											
	VIC A			***VIC B***			***VIC C***			***VIC F***		
DIMENSIONS	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***
Elements/Aspects Performed	3.000	.000	4	3.000	1.155	4	3.000	1.155	4	1.000	.000	4
Ease of Performance	3.500	.577	4	1.500	.577	4	3.000	1.155	4	2.000	1.155	4
Tactically Sound Performance	3.500	.577	4	1.500	.577	4	3.500	.577	4	1.500	.577	4
Realistic Performance	3.500	.577	4	1.500	.577	4	3.500	.577	4	1.500	.577	4

Note. Total number of subjects in sample = 2. n=4 derived from collapsing across two tasks.

Appendix G: Acronyms

- A -

AAR	After Action Review
ACR	Advanced Concepts & Requirements
ACTD	Advanced Concepts Technology Demonstration
ADST II	Advanced Distributed Simulation Technology II
AE4	Army Experiment 4
ANOVA	Analysis of Variance
ARI	Army Research Institute
ARL	Army Research Lab
AUSA	Association of the United States Army

- B -

BDI	Boston Dynamics, Inc.

- C -

C4I	Command, Control, Communications, Computers, and Intelligence
CCTT	Close Combat Tactical Trainer
CDF	Core DIS Facility
CDRL	Contract Data Requirements List
CGFTB	Computer Generated Forces Terrain Database
CIS	Combat Instruction Set
COTS	Commercial Off-the-Shelf
CQ	Comfort Questionnaire
CRT	Cathode Ray Tube

- D -

DBBL	Dismounted Battlespace Battle Lab
DI	Dismounted Infantry
DI SAF	Dismounted Infantry Semi-Automated Forces
DIS	Distributed Interactive Simulation
DO	Delivery Order
DSS	Dismounted Soldier Simulation
DT	Dynamic Terrain
DWN	Dismounted Warrior Network
DWN ERT	Dismounted Warrior Network Enhancements for Restricted Terrain

- E -

EM	Electro-Magnetic

- F -

FEA	Front End Analysis
FOR	Field of Regard
FOV	Field of View

- H -

HAC	Hughes Aircraft Corp.
HLA	High Level Architecture
HMD	Head Mounted Display

- I -

IIM	Information Interchange Meeting
IC SAF	Individual Combatant Semi-Automated Forces
IDA	Institute for Defense Analysis
IG	Image Generator
IHAS	Integrated Helmet Assembly Subsystem
IPT	Integrated Product Team
ITQ	Immersive Tendencies Questionnaire

- L -

LAN	Local Area Network
LBE	Load Bearing Equipment
LM	Lockheed Martin
LMIS	Lockheed Martin Information Systems
LMSG	Lockheed Martin Services Group
LOD	Level of Detail
LOS	Line of Sight
LW	Land Warrior
LWSE	Land Warrior Simulation Extension
LWTB	Land Warrior TestBed

- M -

MES	Multiple Elevation Surfaces
ModSAF	Modular Semi-Automated Forces
MOP	Measure of Performance
MOUT	Military Operations in Urban Terrain

- N -

NAWCTSD	Naval Air Warfare Center - Training Systems Division
NPS	Naval Postgraduate School

- O -

ODT	Omni--Directional Treadmill
OSF	Operational Support Facility

- P -

PA	Public Address
PC	Personal Computer
PDU	Protocol Data Unit
PQ	Presence Questionnaire
PVD	Plan-View Display

- R -

RBD	Reality by Design
RCI	Resource Consultants, Inc.
RDA	Research, Development & Acquisition
RGB	Red, Green, Blue

- S -

SAF	Semi-Automated Forces
SAIC	Science Applications International Corp.
SAW	Squad Automatic Weapon
SGI	Silicon Graphics, Inc.
SME	Subject Matter Expert
SS	Soldier Station
SSCOM	Soldier Systems Command
SSQ	Simulator Sickness Questionnaire
STP-21	Small Team Portal into the 21st Century
STRICOM	Simulation, Training & Instrumentation Command
SVS	Soldier Visualization Station

