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Research Report 1704

Small Team Portal Into the 21st Century--STP21

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U.S. Army Research Institute

December 1996

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14. ABSTRACT *(Maximum 200 words)*:

Behavioral scientists from the U.S. Army Research Institute for the Behavioral and Social Sciences assisted the Institute for Defense Analyses (IDA) Simulation Center in conduct of excursions into the virtual 21st Century battlefield. The 1996 Defense Science Board (DSB) Summer Study requested analytical insights about concepts and technologies being considered for small team operations on the DSB's conceptual 21st Century Battlefield. The DSB focused on the concept of using technology to enable small, rapidly deployable forces to accomplish missions previously only available to larger forces.

Exercises were conducted in a virtual simulation environment. U.S. Army and Marine Corps personnel used specially designed devices in a virtual simulation facility to test concepts about the capabilities of small (3- to 12-man) teams operating in a sensor-rich environment. In addition to computer reported data, behavioral and tactical observers documented man-in-the-loop soldier performance and interactions with specific equipment. Combat effectiveness was enhanced through sophisticated communication devices and computers. Personnel were able in the virtual environment to perform tasks similar to those that might occur in a future battlefield scenario. A benefit of the simulation was the ability to portray future missions with prototype equipment.

15. SUBJECT TERMS

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Research Report 1704

Small Team Portal Into the 21st Century - STP21

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FOREWORD

This report presents behavioral observations and human performance analyses obtained by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) in support of a concept exploration conducted by the Institute for Defense Analyses (IDA) Simulation Center. As a part of the 1996 Defense Science Board Summer Study "Tactics and Technology for 21st Century Military Superiority," IDA sponsored a set of excursions into the 21st Century virtual battlefield. ARI provided technical advisory service (TAS). This assistance, related to but not a part of the ARI work program, is an important part of the Army and Department of Defense's training and personnel performance research and development mission.

Personnel from three ARI research units (the Infantry Forces Research Unit at Fort Benning, the Simulator Systems Research Unit at Orlando, and the Advanced Training Methods Research Unit in Alexandria) worked together with IDA personnel on the virtual simulation-based excursion entitled "The Small Team Portal Into the 21st Century (STP21)." Data collected from the virtual environment's conceptual battlefield provided insight into future small team capabilities and demonstrated the value of virtual simulation environments for concept testing.

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SMALL TEAM PORTAL INTO THE 21ST CENTURY—SPT21

EXECUTIVE SUMMARY

Research Requirement:

As a part of the 1996 Defense Science Board (DSB) Summer Study "Tactics and Technology for 21st Century Military Superiority," the Institute for Defense Analyses Simulation Center, assisted by behavioral scientists from the U.S. Army Research Institute for the Behavioral and Social Sciences, conducted a set of excursions designed to provide analytical insights about concepts and technologies being considered for small team operations on the DSB's conceptual 21st Century battlefield.

The DSB focus was on the concept of using technology to enable small, rapidly deployable forces to accomplish missions previously only available to larger forces. An additional area of interest was the viability of a virtual simulation for concept exploration.

Procedure:

This report documents a series of exercises conducted in a virtual simulation environment using man-in-the-loop virtual excursions into the 21st Century battlefield. U.S. Army and Marine Corps personnel used specially designed devices in a virtual simulation facility to test concepts about the capabilities of small (3- to 12-man) teams operating in a sensor rich environment. In addition to computer recorded performance data, behavioral and tactical observers documented soldier performance and interactions with specific equipment.

Findings:

Combat effectiveness, although hampered by constraints from present day and prototype equipment, was enhanced through sophisticated communication devices and computers. Personnel were able in the virtual environment to perform tasks similar to those that might occur in a future battlefield scenario. A benefit of the simulation was the ability to portray future missions with prototype equipment to determine potential for success. An additional benefit came from the ability to provide man-in-the-loop human performance data in the initial stages of concept exploration.

Utilization of Findings:

The results of these excursions were briefed back to the DSB in August 1966. Intermediate briefings and demonstrations in the virtual simulation facility were provided as in-progress reviews and to sponsors throughout the course of the research. It is apparent that the potential for future experimentation and concept exploration using the techniques of virtual simulation offers many benefits.

SMALL TEAM PORTAL INTO THE 21ST CENTURY--SPT21

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Introduction

In response to a request from the Under Secretary of Defense for Acquisition and Technology, the Defense Science Board (DSB) initiated a 1996 Summer Study "Tactics and Technology for 21st Century Military Superiority." The overall DSB focus was on the concept of enabling relatively small rapidly deployable forces to accomplish missions heretofore only possible with much larger and massed forces. Small (3-12 man) teams, specially equipped and trained, would achieve enhanced combat capability from remote sensors and weapons. Questions revolved around mission expectations, operational and technical capabilities to enhance team effectiveness, flexibility, and survivability.

The DSB requested assistance from, among others, the Institute for Defense Analyses (IDA) Simulation Center in Alexandria, VA. IDA was to provide analytical insights about concepts and technologies being considered for small team operations on the DSB's conceptual 21st Century Battlefield (2010-2015 timeframe) by developing a virtual simulation system to support man-in-the-loop excursions. The system had a simulated intermediate leader portal, two small team portals, and control cells representing higher headquarters, support elements, and computer generated forces.

Excursion Concept

The study of rapidly deployable, specially equipped teams supported by remote sensors has several target audiences and proponents. The IDA simulation was named Small Team Portal into the 21st Century (Virtual) Battlefield, or STP21. Related programs include the U.S. Marine Corps Sea Dragon, the Training and Doctrine Command (TRADOC) Army After Next, the U.S. Army Infantry School Rapid Force Projection Initiative (RFPI), and the Defense Advanced Research Projects Agency (DARPA) Small Unit Operations (SUO).

IDA's goal was to assess small unit battlefield operations, and at the same time, to evaluate the STP21 virtual simulation as a tool for studying future operations. More specifically, the STP21 exercise was designed to investigate the ability of small independently operating units to remotely place precision fires on long range targets, using sophisticated sensor suites and digitized equipment. In addition, the intent was to assess the ability of small groups of soldiers, in a semi-autonomous mode, to perform functions formerly done by a larger force with more equipment. (See Coe, Madden, Mengel, & Wright, 1996, for greater detail.)

Data collection addressed three essential elements of analysis (EEA):

EEA 1 explored enhancement of small team situational awareness through sensors and two computer devices: palmtop personal data assistants (PDA), and the laptop Map of the Future (MOF).

EEA 2 explored enhancement of combat effectiveness by measuring remote fires and use of specialized devices.

EEA 3 examined the utility of individual and small team virtual simulation in concept exploration.

Army Research Institute Role

IDA requested that behavioral scientists from the Army Research Institute (ARI) participate in the simulation exercise as observers during the tactical scenarios. ARI was to look at several broad areas. Issues included the small team's ability to manage large amounts of data, training on surrogate equipment, man-machine interface, and identification of the skills needed to operate on the DSB's conceptual 21st Century Battlefield.

Five research psychologists from ARI (two from the Infantry Forces Research Unit at Fort Benning, GA, two from the Simulator Systems Research Unit at Orlando, FL, and one from the Advanced Training Methods Research Unit at Alexandria, VA) participated in the evaluation from June through August, 1996. ARI developed and administered questionnaires to measure participant attitudes toward and difficulties with use of the specialized equipment, conducted interviews, and observed the scenarios.

This report documents the observations made and research performed in support of the IDA DSB concept explorations. It comments on four specific areas related to the concept of small unit operations: equipment, personnel, training, and simulation.

ARI Perspective on the Value of Simulation

Virtual simulations can enhance the concept development process by providing an opportunity to assess mission performance with humans "in the loop," performing tasks as they are expected to once the system is fielded. Information about their performance can be collected and analyzed to evaluate the concept and identify ways to improve it. The information can vary from empirical data about response times and performance accuracy to more subjective reports by subject matter experts about problems likely to be encountered in a field situation. Virtual simulations permit this information to be obtained prior to the development of a complete physical prototype.

Information about how humans perform in these virtual simulations can be used in several ways. First, it can help to assess the overall feasibility of the concept itself. (For example, can human operators detect targets and submit fire requests rapidly enough to accomplish the mission successfully?) Second, it can help to refine the system functional requirements. (Elevated sensor magnification must be at least 6X or targets cannot be detected beyond 2 km.) Third, it can help design tasks and organizations, assign system functions to human operators or automated components, and organize human functions into duty positions. (Each element requires three personnel for effective operations.) Fourth, it can help identify the necessary abilities and prerequisite skills required to perform the jobs successfully. (All operators require a high degree of general computer literacy and understanding of friendly and enemy battalion-level tactics.) Finally, it can identify training needs and support the development and evaluation of operator training.

Approach and Procedures

Simulation Center Facility

The IDA Simulation Center, conceptualized as an integrating center, permits a variety of excursions and explorations. Commercial off-the-shelf equipment and prototype specialty equipment are integrated as needed for concept demonstrations and experimentation. The facility is permanent, but on-site equipment varies with the specific area of investigation, thus the concept of an integrating, rather than dedicated facility.

Participants

Two U.S. Marine Corps captains served as Fire Direction Center (FDC) controllers. During the first week of testing, two Army National Guard captains, supplemented by IDA civilian personnel, participated as test subjects for early operational trials. In the second week, six Marine second lieutenants participated in various team configurations. For example, in one configuration, two were on one team, three on another, and one served as the intermediate team leader.

