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LEATHERNET: AN EVALUATION AS A MISSION PLANNING AND BRIEFING TOOL

by

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LEATHERNET: AN EVALUATION AS A MISSION PLANNING AND BRIEFING TOOL

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The author evaluates LeatherNet, a Distributed Interactive Simulation compliant, virtual simulation system being developed by the Advanced Research Projects Agency to demonstrate Modeling and Simulation(M&S) technologies and to partially fulfill the U. S. Marine Corps M&S goals. The research focuses on evaluation of LeatherNet as a mission planning and briefing tool for Marine infantry company commanders, staff, and subordinate leaders. Evaluation is based on user perception and user performance on a live fire range subsequent to using the system. The user surveys indicate high user acceptance and belief that LeatherNet is a valuable mission planning and briefing tool and that LeatherNet has a good potential to be an effective training tool for commanders and their staffs. User performance, evaluated by subject matter experts on a live fire range, showed no statistically significant improvement for groups exposed to LeatherNet when compared to groups that did not use LeatherNet. The author eplains why true differences, even if they do exist, would be difficult to detect due to the lack of experimental control and recommends action to be taken by the Marine Corps to conduct further testing with greater experimental control. The author also suggests steps the Marine Corps can take to optimize its investment in M&S.

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I. INTRODUCTION

A. RESEARCH OBJECTIVE

The purpose of this thesis is to determine the training effectiveness of using LeatherNet, a virtual simulation system that models several Marine Corps live fire and maneuver ranges, to train infantry company command element staff and subordinate leaders. The evaluation specifically addresses LeatherNet as a tool to conduct mission briefing and mission planning. Training effectiveness is measured through user performance evaluations, conducted by subject matter experts on live fire and maneuver exercises, after user exposure to the LeatherNet system. User perception is also used to determine training effectiveness as measured through user surveys.

B. SCOPE OF THIS STUDY

The scope of this evaluation is limited to testing the training effectiveness of using LeatherNet as a mission planning and mission briefing tool. To make a comprehensive assessment of the training effectiveness of LeatherNet, with a high degree of accuracy, would require many factors not available at the time of this study. First, the system is not mature enough to allow comprehensive testing of some system capabilities such as interactive force on force war gaming for mission rehearsal. Second, many features of LeatherNet that might have been tested, were not, due to user resistance to features they felt did not behave realistically or were too time consuming to use. Thirdly, funding and personnel to conduct a true experimental test could not reasonably be made available, nor is such a test desirable for this particular stage of development of LeatherNet. Determining the training effectiveness of military simulation systems is difficult, complex, and costly, particularly for systems designed for collective training. Therefore, the expense of conducting a true experiment on a demonstration project still under development cannot be justified. The user survey and user performance evaluation are intended only as indicators of user acceptance and as a preliminary evaluation of the system's value for future reference.

C. MILITARY SIMULATION DEVELOPMENTS

Short of combat, all training, mission rehearsals, and exercises conducted in preparation for war can be considered simulation. With the advance of computer technologies, many of the functions of field training can now be further simulated using virtual simulation rather than using live participants in field exercises to simulate the actions of combatants. The U.S. military is more reliant upon simulation than is generally realized. Development and testing of new weapons such as aircraft, tanks, and ships are accomplished with extensive use of simulation to test their value. Furthermore, the crews of many weapons systems now rely heavily on simulators for training, and commanders can develop and test battle plans and tactics on simulators using combat models. Simulation has the potential to be used for a wide range of applications including training, testing, evaluation, mission rehearsal, and system acquisition [Ref. 1: p. I-2].

The U.S. military employs three forms of simulation to train its forces and portray what happens when one military force engages another: (1) constructive simulation which uses mathematical models of combat to simulate warfare for everything from a single weapons system to national warfare, (2) live simulation involving real military forces and simulated weapons effects, and (3) virtual simulation using computers to simulate warfare in synthetic, computer generated environments. [Ref. 1: p. I-4]

1. National Defense Issues

Since the end of the Cold War, several trends have provided impetus to increase reliance upon modeling and simulation within the Department of Defense (DoD). Although maintaining combat readiness is essential for the military, resources devoted to maintain combat readiness have steadily declined since the demise of the Soviet threat. The decline can be expected to continue for the foreseeable future as the nation continues to grapple with the federal budget deficit. Second, despite the diminishing resources, the DoD has seen no lessening of its operational tempo, and in fact, has experienced a proliferation of missions and contingencies. As funding has diminished, future readiness in terms of recapitalization and modernization is at risk of being sacrificed to pay for near term commitments. [Ref. 2: p. 2-6]