- T -

TASC	Technical Automation Services Corporation
TDQ	Task Difficulty Questionnaire
TECOM	Test and Evaluation Command
TEMO	Training, Exercises, & Military Operations
TIM	Technical Interchange Meeting
TRAC WSMR	TRADOC Analysis Center - White Sands Missile Range
TS	Total Severity
TTES	Team Tactical Engagement Simulator

- U -

USAIC	US Army Infantry Center
USEX	User Exercises
USMC	US Marine Corps

- V -

VIC	Virtual Individual Combatant
VMF	Variable Message Format
VSD	Virtual Space Devices

- W -

WBS	Work Breakdown Structure
WISE	Walk-In Synthetic Environment

Appendix H: Bibliography of DWN-Related Papers

Anschuetz, R., Jones, C., Kelly, P., Molnar, J. & Jones, T. (1997) "Compliance Testing Issues for Individual Combatant Simulators," *Proceedings of the Spring 1997 Simulation Interoperability Workshop*, pp. 1141-1146.

Anschuetz, R., Jones, C., Kelly, P., Molnar, J., & Jones, T. (1996) "Human Immersion into the DIS Battlefield," *Proceedings of the 18th Interservice/Industry Training Systems and Education Conference*, pp. 382-399.

Barham, P. T., & Jones, T. A. (1996) "Individual Combatants in Dismounted Warrior Network," To appear in *Proceedings of the Fall 1997 Simulation Interoperability Workshop.*

Bell, P. M., & Freeman, R. (1996) "Measuring Fidelity Differentials in Distributed Interactive Simulation Systems," *Proceedings of the 14th DIS Workshop*, pp. 965-970.

Bell, P. M., & Freeman, R. (1995) "Qualitative and Quantitative Indices for Simulation Systems in Distributed Interactive Simulation," *Proceedings of the 13th DIS Workshop*, pp. 171-174.

Berkowitz, J. P. (1996) "Considerations for the Use of Entity-based Simulations for Tactical Decision Making Training," *Proceedings of the Sixth conference on Computer Generated Forces and Behavioral Representation*, pp. 131-139.

Burrell, J. et al. (1996) "Anti-Armor Advanced Technology Demonstration: Summary of All Experiments", *Proceedings of the 15th DIS Workshop*, pp. 329-338.

Carr, F. H. (1997) "Achieving Interoperability by Stimulating C$I Systems and Allowing Their Control of the Simulated Battlefield," Proceedings of the Spring 1997 Simulation Interoperability Workshop, pp. 951 - 957.

Coe, G. & Lewis, R. (1996) "Validation of Distributed Simulations for Training," *Proceedings of the 15th DIS Workshop*, pp. 835-842.

Darken, R., Cockayne, W., & Carmein, D. (1997) "The Omni-Directional Treadmill: A Locomotion Device for Virtual Worlds," to appear in *Proceedings of the User Interface Software and Technology Conference,* Bath, Canada, ACM Press.

Department of Defense. (1994). DoD Directive 5000.59: Modeling and Simulation (M&S) Management Definitions, *http://www.dmso.mil/docslib/mspolicy/directive.html*, January 4, 1994.

Defense Modeling and Simulation Office. (1995) Glossary of Modeling and Simulation (M&S) Terms- Draft, *http://www.dmso.mil/docslib/mspolicy/glossary/glossary.html*, August 28, 1995

Drinkwater, D. M., Gagnon, G. L., & Stender, J. F. (1996) "Exercise Preparation - Applying the 1278.x Standards," Proceedings of the 15th DIS Workshop, pp. 743-748.

Eisenhardt, J. (1996) "Assessing Fidelity: A Common HLA/DIS Paradigm," *Proceedings of the 14th DIS Workshop*, pp. 1073-1086.

Endsley, M. R. (1995) "Toward a Theory of Situational Awareness in Dynamic Systems," *Human Factors*, Santa Monica, CA. HF Society, 37(1), pp. 32-64.

Foster, L. (1997) "Fidelity in Modeling and Simulation," Proceedings of the Spring 1997 Simulation Interoperability Workshop, pp. 473-482.