General Concept

Two weeks of data collection were planned. According to the original plan, an overview and training on the equipment would be followed by computer-based simulation exercises during the remainder of the week. Each day's trials would end with after action reviews (AARs) to elicit lessons learned. The second week was to repeat the first with different test subjects. Each day was to be increasingly more complex, to test the limits of the simulation and to develop engagement timelines to measure situational awareness and combat effectiveness. The opposing force (OPFOR), terrain, and sensors were to be varied, as well as team size and mobility. ARI was to address the human factors and behavioral interface issues. Specific items of interest were operator workload, equipment problems that impacted on test subject ability to conduct the mission, and simulator sickness or fatigue.

Difficulties interconnecting the prototype equipment forced changes to data collection and the overall plan. The first week became a pilot week to resolve problems and make equipment changes. Standing operating procedures (SOPs) for equipment use and radio communications were developed. The second week provided data and performance measures related to the EEAs.

Facilities and Equipment

The Simulation Center consisted of an exercise control area (ECA), two small team portals, and an intermediate team leader portal/station, plus tactical (military) and behavioral observer stations. The small team and leader stations were networked to the ECA that supported the team portals. (See layout at Figures 1 and 2.) ECA equipment included the simulated FDC/Fire Support Station, the OPFOR Control Center, and the Remote Sensor Center/Intelligence Station. A briefing area was available.

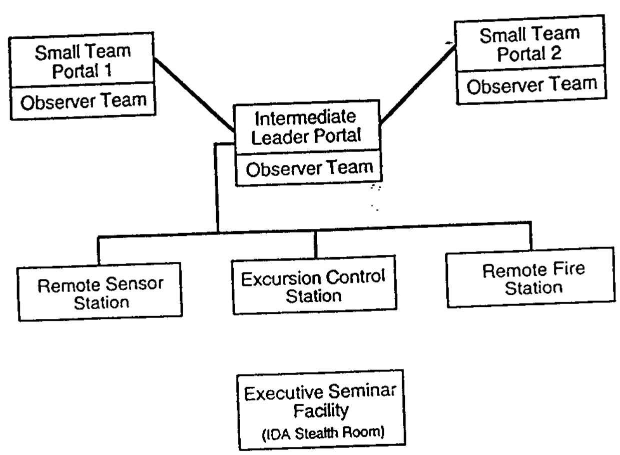

Figure 1. STP21 Simulation Center concept exploration facility.

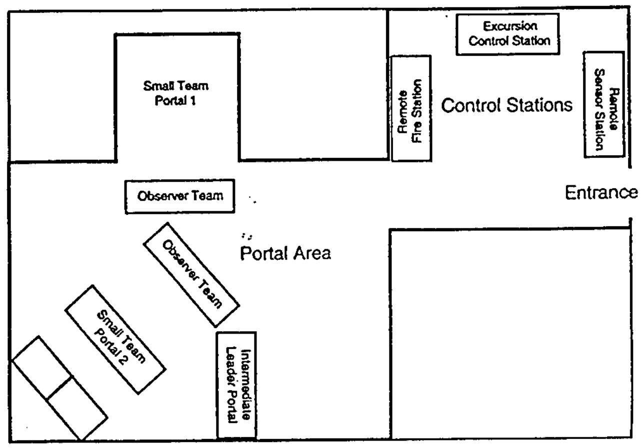

Figure 2. STP21 simulation facility layout.

The Fire Support Station received and responded to calls from the team portals. The remote fire station delivered artillery, missile, naval gunfire, and close air support in response to preplanned fire requests or requests for fire from a team or intermediate leader. After player calls for fire, weapons were selected and status reported. This station was operated by the Marine captains, assisted by an IDA civilian. IDA also staffed the Sensor Station and the Modular Semi-Automated Forces (ModSAF) OPFOR control center.

The intermediate leader station was a coordination cell located in an area adjacent to one of the teams. Teams had voice radio communication with the leader, and with each other, as well as with the FDC. Each player had earphones for aural replication of battlefield noises and engine sounds in addition to normal radio traffic; only one key player at each station had radio communication. The team portals and the intermediate leader station equipment could be observed by the operational observers and behavioral analysts. Observer monitors slaved to the team equipment replicated the soldiers' views; the virtual terrain was easily visible from all locations.

The team stations had both disparate and common elements of equipment. Portal 1 (Figure 3), was a two person station with a treadmill/treadport motion platform device. The motion of the treadport simulated the soldier walking over terrain. The terrain, a digitized data base, was depicted in the WISE (Walk-In Synthetic Environment). The WISE had three large screens which, via a rear projection device, depicted the terrain and thus appeared to surround the soldier. The soldier on the treadport could stand still, walk or run. (The device would not support a view of the battlefield from the crawl position.) A surrogate vehicle was also available at this portal.

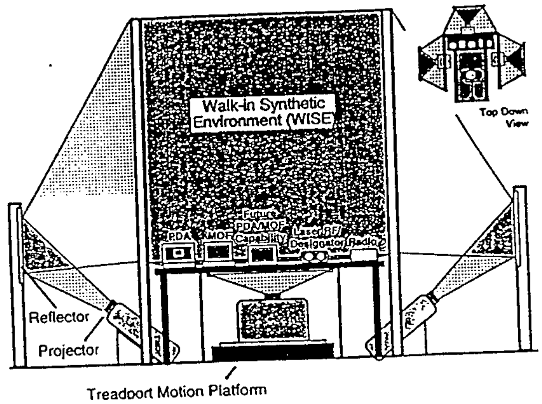

Figure 3. Portal 1.

Portal 2 (Figure 4) was a two-person, then eventually a three-person "mobile" station, where one person could drive, in addition to assisting in target location. The surrogate vehicle, the Dial-A-Tank, had a steering yoke shift lever, and foot pedals which the operator could use to control forward and reverse motion, acceleration and braking, and direction. The terrain data base was depicted on two large screens to the front of the vehicle. In actuality the team was seated at a table.

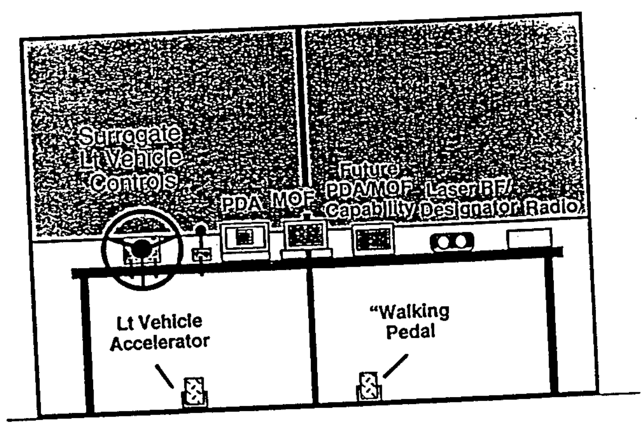

Figure 4. Portal 2.

The Melios (Mini Eyesafe Laser Infrared Observation Set) was the sensor device used at Portal 1. A variation on current equipment, Melios was a ten power binocular-like hand held device. It had an embedded laser range finder that permitted the operator to laze on a target, with target range and azimuth depicted on a small screen display monitor. Target information was relayed back to the FDC. The system featured a second laze capability designed to predict the location of the target over time.

The sensor used at Portal 2 was known as COVER. A simulated tethered aerial sensor, COVER could be elevated from tree top level up to 300 feet in the air above the team's position, and turned for a 360 degree view. The COVER, like the Melios, had a laser range finder that gave range and azimuth to any target detected. It was designed to provide both optical and thermal views, although only the day capability was demonstrated. COVER was operated by a joystick; the input and view from the sensor were depicted on a small screen monitor at the soldier's station.

Each portal had two data entry/receipt devices for text and graphic data communication and display. The Grunt was linked either to the Melios or the COVER device. Grunt was a small computer keypad with data entry by means of a stylus. It displayed the range and azimuth from the Melios or COVER, together with global positioning system (GPS) information, and enabled an operator to call for fire. Preformatted messages could be accessed and sent after the operator inserted grid location and other selected information. Free text messages could be sent, but Grunt had no receiving capability.

The other data entry device was the Map of the Future (MOF). The MOF, conceptually a pocket-sized fold up electronic map but represented in the simulation by a laptop computer, displayed an electronic digital map. The map was the same terrain database depicted in the WISE at Portal 1 and on the wide screen at Portal 2. Any section of a standard 1:50,000 map sheet could be viewed, and expanded or minimized through a zoom feature. The MOF screen presented a small top-down view of the entire database and a larger display of a map section of a particular slice of terrain. The smaller display contained a "pan" box that the user could move to determine which map section was displayed. Friendly and enemy positions, man-placed sensors, remotely monitored battlefield sensor systems (REMBASS), and minefields could also be positioned and represented on the map. Messages appeared on the MOF as E-mail, and calls for fire could be sent through E-mail back to the FDC. The MOF message function was used for sending and receiving sensor and target information, and for updates on target status.

Excursion Scenarios

In the general scenario, the U.S. supported a European nation. After the threat was turned back, U.S. personnel were inserted from a precision strike battalion to maintain regained ground. This follow-on force, the small teams, was positioned and equipped with devices for detecting and identifying targets, processing fire requests, and communicating these requests to a fire direction center at another location.