While the threat of a major East/West confrontation has subsided, smaller scale regional contingencies have multiplied as nationalistic movements, ethnic disputes, and rivalries once suppressed by communist regimes continue to inflame the former Warsaw Pact countries. Additional challenges are posed by countries such as Iraq and North Korea which threaten the security of their neighboring countries, while countries such as Libya, China and Iran pose less imminent threats. In addition to containing the spread of regional disputes, the U.S. military must also be prepared to combat terrorism and the use of nuclear, biological, or nuclear agents. Ongoing efforts to obtain these agents from the stockpiles of the old Warsaw pact countries, or to manufacture them in various hostile Third World nations present a significant and growing threat to the U.S. and its allies. The combination of these less predictable threats in far flung areas of the globe increase the difficulty of maintaining a military capability to deal with them. [Ref. 3]

As part of the current national military strategy, the military has increasingly been used for peacetime engagements or Operations Other Than War (OOTW). In order to promote regional security and stability, U.S. forces have frequently been called upon to conduct nation building, security assistance, humanitarian, counter drug/terrorism, and peacekeeping missions. Recent operations in Haiti, Rwanda, and Somalia, as well as the current operations in Bosnia demonstrate such OOTW. [Ref. 2: p. 6-12]

Not only have resources diminished, encroachment by civilian communities upon military bases, continued base closing in the U.S., and the loss of overseas bases and training areas as the U.S. reduces its overseas military presence, have further constrained the military's training opportunities. The loss of training areas is further aggravated by increased environmental regulations and endangered species protection which erode the military's unlimited access and use of many of its remaining training areas.

The increasing cost of training is another constraint that limits the ability of the DoD to maintain high readiness levels. As weapons systems have become more sophisticated with the use of precision munitions and high technology weapons platforms, both the cost of the munitions and the weapons systems have increased dramatically. It is not uncommon for Soldiers and Marines to be allowed a single, or even no, live fire shots in a year's time from

some of the more sophisticated missile systems for which they are crew members. Even some of the more common anti-tank missile systems such as the TOW and Dragon systems have munitions costs that typically limit the expenditure of live missiles for training purposes to one or two missiles per year. Many weapons platforms, such as the M1 Abrams tank and the F-18 aircraft, are increasingly expensive to operate, due to fuel and maintenance costs, regardless of the amount of training munitions expended. The net result of these cost increases in an era of reduced funding is that the services are often forced to balance between readiness training and investment in force structure. [Ref. 4: p. 2-4]

2. Simulation Benefits

As the Commandant of the Marine Corps pointed out in his planning guidance, in an era of diminishing resources, history has shown that Marines can survive both as individuals, and as an institution, if they remain highly trained and ready. He notes that the Marine Corps has always turned to training and education systems to keep its warfighting edge. At several points in his guidance he makes reference to his general statement that "the use of simulation, virtual reality models, and various warfighting games can make subsequent field training more effective." [Ref. 5]

In short, modeling and simulation can be for the U.S. Armed Forces what gliders and cardboard mockup tanks were to the German Wehrmacht prior to World War II, when more attractive and realistic training options were prohibited. Despite constraints being placed on the military's ability to conduct training in the traditional manner, large scale use of virtual simulation, imagination, and resourcefulness in implementing the emerging modeling and simulation technologies, can help enable the DoD to avoid unpreparedness by augmenting live training and thus providing the basis of future battlefield success.

In the context of current and expected future developments within the DoD and the U. S. Marine Corps, several assumptions have been made by the Marine Corps Modeling and Simulation Management Office (MCMSMO) that drive the need for increased reliance on modeling and simulation. The most significant of these are as follows:

1. That resources for DoD will be constrained for the foreseeable future.
2. That DoD will continue to develop joint tactics, exercises and operations to include joint simulation.