Foster, L., & Feldmann, P. (1996) "Defining a Fair Fight," Proceedings of the 14th DIS Workshop, pp. 147-153.

Foster, L. & Feldmann, P. (1995) "The Limitations of Interactive Behavior for Valid Distributed Interactive Simulation," *Proceedings of the 13th DIS Workshop*, pp. 175-189.

Fowlkes, J. E., & Norman, E. L. (1995) "Team Performance Measurement Issues in DIS-based Training Environments," *Proceedings of the 17th Interservice/Industry Training Systems and Education Conference*, pp. 272-280.

Glazewsky, S. R., & Rolek, E. P. (1997) "An Investigation on Gathering Human Factors Data within Advanced Distributed Simulations," Proceedings of the Spring 1997 Simulation Interoperability Workshop, pp. 257-264.

Goldiez, B. F. (1996) "Techniques for Interoperability Between Terrain Data Bases," *Proceedings from the 18th Interservice/Industry Training Systems and Education Conference*, pp. 350-358.

Goldiez, B., Graniela, B., & Roman, R. (1995) "Standard Methods for Evaluating Coordinate Conversion Routines and Creating a Library of Routines," *Proceedings of the 13th DIS Workshop*, pp. 155-169.

Goldshen, A. (1997) " Role of the CSIL Agent for Distributed Simulations," *Proceedings of the 1997 Spring Simulation Interoperability Workshop,* pp. 651- 656.

Granieri, J. P., & Badler, H. I. (1994). *Simulating humans in VR,* In H. Jones, R. Earnshaw, J. Vince, (Eds.), Proceedings of the 1994 International Conference on Applications of Virtual Reality. Leeds, UK: The British Computer Society.

Hardis, K. C., & Sureshchandran, S. (1995) "Terrain Database Correlation Testing within Database Generation Systems for DIS," *Proceedings of the 13th DIS Workshop*, pp. 367-378.

Hereford, J. (1996) "Terrain Standards Considerations for Advanced Simulation Exercises," *Proceedings of the 14th DIS Workshop*, pp. 463-472.

Horey, J. D., Fowlkes, D. H., & Reif, R. S. (1995) "Military Operations on Urbanized Terrain (MOUT) Training in Synthetic Environments Using the Team Target Engagement Simulator (TTES)," *Proceedings of the 17th Interservice/Industry Training Systems and Education Conference*, pp. 671-679.

Howard, M. D., Hoff, B., & Tseng, D. Y. (1996) "Individual Combatant Development in ModSAF," *Proceedings of the Fifth conference on Computer Generated Forces and Behavioral Representation*, pp. 479-486.

Institute for Electronics and Electrical Engineers. (1996a) "IEEE 1278.3: Standard for Distributed Interactive Simulation – Exercise Management and Feedback. "

Institute for Electronics and Electrical Engineers. (1996b) “IEEE 1278.4: Standard for Distributed Interactive Simulation – Verification, Validation, and Accreditation. ”

Institute for Electronics and Electrical Engineers. (1996c) “IEEE 1278.5: Standard for Distributed Interactive Simulation – Fidelity Description Requirements. ”

Institute for Electronics and Electrical Engineers. (1995a) “IEEE 1278.1: Standard for Distributed Interactive Simulation – Application Protocols.”

Institute for Electronics and Electrical Engineers. (1995b) “IEEE 1278.2: Standard for Distributed Interactive Simulation – Communications Services and Profiles. ”

Institute for Simulation and Training. (1996) “Exercise Management & Feedback (EMF) Rationale Document - DRAFT.” October, 1996.

Institute for Simulation and Training. (1995) “A Report on the 1994 I/ITSEC Distributed Interactive Simulation Demonstration,” May 10, 1995.

Institute for Simulation and Training. (1994) “Demonstration of Dissimilar Simulator Networking,” July 14, 1995.

Klasky, R., Anschuetz, R., Molnar, J., & Jones, T. (1996) “Dismounted Soldier System: The First Virtual Soldier Simulator,” *Proceedings of the 14th DIS Workshop*, pp. 43-50.