The overall intent was to specify targets and their priority for destruction, using the varying sensor capabilities available to the U.S. team. Measures of effectiveness included target detection, identification and request time, numbers of targets attacked, area of control, workload and task management.

The players were given overall rules of engagement with instruction on positive identification of targets to preclude civilian casualties. Players were to observe the battlefield, call for and adjust fires on valid targets, and designate targets as appropriate. They were to report battle damage, coordinating with each other and the intermediate leader. The intermediate leader's role was to exercise command and control over the targeting element, to plan the operation, and to service targets if appropriate. The focus was on the small team portals.

The primary terrain data base was the wooded mixed terrain of Hohenfels, Germany, shown in the Synthetic Theater of War, Europe (STOW-E) database. Some excursions employed the Hunter-Ligget desert database of 29 Palms, California, or the simulated urban terrain of the McKenna MOUT Site at Fort Benning, Georgia. All exercises were in daylight mode. Potential threat targets were tank and/or BMP platoons, trucks, and dismounted infantry.

Data Collection

Automated data collection provided by the computer system provided information on target presentation, exposure times, time to hit and kill, calls for fire, and battle damage assessment. Data were collected for both portals, and for all sensor suites and weapon systems. These data, transparent to the players, were collected by IDA's distributed interactive simulation network to supplement the observational data collected by tactical and behavioral observers.

The operational and behavioral observers maintained worksheets (Appendix A) to record elapsed times and significant events during the excursions. Verbatim comments from the players were also noted, as well as the observers' informal interpretations of what was happening. Observer data sheets were collected daily, and their content linked to the computer generated data. Video coverage was provided by a film crew that was making a demonstration tape to document the simulation exercises and some after action reviews for DSB personnel.

Questionnaires

Several questionnaires were developed to elicit information from the participants before and after the excursions. The STP21 Questionnaire (Appendix B) obtained background data on previous military experience and training, familiarity with items of equipment, and their ability to focus attention on various activities. (Focus items came from the Immersive Tendencies Questionnaire, Witmer and Singer, 1994.) This questionnaire was administered on the first day, prior to the first excursion.

The Health Questionnaire (Appendix C) obtained information on the participants' current state of health. It was administered on the first day of the excursions, after initial training but prior to the first excursion, and on each subsequent day prior to the start of the excursions.

A potential problem with application of simulation technology in the context of military concept development is that participants may experience side and aftereffects similar to, but not limited to, symptoms of motion sickness. Simulator sickness is a concern because it can potentially distract or in other ways degrade the performance of the participants. The Simulator Sickness Questionnaire (SSQ) (Appendix D) was administered prior to the first excursion and after the last excursion each day (before and after immersion) to take pre-existing symptoms into account. (See Lampton, Kraemer, Kolasinski & Knerr (1995) and Kennedy, Hettinger, & Lilienthal, (1988) for further information.)

The Human Factors Equipment and Functions Questionnaire (Appendix E) determined the frequency with which participants performed various tasks and functions and the degree of difficulty they had performing those tasks. It was administered at the end of each day. The Learning Questionnaire (Appendix F) was used to determine difficulty participants had learning to perform various tasks. It also was administered at the end of each day.

The Simulator Questionnaire (Appendix G) asked the extent to which the participants felt immersed in the simulation. The items were taken from a Presence Questionnaire developed by Witmer and Singer (1994). The Simulator Questionnaire was administered after the last excursion on the second and fourth days of week two.

After Action Reviews and Interviews

After Action Reviews (AARs). At the conclusion of each excursion, the Exercise Controller conducted an AAR. The purpose of the AAR was to solicit comments, lessons learned, and other observations. While each AAR was attended by the scenario role players, observers, and some technical support personnel in addition to the exercise participants themselves, the primary focus was on obtaining information from the participants. Each

AAR had two segments. The first focused on the tactical events, the second on aspects of the simulation.

Group interview. The ARI researchers led a group interview on the morning of the last day of the second week. The intent was to solicit information from the participants about manpower, personnel, and training issues. Questions asked were:

- What equipment or procedures worked best? What worked least well?
- What was the hardest task for you to perform? What was the easiest?
- What equipment or procedures, if any, did you need more training on?
- What equipment or procedures did you have the most confidence in? What equipment or procedures did you have the least confidence in?
- What distracted you the most?
- If you participated in the same exercises again, would you do anything differently? If so, what?
- What prior experience or training (if any) helped you in these exercises?
- How many people should be in an observer group? Why?
- What was the most difficult duty position? What was the easiest? Why?
- Do you have any ideas about how to share the workload?
- What do you think a man can do here that a computer can't?
- What did you have to do that you think should be done by computer instead of a human?

Results

Participants

Serving in the portals were six male Marine Corps second lieutenants. All were in the active component, and were in student status. All had BA or BS degrees. In terms of experience, there were two distinct groups of three each. The members of the first group had recently completed Officer Candidate School (OCS) and had a mean of seven months of military service. The members of the second group, who were awaiting the start of OCS, all had prior enlisted service (mean = 7 years, 10 months). Four of the six had had some forward observer training. None were experienced in navigating in simulated terrain databases. None had been to Desert Shield/Desert Storm or to a Combat Training Center.

Their experience with the technology used or simulated in these excursions is shown in Table 1. The generally high level of experience with laptop computers, and to a lesser extent, sending and receiving E-mail, is worthy of note.

Table 1

Participant Experience with Relevant Technology

	Experience			
Technology	None	Limited	Moderate	Considerable
Global Positioning System (GPS)	2	3	1	0
Laser range finders	5	1	0	0
Target designators	5	1	0	0
Helmet mounted displays	5	1	0	0
SIMNET-type environments	6	0	0	0
JANUS	6	0	0	0
Sending/receiving E-mail	2	1	2	1
Laptop computers	0	2	2	2
Thermal sights	3	3	0	0

Note. The numbers in the cells are the number of participants reporting that level of experience.

Participant Immersive Tendencies

Because of the distractions inherent in the simulation facility, participants were asked about their ability to become involved in activities and to ignore distractions. They were also asked about experience with computer and video games. (Responses are shown in Appendix H.) The group showed considerable variability in responses to the questions that asked about involvement in video games, sports, and other activities.

However, most reported that they were good at blocking out distractions, concentrated well on enjoyable activities, switched attention among activities well, and were not easily disturbed when working on a task. While only one reported more than occasional playing of arcade or video games, three reported more than occasional playing of computer games.

Equipment Use

The Human Factors Equipment and Functions Questionnaire provided information about task frequency and difficulty. The Learning Difficulty Questionnaire showed how hard it was to learn to perform certain tasks. While most tasks were equipment specific, a few were general. Some tasks could also be performed with multiple items of equipment. Participants completed the questionnaires, responding only for pieces of equipment that they had used in the immediately preceding excursion. Equipment usage varied considerably, and therefore the number of responses on which these ratings are based does as well. For example, the Treadport was used a total of four times by three different participants, while the Map of the Future was used a total of 24 times by six different participants. Questionnaire means were calculated by first obtaining the mean response for each participant across all six administrations of the questionnaires, and then obtaining the mean across all participants. This had the effect of weighting each participant's response equally, regardless of the number of times each used a particular item of equipment.

COVER

For COVER (see Table 2), distinguishing friendly and neutral targets was rated the most difficult task. As will be presented later, it was also the most difficult for the Melios, the other piece of equipment that required direct visual observation to make this determination. However, this reflects not the equipment, but the simulation, which presented no neutral entities and therefore did not test the capability.

Table 2.

Ratings of COVER Tasks (Means)

Task	Difficulty	Frequency	Learning Difficulty
Distinguish friendly and neutral	3.70	2.90	NA
Making joystick work right	3.33	5.00	NA
Designate targets	3.00	3.53	2.13
Identify targets (name them)	2.97	3.70	2.63
Using the joystick controller	2.93	4.83	3.20
Lazing	2.63	4.37	2.13
Detect targets	2.50	4.10	2.77
Maintaining orientation	2.50	4.70	2.10
Prioritize targets	2.33	2.67	NA
Perform BDA*	2.20	2.67	2.30

N = 9   *Battle damage assessment

Frequency Key: 1-Never; 2-Occasionally; 3-Moderately Often; 4-Frequently; 5-Almost Constantly

Difficulty and Learning Difficulty Key: 1-Very Easy; 2-Easy; 3-Neither Easy nor Difficult; 4-Difficult; 5-Very Difficult

Making the joystick work right, designating targets and using and learning to use the joystick controller were also difficult. Designating a target required placing a cross-hair on the center of the COVER display over a (sometimes moving) target using the joystick controller. The joystick had some undesirable handling characteristics: a wide area of insensitivity around the neutral position, with high sensitivity beyond that band made it easy to overshoot the intended destination.

In the group interview, observing a single target with the COVER was identified as one of the easiest individual tasks while tracking multiple targets was one of the hardest. The viewing conditions of the COVER and the joystick appeared to be the cause. Viewing with the COVER could be done at either normal resolution or 6X magnification. Our crude measurements indicated that the horizontal field of view (FOV) of COVER was 47 degrees at normal magnification, and 4 degrees at 6X. The resolution of the monitor made it difficult to detect distant targets, so participants did most of their searching and tracking at 6X. This was somewhat similar to viewing the world through a soda straw, and made it difficult to switch back and forth between two or more targets, even if azimuth and range were known. They did not slew to the approximate target location under normal magnification, then increase the magnification; they later expressed a desire for a zoom capability on the COVER.