Koechling, J., Crane, A., & Raibert, M. (1997) “People are Not Tanks: Live Reckoning for Simulated Dismounted Infantry Using DI-Guy,” *Proceedings of the Fall 1997 Simulation Interoperability Workshop*, pp. 781-786.

Long, R., McAuliffe, M., & Liu, J. (1996) “DIS Capabilities Statement,” *Proceedings of the 14th DIS Workshop*, pp. 567-570.

Lucas, T., Kerchner, B., Bennett, B., & Friel, J. (1997). “ADS for Analysis: The Reality and the Hype,” *Phalanx*, Vol. 30, No. 3, pp. 10-12.

Moshell, J. M., & Cortes, A. (1995) “Human Figures and the DIS Protocol: An Analysis,” Proceddings of the 13th DIS Workshop, pp. 763-774.

Moskal, P., Johnson, T., Schiavone, G., & Cortes, A. (1994) “A Parametric Approach to Examining Interoperability (IOP) Issues: Initial Experiments,” Proceedings of the 11th DIS Workshop.

Moskal, P. J. & Johnson, T. R. (1995) “Human Performance in a Simulated Tank Gunnery Task Under Varied Terrain correlation Errors,” *Proceedings of the 13th DIS Workshop*, pp. 143-148.

Oser, R. L., & Dwyer, D. J. (1995) “Team Performance in Multi-Service Distributed Interactive Simulation Exercises: Initial Results,” *Proceedings of the 17th Interservice/Industry Training Systems and Education Conference*, pp. 163-171.

Pace, D. (1997) “Preliminary Guidelines for Distributed Simulation Analysis and Engineering (A&E) Applications,” *Proceedings from the 1997 Spring Simulation Interoperability Workshop*, pp. 17-22.

Pate, M., & Roussos, G. (1996) "JLINK - A Distributed Interactive Janus," *Phalanx*, Vol. 29, No. 1, 12-15.

Pratt, D. R., Pratt, S. M., Barham, P. T., Barker, R. E., Waldrop, M. S., Ehlert, J. F., & Chrislip, C. A. (1997a) "Humans in Large Scale, Networked Virtual Environments," *Presence*, Vol. 6, No 5, 547 - 564.

Pratt, D. R., Barham, P. T., Barker, R., & McMillan, S. (1996) "AUSA 95 DI Demonstration," *Proceedings of the 14th DIS Workshop*, pp. 1165-1170.

Pratt, D. R., Barham, P. T., Locke, J., Zyda, M., Eastman, B., Moore, T., Biggers, K., Douglass, R., Jacobsen, S., Hollick, M., Granieri, J., Ko, H., & Badler, N. (1994) "Insertion of an Articulated Human into a Networked Virtual Environment." *Proceedings of the 1995 AI, Simulation and Planning in High Autonomy Systems Conference*, pp. 84-90.

Pratt, S., Brown, S., Ohman, D., & Galloway, J. (1997b) "Soldier Station: A Tool for Dismounted Infantry Analysis," *Proceedings of the Spring 1997 Simulation Interoperability Workshop*, pp. 405-412.

Pratt, S., Pratt, D., Ohman, D., & Galloway, J. (1996) "Soldier Station: Integrating Constructive and Virtual Models." *Proceedings of the Sixth Conference on Computer Generated Forces and Behavioral Representations*, pp. 225-234.

Purdy, R., & Goldiez, B. (1995) "Interoperability Issues Associated with the Use of Dissimilar Simulators," *Proceedings of the 17th Interservice/Industry Training Systems and Education Conference*, pp. 460-474.

Purdy, R., & Schiavone, G. A. (1995) "A Proposal for a Database Correlation PDU." *Proceedings of the 13th DIS Workshop,* pp. 281-288.

Reece, D. (1996) "An Architecture for Computer Generated Individual Combatants," *Proceedings of the Sixth conference on Computer Generated Forces and Behavioral Representation*, pp. 337-344.