Melios

For Melios (see Table 3), as with the COVER, and as discussed above, the most difficult task was distinguishing friendly and neutrals. Seven tasks were performed with both the COVER and the Melios. Five were rated as more difficult on the Melios, and two rated more difficult with the COVER.

Table 3.

Ratings of Melios Tasks (Means)

Task	Difficulty	Frequency	Learning Difficulty
Distinguish friendly and neutral	4.50	2.75	NA
Designate targets	3.67	3.00	2.67
Lazing	3.25	4.00	NA
Perform BDA	3.00	2.75	2.00
Detect targets	2.75	4.00	2.08
Identify targets (name them)	2.50	3.75	2.50
Prioritize targets	2.00	3.00	NA

N = 5

Frequency Key: 1-Never; 2-Occasionally; 3-Moderately Often; 4-Frequently; 5-Almost Constantly

Difficulty and Learning Difficulty Key: 1-Very Easy; 2-Easy; 3-Neither Easy nor Difficult; 4-Difficult; 5-Very Difficult

This may represent chance variation, but it may also reflect the following. COVER was employed while the participant was seated in a chair at a desk but the Melios was employed while the participant was walking, standing or sitting on the Treadport, and was frequently devoting some portion of his attention to maintaining or changing his position. This may have made the Melios tasks appear more difficult. Second, the Melios is a fairly heavy hand-held device (about 6 pounds) and holding it at eye level for an extended period caused fatigue and instability; at Portal 2 the participant's elbows could be braced on the table for support.

These issues were raised in the group interview, with disagreement among the participants on whether the COVER or the Melios was better. COVER provided a more stable viewing platform and was easier to use with eyeglasses. The use of Melios was more intuitive than COVER. The physical movements made with Melios made it easier to return to a previous position. In this sense, Melios contributed to better situational awareness. The weight of Melios was criticized. The green color used to display range and azimuth on the display tended to blend with some backgrounds, making it difficult to read.

Map of the Future

Despite its complexity, the MOF (see Table 4) was not perceived as difficult to use or to learn to use. Only the Call for Fire task received a high difficulty rating. Several factors may account for this.

Table 4.

Ratings of Map of the Future Tasks (Means)

Task	Difficulty	Frequency	Learning Difficulty
Call for fire	3.21	2.73	2.71
Understanding map graphics	2.68	4.36	NA
Make a report, using device	2.65	2.74	NA
Keeping track of things on map	2.63	4.53	2.45
Reading the map	2.49	4.47	NA
Receive a map, using device	2.40	2.56	NA
Seeing the map	2.13	4.64	NA
Using the map	2.09	4.46	NA
Maintaining map orientation	1.77	4.50	1.80
Learn the menus	NA	NA	2.34
Respond to a message	NA	NA	2.16

N = 24

Frequency Key: 1-Never; 2-Occasionally; 3-Moderately Often; 4-Frequently; 5-Almost Constantly

Difficulty and Learning Difficulty Key: 1-Very Easy; 2-Easy; 3-Neither Easy nor Difficult; 4-Difficult; 5-Very Difficult

First, the MOF was a conventional laptop that used a graphical user interface with icons and pull-down menus similar to Windows or Macintosh operating systems. Given the familiarity of the participants with laptop computers, they may have found it easy to learn the basic concepts. Second, since the MOF was used in at least two and usually three duty stations during each excursion, the participants had sufficient practice with it to become proficient in its use. Finally, the MOF was easily modifiable and the software was modified on several occasions during the excursions, based on comments from the participants.

Treadport

With respect to the treadport (see Table 5), the task of doing something else while walking was the only task that was considered difficult. However, it was not performed frequently, so participants had little practice.

Table 5.

Ratings of Treadport Tasks (Means)

Task	Difficulty	Frequency	Learning Difficulty
Doing something else while walking	4.00	1.33	NA
Maintaining orientation	2.33	3.33	NA
Navigate in virtual environment	2.33	2.50	1.63
Maintaining balance	2.33	2.33	2.25
Walking on the Treadport	2.00	2.67	NA
Change orientation	NA	NA	2.88

N = 4

Frequency Key: 1-Never; 2-Occasionally; 3-Moderately Often; 4-Frequently; 5-Almost Constantly

Difficulty and Learning Difficulty Key: 1-Very Easy; 2-Easy; 3-Neither Easy nor Difficult; 4-Difficult; 5-Very Difficult

Grunt

Adjusting fires with the Grunt Personal Data Assistant (see Table 6) was difficult to do and the most difficult Grunt task to learn to do. However, this task was not performed frequently. Overall, the Grunt was considered easy to use. Some problems using the Grunt did surface in the group interviews. The primary problem was a lack of any indication that a message had been

Table 6.

Ratings of Grunt Tasks (Means)

Task	Difficulty	Frequency	Learning Difficulty
Adjust fires with PDA	3.25	1.37	2.93
Composing text messages	2.63	2.06	2.72
Making PDA do what you wanted	2.30	3.87	2.28
Understanding PDA menu	2.11	4.06	1.89
Remembering PDA functions	2.08	3.67	2.17
Understanding PDA symbols	2.06	3.53	NA
Seeing PDA display	2.03	4.17	NA
Realizing a message is waiting	1.72	3.14	2.17

N = 14

Frequency Key: 1-Never; 2-Occasionally; 3-Moderately Often; 4-Frequently; 5-Almost Constantly

Difficulty and Learning Difficulty Key: 1-Very Easy; 2-Easy; 3-Neither Easy nor Difficult; 4-Difficult; 5-Very Difficult

sent, received by another participant, or that a request for fire had been acted upon. The last was not a Grunt problem per se, but reflected the initial lack of a detailed SOP (the FDC should indicate when a request for fire has been filled), and the workload placed on the role players in the simulation.

Dial-A-Tank Surrogate Vehicle

The Dial-A-Tank (see Table 7) was considered easy to use and to learn to use.

System Issues

System issues are related to the general characteristics of the system, simulation, or setting, or to multiple items of equipment. They include non-equipment specific tasks, system integration, suggested system improvements, and team organization and workload. Data on systems issues come from the group interview, observer notes, and to a lesser extent, the few questionnaire items that were not related to items of equipment.

Table 7.

Ratings of Dial-A-Tank Tasks (Means)

Tasks	Difficulty	Frequency	Learning Difficulty
Steering vehicle	2.13	2.38	NA
Maintaining orientation	1.75	3.00	1.93
Navigate in virtual environment	1.63	2.00	2.07
Accelerating vehicle	1.50	2.00	NA
Braking vehicle	1.50	2.00	NA
Stopping Vehicle	1.50	2.00	NA
Drive the Vehicle	NA	NA	2.07

N = 7

<u>Frequency Key</u>: 1-Never; 2-Occasionally; 3-Moderately Often; 4-Frequently; 5-Almost Constantly

<u>Difficulty and Learning Difficulty Key</u>: 1-Very Easy; 2-Easy; 3-Neither Easy nor Difficult; 4-Difficult; 5-Very Difficult

Non-equipment-Specific Tasks

The most difficult of the non-equipment-specific tasks (see Table 8) was keeping track of multiple targets, a result that was also confirmed in the group interview. Closely related was the task of remembering to make corrections. Despite the low difficulty of communications, participants reported in the group interview that the simulation of radio traffic was distracting. The voice-actuated microphones, intended to carry traffic among the elements (station and team leader, station and fire direction center, etc.) also tended to pick up communications intended for other, physically co-located members at the station. Some participants found this distracting. Despite the need of the operator of the simulated radio to listen to both radio and local communications, the earpieces on the headphones completely covered both ears. Thus participants tended to wear them at an angle, leaving one ear uncovered. This eventually became uncomfortable. Either a single-ear headphone or smaller earpieces that do not cover the ear would have alleviated the problem.

Table 8.

Ratings of Non-Equipment-Specific Tasks (Means)

Task	N	Frequency	Difficulty
Keeping track of multiple targets	33	3.84	3.21
Doing multiple tasks simultaneously	26	3.61	2.88
Remembering to make corrections	29	2.29	2.77
Switching among displays	23	3.08	2.49
Maintaining situational awareness	30	4.06	2.47
Communicate (Team & Higher Headquarters)	24	3.48	2.19
Coordinate with team member	24	4.45	2.17

Frequency Key: 1-Never; 2-Occasionally; 3-Moderately Often; 4-Frequently; 5-Almost Constantly

Difficulty Key: 1-Very Easy; 2-Easy; 3-Neither Easy nor Difficult; 4-Difficult; 5-Very Difficult

System Integration

Since the simulation was created largely by building on existing equipment, it is not surprising that some instances of incompatibility and incomplete integration of components were observed. There was no way to hand off a target from the MOF to the Grunt. Early in the week, the MOF showed direction to targets in degrees, while the COVER and Melios reported viewing direction in mils. Changing the MOF readout to mils was simple and could be done using the MOF user menus. However, until someone who knew how to make the change was made aware of the need for it, the participants used plastic protractors, marked in both mils and degrees, as a job aid to make the conversion.

Another problem that participants noted was the difficulty of correlating the various terrain representations. The paper map, MOF, ModSAF, and the visual displays (out the window, COVER, and Melios) each used similar but slightly different representations.

Team Organization and Workload

One of the critical issues related to team organization is the role of the team leader. While he had overall responsibility for the functioning of the targeting elements, he was often out of the information loop. He did not prioritize targets or fire requests and did not know when subordinates requested fires using the Grunt. Despite this, the participants felt that the leader had too much to do to also be a part of a subordinate element. (These excursions did not address other team members responsible for security, logistics, etc.) The most efficient structure of the targeting element of a team was found to be three persons -- Leader/MOF Operator, a Vehicle Driver/COVER Operator and Grunt Operator.

Workload during the excursions varied from long periods during which no targets were visible to periods during which multiple weapons strikes were in flight against enemy targets. Participants reported difficulty managing the latter situation. It was difficult to remember which mission was being fired against what target, and where the target had been and was likely to be when the munitions arrived and designation (for a smart weapon) or battle damage assessment was likely to be required. Even with the viewing elevation provided by the COVER, a target was unlikely to remain in continuous view for the duration of a fire mission. It tended to disappear behind a woodline or terrain elevation. If multiple targets were thought to be in the area, the COVER would search for additional targets after a fire mission had been requested, and then, at the designated time, try to relocate the first target.

As the number of targets increased, so did the complexity of this operation. One group used paper and pencil to record target number, type, and last known location. The only automated support in this operation was an algorithm that predicted target location based on a straight line, constant speed, extrapolation from two consecutive lasings. Unfortunately, land combat vehicles rarely travel in a straight line at a constant speed for the duration of a 10 to 20 minute engagement cycle.

Suggested System Improvements

The system improvements that the participants suggested focused primarily on ways to help them deal with periods of high workload. The first was the development and use of "fire and forget" weapons or ones with automatic tracking sensors. A less sophisticated, partial solution would be to provide a capability on COVER to memorize and return to a previous location, much like a "last channel" button on a TV remote. Another solution would be to provide a way to indicate, on the fire request, that you do not expect to be able to maintain line of sight to a target. This would alert the FDC not to fire a weapon that required designation. A final proposed system improvement was the addition of thermal and infrared capability to the COVER.

Situational Awareness

It appears that the use of the various technological items both increased and decreased participant situational awareness. By providing an integrated picture of the friendly and the enemy situation (as could be determined from various intelligence assets), they provided good "global" situational awareness, i.e., the big picture. However, by focusing their attention on a few display screens during periods of high workload and stress they decreased "local" situational awareness. Several instances were observed in which enemy were in clear view on the "out the window" displays, but were not detected. In these high workload situations, participants tended to focus attention on their device displays, and paid little attention to the simulated "out the window" view. This is a common phenomenon called "attentional narrowing" (Endsley, 1995).

There were numerous reasons for this that might not apply in combat. First, given the tactical situation, the out-the-window view was a low priority information source. The soldiers needed to attack the targets beyond unaided visual range. Second, close-in targets were rare, so there was little reinforcement for using the out-the window view. Third, the COVER could be used to provide the same information with less disruption of ongoing activities. Fourth, the low resolution of the simulation made it difficult to detect targets with unaided vision. Finally, by the time a target was detected with unaided vision, it was too late to call in fire. No munitions could arrive in time and the team had no organic firepower.

Fatigue and Side Effects

The results of the post-immersion questionnaire are shown in Appendix I. There was a slight tendency for the participants to report more immersion as they became more familiar with the system. Scores for the second administration (day 4) were generally higher than those for the first (day 2). There was also a wide range of responses to most of the items, reflecting substantial individual differences in how the participants responded to the simulation. The general tone of the responses was that they were able to become involved in the virtual environment experience, adjusted quickly to it, became at least reasonably proficient in moving and interacting with it, and most, at least occasionally, felt completely focused on the task or environment.

The pre- and post-simulation self-ratings on simulator sickness are presented in Table 9. (Symptoms for which there were only ratings of "none" are omitted from the table, as is the unused "severe" rating.) This table provides a comparison of the baseline (pre) and the post-ratings. Initially only the symptom blurred vision was rated as high as "moderate;" in all other instances symptoms were rated "none" or "slight." In the post-simulation ratings, of the 16 symptoms, 8 were rated at least once as slight or moderate. Slight fatigue was the most frequently reported symptom, followed by eyestrain, fullness of the head, and blurred vision. The one instance of moderately blurred vision was reported by the same individual who had reported that problem on the pre-simulation questionnaire for that day.

Participants reported in the group interview that they felt they would be unable to perform this type of activity for 8-10 hours. Participation in the simulation produced some symptoms of discomfort among the participants. Fatigue, eyestrain, and a feeling of pressure in their head were common symptoms. No one considered symptoms to be severe.

Table 9

Pre- and Post-Simulation Self-Ratings of Severity of Simulator Sickness Symptoms (Percent)

Symptom	% None		% Slight		% Moderate	
	Pre	Post	Pre	Post	Pre	Post
Fatigue	79	37	21	62		
Eye strain	96	54	4	37	0	8
Fullness of the head	92	67	8	33		
Blurred vision	92	88	4	8	4	4
General discomfort	96	87	4	12		
Headache	96	100	4	0		
Dizzy (eyes open)	100	96	0	4		
Difficulty concentrating	92	96	8	4		
Difficulty focusing	92	96	8	4		

Personnel, Skill, and Training Requirements

Participants were asked what prior experience or training helped in these exercises. One factor noted was computer experience. As discussed earlier, all participants reported at least some experience with laptop computers, and four of the six reported experience sending and receiving E-mail. Although they were not asked about experience with computers in general, it was obvious that they were quite familiar with the basics of interacting with computers: cursor control, icons, pull-down menus, and display windows. A related factor was experience with computer games. Participants saw this as highly relevant. Five reported some computer game playing, and three indicated more than occasional game playing. For actual deployment of an STP21 team, more computer expertise would be required. Soldiers would not only have to know how to use the systems, but also to diagnose and correct hardware and software problems that might arise.

Participants also reported that prior leadership experience and tactical experience were beneficial. Forward observer training was considered largely irrelevant because current FO procedures are not applicable to the future digital environment's long range engagement cycles for remotely delivered weapons, although it did provide familiarity with basic concepts.

Participants reported that they began to feel comfortable with the equipment and their roles by the end of the second or the beginning of the third day. However, it was clear from their comments and questions during AARs and from observer notes that they were still learning after this time. Some training was actually conducted on the morning of the fourth day. They expressed a need for additional and more structured training, with specially designed training scenarios and a "coach" to provide advice. They noted that most computer games provide training scenarios.

Discussion

Overview

Within certain limits the concept, and the simulation of that concept, worked quite well as the flexibility inherent in the simulation permitted modification both to scenarios and equipment. The EEAs were addressed, if informally.

The first objective or EEA dealt with small team situational awareness, whether devices assisted in utilization of sensor information, and the added value for each kind of sensor. The second, related, EEA explored enhanced combat effectiveness, through bringing accurate and timely fires in support of neighboring teams and a higher headquarters.

The overall concern was whether the teams could utilize information received from sensors and the various PDAs. Although effectiveness varied, the teams were able to perform the required tasks. Both information receipt and use were demonstrated.

Measures of performance included the ability to service targets, and the timeline from presentation through calls for fire and adjustment if needed. Timelines were difficult to obtain, due primarily to difficulties with the prototype equipment. Also of interest was team survivability -- whether they could engage before they were themselves engaged. Teams were occasionally overrun, perhaps due to the tendency to become focused on the device they were using rather than the situation.

Another concern was the amount of terrain over which any one team could be expected to maintain observation -- the maximum limits of awareness. Generally, a 360 degree area of responsibility proved too great. A balanced team has roles and responsibilities allocated to maximize combat effectiveness. While individual situational awareness should be enhanced, combat power is enhanced through team work.

The third EEA focused on the simulation as a concept exploration tool. This included the transparency of the simulation to the players -- their ability to accept it and the prototype equipment, and finally, the capability of the simulation to provide meaningful data. The simulation provided useful information. Some training issues (prototype equipment, practice effects) and simulator issues (sickness, artificiality) were potential distracters. Difficulty with equipment was undeniable (the COVER joystick), and practice effects were apparent (MOF); they could be overcome with better equipment and more training time. For the duration of these exercises, simulator sickness was not an issue; the artificiality of the environment was of little impact, and may have lessened any ill effects.

The simulation fidelity was adequate for representing the critical role that the small team can play in dealing with incomplete, imprecise, or erroneous information from electronic and other remote sensors. However, limitations in visual fidelity made it difficult to distinguish military from civilian entities. Therefore, the simulation could not demonstrate a benefit of having observers on the ground: avoiding collateral damage to civilians and civilian structures.

Lessons Learned: Equipment

It is fully acknowledged that the specific equipment used in the simulation is different from that which would be found on the battlefield of the year 2010. However, certain lessons learned merit discussion.

Treadport. The scenarios, as run, provided no opportunities to take advantage of the unique capabilities of the treadport. No observation points were accessible only on foot, and observation from a prone position was not possible. When movement was required to obtain or maintain line of sight to a target, it had to be accomplished more rapidly than could be done by foot. Questions remain about the value added of this concept in this domain.