Reece, D. & Wirthlin, R. (1996a) "Detection Models for Computer Generated Individual Combatants," *Proceedings of the Sixth conference on Computer Generated Forces and Behavioral Representation*, pp. 409-416.

Reece, D. (1996b) "Control of a CGF Fireteam with Voice and Gesture Commands," *Proceedings of the Sixth conference on Computer Generated Forces and Behavioral Representation*, pp. 471-477.

Reece, D. & Tu, H. (1996c) "Representations of Buildings for Individual Combatant CGF," *Proceedings of the Sixth conference on Computer Generated Forces and Behavioral Representation*, pp. 545-554.

Reece, D. (1996d) "Modeling Individual Humans for Computer Generated Forces," *Proceedings of the 18th Interservice/Industry Training Systems and Education Conference*, pp. 411-419.

Richbourg, R. F., Ray, C. K., & Campbell, L. W. (1995) "Tactical Operations Planning as a Metric for Terrain Fidelity," *Proceedings of the 13th DIS Workshop*, pp. 93-101.

Rothenberg, J. (1996) "Verification, Validation and Certification of DIS Exercise Data," *Proceedings of the 14th DIS Workshop*, pp. 835-840.

Roussos, G. G. (1996) "Attaining Interoperability between ModSAF and JANUS," *Proceedings of the 15th DIS Workshop*, pp. 171-180.

Ruth, T. (1996) "Guidelines Lessons Learned for Conducting a Credible DIS Experiment," *Proceedings of the 15th DIS Workshop*, pp. 391-394.

Saunders, R. (1995) "It's About Time, It's About Space - Time and Space in DIS," *Proceedings of the 12th DIS Workshop*, pp. 63-66.

Schow, G., Freeman, R., Lashley, T., & Swauger, J. (1997) "Mathematical Foundations for a Fidelity Differential Calculus," *Proceedings of the Spring 1997 Simulation Interoperability Workshop*, pp. 161-166.

Sikora, J., & Coose, P. (1995) "What in the World is ADS?," *Phalanx - Special Issue on Advanced Distributed Simulation (ADS)/Distributed Interactive Simulation (DIS)*, 28(2), p. 1-7

Smith, R. D. (1995) "The Conflict Between Heterogeneous Simulations and Interoperability," *Proceedings of the 17th Interservice/Industry Training Systems and Education Conference*, pp. 489-496.

Smith, R. (1996) "I^N: The 'N' Dimensions of Interoperability," *Proceedings of the 18th Interservice/Industry Training Systems and Education Conference*, pp. 341-349.

Smith, S., & Marshak, W. (1995) "Human Factors Engineering in the DIS/ADS Environment," Proceedings of the 13th DIS Workshop, pp. 735-739.

Simulation, Training and Instrumentation Command. (1997) *Dismounted Warrior Network Front End Analysis Experiments Final Report*, Dismounted Warrior Network DO #0020, CDRL AB06, Orlando, FL.

Stanzione, T., & Evans, A. (1996) "Multiple Elevation Structures in the Improved Computer Generated Forces Terrain Database," *Proceedings of the Sixth conference on Computer Generated Forces and Behavioral Representation*, pp. 533-543.

Sureshchandran, S. (1995) "Qualitative and Quantitative Comparison of Images from Dissimilar Image Generators in Visual Simulation," *Proceedings of the 12th DIS Workshop*, pp. 59-66.

Tanenbaum, A. S. (1989) *Computer Networks*, 2nd ed., Prentice Hall, Englewood Cliffs, NJ.

Tourville, S. J., Spiker, V. A., Silverman, D. R., & Nullmeyer, R. T. (1996) "An Assessment Methodology for Team Coordination in Combat Mission Training," *Proceedings from the 18th Interservice/Industry Training Systems and Education Conference*, pp. 79-89.

U.S. Army TRADOC Analysis Center - White Sands Missile Range. (1996) *JANUS Version 6.0 Documentation.*

Zyda, M., Pratt, D., Pratt, S., Barham, P., & Falby, J. (1995) "Inserting the Human into the Networked Synthetic Environment," *Proceedings from the 13th DIS Workshop,* pp. 103-106.