Dial-A-Tank. This surrogate was rarely used for mobility. When it was used, it was apparent that the soldiers were having difficulty in maintaining orientation. Additionally, there was a tendency to drive using the MOF display rather than the terrain display.

Map of the Future. The original concept was for the MOF to be used only as a map; in practice it was used to call for and receive fire missions, and for E-mail. The MOF was clearly not designed for these missions. The map scale was not suitable for the size of the area available; preformatted messages were not well thought out. Provisions were not made for feedback on requests for fire and targeting effects, but need for feedback was clearly demonstrated.

Melios. The current configuration of Melios may have precluded seeing the advantages of this device. Besides the previously noted weight problems, and the difficulty of using Melios while on a treadmill, Melios would be most useful in flat and desert-like terrain, rarely available in this scenario.

COVER. While the concept appears viable, the specific implementation (joystick control) does not. The joystick was often unresponsive, erratic, and could not be held steady. It impacted on the operators' abilities to use the device effectively. A fielded, future version would respond better, and could have locations (grids, direction, azimuth) displayed directly on the MOF.

Grunt. The consensus was that this device was in many respects redundant to, and less useful than, the MOF. Having two systems, with different conventions and key strokes, is inefficient. A single device would reduce training time and COVER and Melios could be linked directly to the MOF rather than to the Grunt.

Lessons Learned: Personnel, Organization, Workload

Three person groups seemed most useful, with the team leader assisting by filtering information (nice to know vs. need to know). The groups that appeared to do well assisted each other and developed SOPs. Within-group communication and cooperation are critical -- groups need to work together to service targets, and frequently can share in the identification process. They also need a predetermined between-group plan for target hand-off, if a target passes from one sector to another.

The tendency of the participants to lose local situational awareness, particularly in high stress situations, points out the need for a separate element of the team to maintain local security. The fatiguing nature of the tasks suggests a need for multiple shifts of operators.

Workload and performance issues are largely personality driven. There were apparent differences between the groups where there was almost no chatter, and those where it was common. When there was little to do, each of the soldiers acted bored or complacent and occasionally lost focus. Although some did better with pressure, others were sometimes apparently overloaded. The small remotely placed team may require a special kind of personal discipline to ensure that attention and awareness are maintained throughout a period of inactivity. Some personnel selection and qualification issues will have to be addressed.

Lessons Learned: Observer and Participant Training

Training is critical for equipment, tactics, techniques and procedures. It must include not only learning to use new equipment, but a chance to practice or experiment with it. Observers must also be trained, both on the hardware and on observation techniques. Observers need to hear team cross talk and radio traffic, and share the soldier's field of view. Only in this way can an observer evaluate operator performance. For example, the Grunt observer monitor was not useful because the process of creating messages prior to their display on the screen was not visible. The same observers also need to be available every day to note posture changes, signs of fatigue, eyestrain, etc., and to get a feel for the simulation and for player personalities.

Although radio traffic should be downplayed, personnel need instruction on communication procedures, call signs, etc. For example, a training deficiency became apparent with the radio's voice activated mike. Only the experienced soldiers knew to start messages with double words ("shooter, shooter"), the first word to activate the mike, the second to start the message.

Just as there are conventions for use of radios, soldiers need SOPs (acronyms, abbreviations, formats) to be used in the simulation. Perhaps the most important skill requirement for team members will be a relatively high degree of computer literacy. All of the devices were slower to perform than typical office equipment. Operator unfamiliarity with system speed caused extra work, either through resending messages, or restriking keys. For example, maps required a finite time to recreate when they were moved -- impatient keystrokes did not speed up the system. Variability in operator performance and efficiency might also be attributed to, for example, differing typing ability levels. Additional training would alleviate some of these problems and improve system performance.

Scanning and searching for soft-skinned or personnel targets at short ranges in a limited sector, and preparing for direct fire weapon engagements, do not prepare the soldier for the wide and long range area search required in this simulation. They lacked scanning and searching techniques, and did not know about being systematic, using patterns, or varying power to get better or different perspectives. Training such as is available for Scouts or long range surveillance units (LRSU) may be required.

Small team members need cross training on all of the devices. This is mandatory as a casualty backup plan, but also helps with work and rest plans, boredom, and stress reduction. A single device (like the MOF) which can accomplish multiple functions and can be distributed to each of the players, may be a way of sharing workload while maintaining efficiency. SOPs are critical; job aids may help in keeping track of information.

Lessons Learned: Simulations

Some of the most valuable lessons from simulation this far in advance of development do not have to do with the man-machine interface of specific items of equipment (keyboard layouts or menus), but with interfaces among the various systems and the load they put on the humans in the loop (manually transcribing information from one electronic system to another). Fifteen years ago, only a few computer scientists would have been familiar with the windows-based interface used in these systems. Today, it is widely understood. Whatever the advances in computer interface technology over the next fifteen years, it seems certain that they will render obsolete any interface changes made today. However, basic human capabilities and limitations will remain unchanged, and systems designs will have to allocate functions between humans and computers in a way that best takes advantage of those capabilities and limitations.

The exercises demonstrated that simulations can contribute to the development of new concepts in the following ways:

Improving equipment design. Using simulation for development helps improve the design of equipment and systems. The simulation identified operator interface capabilities and problems with each piece of equipment, and the impact on operator workload. As in the STP21 demonstration, this can occur even if it is not possible to obtain detailed quantitative data on operator performance. The simulation afforded the opportunity to make changes to items of hardware and software during the exercises.

Demonstrating concepts. Simulation can be used to demonstrate concepts, as long as participants know the intent and limitations of the simulation. Participant training is required to ensure that the simulation will be able to show the value of each piece of equipment.

Placing humans in the loop. It also showed the value of putting the human back in the loop. Modeling can quickly be invalidated by individual differences in performance. Operators take shortcuts and make mistakes.

Increasing innovation. Soldiers in the field environment are often hampered by what they already know ("we always do it this way") because there is a frame of reference for everything. In a simulation, reality is suspended, and participants may be more open to new ideas, often on some very basic things.

Simulator sickness was not a serious problem. The SSQ scores were lower than levels observed after initial training with a tank driver simulator (Lampton et al., 1995) and in experiments in virtual environments using helmet mounted displays (Lampton et al., 1994). The symptoms observed here may have resulted from several factors. Any simulator that portrays self-motion may produce simulator sickness. In both the WISE and the vehicle screens, motion was depicted periodically and was observable by all the team members at each particular station, not just the person walking or running on the WISE, or driving the vehicle. Also, because of the low level of illumination of the displays and ambient light, displays were frequently difficult to view. This may have contributed to eye strain or fatigue.

Recommendations for Future Excursions

Part of the value of this simulation is in learning how to do it better another time. If these excursions were repeated, with different equipment characteristics, the results might be very different.

From a system design standpoint, the equipment that supports STP21 must be an integrated system. The human should not be in the role of the conduit passing information from one component to another. Effective information management requires feedback. Units need reporting SOPs. Update reports at random intervals overload even experienced personnel.

Despite attempts to use digital communication throughout, voice communication was faster, more efficient, and probably caused fewer errors. The soldiers relied on the familiar system, the one from which they received immediate and reliable feedback. Feedback needs to be designed into the digital communications as well.

Conventions are needed for tracking messages. To assist in information management, E-mail must indicate senders, priorities, and the time. Changes needed are better ways to accept, send, save and delete messages, as well as a better way to display them. Some preformatted messages are mandatory.

There must be a way to designate or identify a potential target and follow it, assessing speed, direction, etc., without having to go through a laborious device-based process. Each time attention is diverted from the field of view, potential information is lost.

Equipment changes need to be directed toward saving time and making processes more efficient, to reduce errors, leave fewer things to memory, improve the operator's ability to use the devices, and maintain situational awareness. One device should be able to combine the functions of the Grunt, the MOF, and any kind of PDA, with only one set of protocols to learn. This would also ease training.

Conclusions

Overall, this research project reinforced the view that virtual simulations can greatly enhance the concept development process by providing the capability to assess mission performance before a system is fielded. Modeling cannot incorporate the dynamics of a small team the way a simulation does.

The STP21 simulation was hampered by present day equipment, and perhaps by preconceived ideas. Borrowed equipment did not link well in the simulation environment, but simulations are ideal for first steps. Prototype equipment, despite issues related to hardiness, interconnectivity, and linking, is characterized by the inherent ability to change it.

Other limitations of these excursions as STP21 predictors should be noted. First, equipment components were not designed to function as an integrated system, and their future design might be very different. Procedures for employment were not fully developed and tested, and personnel were not thoroughly trained. They had not adequately learned and practiced the basic procedures, e.g., scanning and target identification. As a result, the data collected probably underrepresented performance that might actually be achieved.

In the independent small team environment, soldier selection and training are critical. Issues such as workload, fatigue, boredom, and stress need to be addressed. With respect to task overload, there clearly were times when the soldiers could not keep up with the action. This was partially due to the awkwardness of the equipment but even if it had worked well, they would have reached overload fairly quickly without an automated fire-and-forget system.

The amount of information available to a team needs to be evaluated and it will be important to make some decisions about use of technology. Simply automating and speeding up current procedures may just make errors faster and more frequent. Just because information is available does not guarantee that it is useful.

The intended precise element by element timeline -- how long it takes for an observer to receive information, call for fire, and get munitions on a target -- was not obtained. But the simulation showed that the mission could be accomplished by the soldiers, and rough estimates derived. The concept of a small team portal appears viable, and the simulation facility proved to be an appropriate place to demonstrate it.

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LIST OF ACRONYMS

AAR	After Action Review
ARI	Army Research Institute
BDA	Battle Damage Assessment
DARPA	Defense Advanced Research Projects Agency
DSB	Defense Sciences Board
ECA	Exercise Control Area
EEA	Essential Elements of Analysis
FDC	Fire Direction Center
FOV	Field of View
GPS	Global Positioning System
IDA	Institute for Defense Analyses
ITQ	Immersive Tendencies Questionnaire
LRSU	Long Range Surveillance Unit
MELIOS	Mini Eyesafe Laser Infrared Observation Set
ModSAF	Modular Semi-Automated Forces
MOF	Map of the Future
OCS	Officer Candidate School
OPFOR	Opposing Forces
PDA	Personal Data Assistant
PQ	Presence Questionnaire
REMBASS	Remotely Monitored Battlefield Sensor Systems
RFPI	Rapid Force Projection Initiative
SIMNET	Simulation Network
SOP	Standing Operating Procedures
SSQ	Simulator Sickness Questionnaire
STOW-E	Synthetic Theater of War - Europe
STP	Small Team Portal
SUO	Small Unit Operations
TRADOC	Training and Doctrine Command
WISE	Walk-In Synthetic Environment

Appendix A

Observer Worksheet

OBSERVER DATA COLLECTION SHEET - STP21 Excursions

Observer Name __________ Date/Time ________

Location: STP1 (treadport) "jogger" STP2 (dial-a-tank) "biker" Leader Station "walker"

Excursion Number _____ Trial Number _____ Probe Number ______

Data Base: mixed ___ desert ___ urban ___ day/night

Equipment: Dial-a-tank / Foot Pedal
MOF
Cover w joystick
Treadport
Grunt II PDA
GATH w melios

STARTEX ________ EXDEX ________

TIME	EVENT	NOTES/OBSERVATIONS

Appendix B

STP21 Questionnaire

SECTION I (background information)

1. Specialty Code/Branch/MOS _________

2. Rank _________

3. Time in service Years _____ Months _____

4. What is your current duty position?

5. Which military schools have you attended? (e.g., basic and specialty courses, etc. List all.)

6. Civilian education: degree ___ major ___

7. Do you have difficulty distinguishing colors (color blind, color weak, etc.)? Yes ____ No ____

8. Which of the following duty positions have you held? Check all that apply, and as appropriate, whether at battalion or brigade level.

   TOW/Tank/BFV Gunner _____ Tank/BFV/LAV Commander _________

   Platoon Leader ________ Specialty Platoon Leader (specify) ______

   Company XO _____ Company Commander __________

   Staff Officer (specify) _________

   Engineer officer _____ NBC/Chemical officer _____ ADAO _____

   CESO/SIGO _____ LNO/ANGLICO _______ Other (specify) ____

   FO _____ FSO _____ FSCOORD _______

If you have had **any experience or training** as a forward observer, or in requesting/calling for fires, please describe this experience -- duty position, location, etc.

9. Have you participated in rotations at any CTC? How many - where?

10. Did you participate in Desert Shield/Storm? Yes __ No ___ Describe.

3. 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

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

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

5. How well do you concentrate on enjoyable activities?

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

6. 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

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

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

8. 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

9. How often do you play games on computers?

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

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

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

11. 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

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

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

Appendix C
Health Questionnaire

1. Are you in your usual state of alertness? YES NO

2. Do you have any illness? YES NO

If yes, please state the nature of your illness (flu, cold, headache, sinus problems, etc.).

3. Please indicate medications you have used in the past 24 hours: (You need not include prescription medication routinely taken on a daily basis.)

(a) NONE

(b) Sedatives or tranquilizers

(c) Aspirin, Tylenol, other analgesics

(d) Anti-histamines

(e) Decongestants

(f) Other (specify):

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

5. Was this amount sufficient? YES NO

6. Did you do any PT in the last 24 hours? YES NO

Appendix D

Symptom Checklist

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: ____

____

* Fullness of head is a sensation of pressure in the head, just short of a headache.

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

Appendix E

Human Factors Equipment and Functions Questionnaire

For each of the following areas, please use the following three scales. Indicate your answer in the table below.

How frequently did you do this during the last scenario? (Frequency)

1 Never
2 Occasionally
3 Moderately Often
4 Frequently
5 Almost constantly

How difficult was it to use the equipment or perform the task? (Do)

1 Very Easy
2 Easy
3 Neither Easy nor Difficult
4 Difficult
5 Very Difficult

	FREQUENCY	DO
Maintaining situational awareness		
Switching among displays - from MOF to PDA to big screen, etc.		
Keeping track of multiple targets		
Remembering to make last minute corrections per FSO instructions		
Doing multiple tasks simultaneously		
Dial a Tank Surrogate Vehicle		
Accelerating vehicle		
Braking vehicle		
Stopping vehicle		
Steering vehicle		
Maintaining orientation		
Navigate in virtual environment		
Treadport		
Walking on the treadport		
Maintaining orientation		
Navigate in virtual environment		
Maintaining balance		
Doing something else while walking		
Map of the Future		
Maintaining map orientation		
Seeing the map		
Understanding map graphics		
Keeping track of things on map		
Reading the map		
Using the map		

Receive a report, using device		
Call for fire		
Make a report, using device		
Grunt II PDA		
Seeing PDA display		
Understanding PDA menu		
Realizing a message is waiting		
Remembering PDA functions		
Understanding PDA symbols		
Composing text messages		
Making PDA do what you wanted		
Adjust fires with PDA		
GATH/Melios		
Detect targets		
Identify targets (name them)		
Prioritize targets		
Designate targets		
Distinguish friendly & neutral		
Perform BDA		
Lazing		
COVER		
Detect targets		
Identify targets (name them)		
Prioritize targets		
Designate targets		
Distinguish friendly & neutral		
Perform BDA		
Using the joystick controller		
Making joystick work right		
Maintaining orientation		
Lazing		
COMMO		
Communicate (Team & Higher HQ)		
Coordinate with team member		

SECTION II (experiences)

1. For each item in the table below, please indicate your experience level using the following scale:

1 = none
2 = limited
3 = moderate
4 = considerable

Equipment/Simulated Environments	Experience Level
Global Positioning System (GPS)	
Laser Range Finders	
Target Designators	
Helmet Mounted Displays	
SIMNET-Type Environments	
JANUS	
Sending/Receiving E-mail	
Laptop Computers	
Thermal Sights	
Other Simulations (name & describe)	

2. Have you ever navigated in a terrain data base? Yes __ No __

If yes, describe where, when, mounted, dismounted, etc.).

SECTION III (focusing)

Answer by marking an "X" in the appropriate box of the seven point scale. Consider the whole scale when responding, as intermediate levels may apply. For example, if your response is once or twice, mark the 2nd box from the left. If your response is many times but not extremely often, then the 6th (or 2nd box from the right) should be marked.

1. 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

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

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

NOT VERY GOOD — SOMEWHAT GOOD — VERY GOOD

Appendix F

Learning to Use the Equipment

Please use the following scale. Indicate your answer in the table below.
How difficult was it to learn to use the equipment or perform the task?

1 Very Easy
2 Easy
3 Neither Easy nor Difficult
4 Difficult
5 Very Difficult

Equipment Name	Difficulty
Dial a Tank	
Drive the vehicle	
Maintain orientation	
Navigate in virtual environment	
Treadport	
Change orientation	
Keep your balance	
Navigate	
Map of the Future	
Maintain map orientation	
Keep track of things on map	
Learn the menus	
Respond to a message	
Call for fire/send message	
Grunt II PDA	
Understand menu	
Realize a message is waiting	
Remember PDA functions	
Compose text messages	
Make PDA do what you wanted	
Adjust fires with PDA	
GATH/Melios	
Detect targets	
Identify targets (name them)	
Designate targets (laze)	
Perform BDA	
COVER	
Detect targets	
Identify targets (name them)	
Designate targets (laze)	
Perform BDA	
Use the joystick controller	
Maintain orientation	

Appendix G

Simulator Questionnaire

Section 1 <u>SIMULATOR REALISM</u>

Characterize your experience in the simulation, by marking an "X" in the appropriate box of the 7-point scale. Consider the entire scale when making your responses, as intermediate levels may apply. Answer the questions in the order that they appear. Do not skip questions or return to a previous question to change your answer.

1. How natural did your interactions with the environment seem?

|_____|_____|_____|_____|_____|_____|_____|

EXTREMELY ARTIFICIAL — BORDERLINE — COMPLETELY NATURAL

2. How much did the visual aspects of the environment involve you?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL — SOMEWHAT — COMPLETELY

3. How natural was the mechanism which controlled movement through the environment?

|_____|_____|_____|_____|_____|_____|_____|

EXTREMELY ARTIFICIAL — BORDERLINE — COMPLETELY NATURAL

4. How compelling was your sense of objects moving through space?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL — MODERATELY COMPELLING — VERY COMPELLING

5. How much did your experiences in the virtual environment seem consistent with your real world experiences?

|_____|_____|_____|_____|_____|_____|_____|

NOT CONSISTENT — MODERATELY CONSISTENT — VERY CONSISTENT

6. Were you able to anticipate what would happen next in response to the actions that you performed?

|_____|_____|_____|_____|_____|_____|_____|

NOT AT ALL — SOMEWHAT — COMPLETELY

7. How completely were you able to actively survey or search the environment using vision?

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

NOT AT ALL — SOMEWHAT — COMPLETELY

8. How compelling was your sense of moving around inside the virtual environment?

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

NOT COMPELLING — MODERATELY COMPELLING — VERY COMPELLING

9. How closely were you able to examine objects?

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

NOT AT ALL — PRETTY CLOSELY — VERY CLOSELY

10. How well could you examine objects from multiple viewpoints?

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

NOT AT ALL — SOMEWHAT — EXTENSIVELY

11. How involved were you in the virtual environment experience?

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

NOT INVOLVED — MILDLY INVOLVED — COMPLETELY ENGROSSED

12. How much delay did you experience between your actions and expected outcomes?

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

NO DELAYS — MODERATE DELAYS — LONG DELAYS

13. How quickly did you adjust to the virtual environment experience?

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

NOT AT ALL — SLOWLY — LESS THAN ONE MINUTE

14. 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

15. Were you involved in the scenarios to the extent that you lost track of time?

|________|________|________|________|________|________|________|
NOT AT ALL — SOMEWHAT — COMPLETELY

16. Were there moments during the scenarios when you felt completely focused on the task or environment?

|________|________|________|________|________|________|________|
NONE — OCCASIONALLY — FREQUENTLY

17. How easily did you adjust to the control devices used to interact with the virtual environment?

|________|________|________|________|________|________|________|
DIFFICULT — MODERATE — EASILY

Section 2 - DISTRACTORS

1. 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 PERFORMANCE

2. 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

3. To what extent did events occurring outside the virtual environment distract from your experience in the virtual environment?

|________|________|________|________|________|________|________|
NOT AT ALL — MODERATELY — VERY MUCH

4. 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

Appendix H

Results of the Participant Immersive Tendencies Questionnaire

1. 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?

XX	X		X		XX	
NEVER			OCCASIONALLY			OFTEN

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

	X			XX	XXX	
NOT VERY GOOD			SOMEWHAT GOOD			VERY GOOD

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

X	XXX	X	X			
NEVER			OCCASIONALLY			OFTEN

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

X	XX		X		X	X
NEVER			OCCASIONALLY			OFTEN

5. How well do you concentrate on enjoyable activities?

			X		XXX	XX
NOT AT ALL			MODERATELY WELL			VERY WELL

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

X	XXX	X		X		
NEVER			OCCASIONALLY			OFTEN

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

	XXX	X	X	X	
NEVER		OCCASIONALLY			OFTEN

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

		X	X	X	XXX	
NOT SO EASILY			FAIRLY EASILY			QUITE EASILY

9. How often do you play games on computers?

X	XX			XX	X	
NOT AT ALL			OCCASIONALLY			FREQUENTLY

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

X		XX	X	X		X
NONE	ONE	TWO	THREE	FOUR	FIVE	SIX OR MORE

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

	XXX			XX	X	
NEVER			OCCASIONALLY			FREQUENTLY

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

	XXX	XX	X			
NEVER			OCCASIONALLY			OFTEN

APPENDIX I

Immersion Questionaire Results

Table I-1

Immersion Question Means For The First And Second Administrations

Stem	Admin 1	Admin 2	Mean
1. How natural did your interactions with the environment seem?	3.00	3.83	3.42
2. How much did the visual aspects of the environment involve you?	4.50	4.17	4.33
3. How natural was the mechanism which controlled movement through the environment?	3.00	3.83	3.42
4. How compelling was your sense of objects moving through space?	3.67	5.17	4.42
5. How much did your experiences in the virtual environment seem consistent with your real world experiences?	2.83	3.33	3.08
6. Were you able to anticipate what would happen next in response to the actions that you performed?	4.17	5.00	4.58
7. How completely were you able to actively survey or search the environment using vision?	3.83	4.00	3.92
8. How compelling was your sense of moving around inside the virtual environment?	4.00	4.00	4.00
9. How closely were you able to examine objects?	3.33	4.33	3.83
10. How well could you examine objects from multiple viewpoints?	3.00	3.67	3.33
11. How involved were you in the virtual environment experience?	4.83	4.50	4.67
12. How much delay did you experience between your actions and expected outcomes?	3.33	3.50	3.42
13. How quickly did you adjust to the virtual environment experience?	5.67	5.67	5.67
14. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?	4.83	5.00	4.92

15. Were you involved in the scenarios to the extent that you lost track of time?	3.17	4.00	3.58
16. Were there moments during the scenarios when you felt completely focused on the task or environment?	4.33	4.67	4.50
17. How easily did you adjust to the control devices used to interact with the virtual environment?	4.67	4.50	4.58
D1. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?	3.50	4.17	3.83
D2. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?	4.67	4.50	4.58
D3. To what extent did events occurring outside the virtual environment distract from your experience in the virtual environment?	4.17	4.50	4.58
D4. Overall, how much did you focus on using the display and control devices instead of the virtual experience and experimental tasks?	2.67	2.67	2.67

Note. Scale values range from 1 to 7, with 1 indicating low immersion and 7 indicating high immersion.

Table I-2

Distribution of Immersion Questionnaire Responses
(Administrations 1 And 2 Combined)

1. How natural did your interactions with the environment seem?

	XXXX	XX	XXX	XXX		
EXTREMELY COMPLETELY ARTIFICIAL			BORDERLINE			NATURAL

2. How much did the visual aspects of the environment involve you?

	X	X	XXXXX	XXX	XX	
NOT AT ALL			SOMEWHAT			COMPLETELY

3. How natural was the mechanism which controlled movement through the environment?

XX		XXXX	XXX	XXX		
EXTREMELY ARTIFICIAL			BORDERLINE			COMPLETELY NATURAL

4. How compelling was your sense of objects moving through space?

	X	XXX	XX	XX	XXXX	
NOT AT ALL			MODERATELY COMPELLING			VERY COMPELLING

5. How much did your experiences in the virtual environment seem consistent with your real world experiences?

X	XXX	XXX	XXXXX	X		
NOT CONSISTENT			MODERATELY CONSISTENT			VERY CONSISTENT

6. Were you able to anticipate what would happen next in response to the actions that you performed?

	XX		XX	XXXXX	XXX	
NOT AT ALL			SOMEWHAT			COMPLETELY

7. How completely were you able to actively survey or search the environment using vision?

	XX	XX	XXXX	XXX	X	
NOT AT ALL			SOMEWHAT			COMPLETELY

8. How compelling was your sense of moving around inside the virtual environment?

		XXXX	XXXXX	XX	X	
NOT COMPELLING			MODERATELY COMPELLING			VERY COMPELLING

9. How closely were you able to examine objects?

	XXXX	XX	X	XX	XXX	
NOT AT ALL			PRETTY CLOSELY			VERY CLOSELY

10. How well could you examine objects from multiple viewpoints?

X	X	XXX	XXXX	XX	X	
NOT AT ALL			SOMEWHAT			EXTENSIVELY

11. How involved were you in the virtual environment experience?

		X	XXXX	XXXXX	XX	
NOT INVOLVED			MILDLY INVOLVED			COMPLETELY ENGROSSED

12. How much delay did you experience between your actions and expected outcomes?

		X	XXXXX	XXXX	XX	
NO DELAYS			MODERATE DELAYS			LONG DELAYS

13. How quickly did you adjust to the virtual environment experience?

			X	XXX	XXXXXXX	X
NOT AT ALL			SLOWLY			LESS THAN ONE MINUTE

14. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

|________|________|________|__XXXX__|_XXXXX__|___XXX__|________|

NOT PROFICIENT PROFICIENT — REASONABLY PROFICIENT — VERY

15. Were you involved in the scenarios to the extent that you lost track of time?

|____X___|___XXX__|__XX____|___XX___|___XX___|___XX___|________|

NOT AT ALL — SOMEWHAT — COMPLETELY

16. Were there moments during the scenarios when you felt completely focused on the task or environment?

|________|________|__XX____|__XXXX__|__XXXX__|___XX___|________|

NONE — OCCASIONALLY — FREQUENTLY

17. How easily did you adjust to the control devices used to interact with the virtual environment?

|________|________|__XXX___|___XX___|__XXXX__|__XXX___|________|

DIFFICULT — MODERATE — EASILY

D1. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

|___XX___|____X___|__XXX___|_XXXXX_|____X___|________|________|

NOT AT ALL — INTERFERED SOMEWHAT — PREVENTED TASK PERFORMANCE

D2. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

|________|________|__XX____|__XXX___|__XXXXX_|__XX____|________|

NOT AT ALL — SOMEWHAT — COMPLETELY

D3. To what extent did events occurring outside the virtual environment distract from your experience in the virtual environment?

|___XXX__|__XXXXX_|____X___|____X___|___XX___|________|________|

NOT AT ALL — MODERATELY — VERY MUCH

D4. Overall, how much did you focus on using the display and control devices instead of the virtual experience and experimental tasks?

|________|________|____X___|_XXXXXXX|___XXX__|____X___|________|

NOT AT ALL — SOMEWHAT — VERY MUCH