3. That the cost of weapons platforms and munitions will continue to increase as they become more sophisticated.
4. That training areas will continue to have constraints imposed upon their use by civilian communities and agencies [Ref. 6: p. 1-6]

Despite diminishing resources, the military's investment in simulation will continue to expand. Within the Marine Corps, modeling and simulation technologies will be used for many varied applications to include validation of requirements and doctrine, testing and evaluation, training combat forces, improvement of acquisition processes, and mission planning, preview and rehearsal. [Ref. 7]

The primary reason for the use of simulation is economic. Virtual simulation for example, allows commanders and staffs to experiment without the cost of fuel, ammunition, equipment maintenance, and large numbers of personnel. Training can be accomplished at a small fraction of the cost of using real systems in the field. A single TOW anti-tank missile costs $11,500, but a single TOW shot in the Precision Gunnery Training System (PGTS) costs only $.05 [Ref. 21]. Likewise, the cost of operating an M1 Abrams tank is approximately $92.00 per mile and transit to a gunnery range for a tank platoon can cost thousands of dollars, but the cost of the Unit Conduct of Fire Trainer (UCOFT) is only $.25 per hour. [Ref. 8: p. 18]

Many simulators such as the UCOFT provide training enhancement in addition to the cost savings. Various studies of the UCOFT have found that tank crews trained on the system experience substantial gains in the percent of targets acquired, engaged, hit, and destroyed and that they open fire with their first round 25% faster than conventionally trained gunners [Ref. 21]. The Indoor Simulated Marksmanship Trainer (ISMT) can similarly improve training that can be difficult if not impossible to replicate on a real range. For the M203 grenade launcher, for example, the system provides detailed, accurate measurements of the gunners sight picture and sight alignment for each shot. Thus, deficiencies that would normally go unnoticed can be coached. [Ref. 8: p. 19]

Linking of various simulators allows training to be distributed over great distance at minimal cost. Since networked simulators share common databases, participants using the simulators can "see" the same visual images from their relative positions in the terrain

database. Entities, that represent individuals, units, vehicles, or aircraft can see the same targets, and each other regardless of the location of the simulator, and more importantly, the personnel participating in the simulation. The result is significant cost saving by avoiding the need to physically bring forces together to train together.

As an indicator of the savings possible, in the 1992 REFORGER (Return of Forces to Germany) exercise, the Army used constructive simulation to avoid 34 million dollars in costs as compared the same exercise in 1988 without simulation [Ref. 9]. The 1992 exercise allowed more commands to participate in the event, although the number of troops participating in the live exercise was reduced. The net result was that many units had the benefit of participating in an exercise without the expense of transporting all the personnel and equipment typically necessary.

Virtual simulators provide the benefit of allowing the user to experience the virtual model of the real world he would not otherwise be able to experience due to fiscal constraints, occupation by hostile forces, or simply being too dangerous for peacetime operations [Ref. 9]. Using the virtual model, the user can freely navigate the terrain, viewing the environment from both the friendly and enemy perspectives, conduct mission planning, and conduct war gaming against a synthetic enemy, to mention just a few of the options available to the user.

With the growth of environmental concerns upon our existing training areas, not to mention the loss of training areas, modeling and simulation technologies offer a viable alternative while ensuring the protection of both endangered species and encroaching civilian communities. Constructive and virtual simulation require little, if any, deployment of troops to the field, and they can act as a mechanism to reduce the size of the live simulation force without sacrificing the training objectives. Virtual and constructive simulations leave behind no dud ordnance, fuel spills, or environmental degradation like that typically resulting from large scale field exercises.

3. Simulation Limitations

The benefits of virtual simulation are many but several drawbacks or potential drawbacks do exist. The possibility exists that as the use of simulation increases, reduction

in training on the actual equipment and reduced participation in live simulations can also reduce both the user's confidence in the use of the actual equipment and the military readiness of the force. Additionally, if the behaviors of a simulator do not accurately model the real world, the simulator may instill habits that are incorrect for use with real scenarios and equipment. Accurate models of the characteristics of weapons systems, individual combatants, command and control structures, various sensors, and weather, to mention a few of the elements requiring modeling in military simulators, are difficult to attain. Furthermore, the modeling data may not exist or may be prohibitively expensive to develop. The use of funds for development and procurement of simulation systems of unknown value can be a dubious undertaking that has the potential to detract from military readiness. In addition, the value of a simulation system cannot easily be determined until the system reaches mature stages of its development and user testing takes place, which is after the bulk of the development costs have been incurred. Finally, the potential exists for the compromise of security if access is gained to networks that support interactive simulation, exposing sensitive tactics and weapons capabilities. [Ref. 1: p. I-14]

4. Simulation Technologies

Several factors are driving the need for ever greater reliance upon virtual simulation. As previously mentioned, the ability to conduct live simulation will be fiscally constrained in an era of military downsizing, exerting pressure to reduce the size and number of live simulations. Reduction in the size and number of available training areas, and the inability to adequately simulate weapons effects on live personnel and equipment are also prime factors driving the need for virtual simulation.

Perhaps the most significant driver increasing the role of simulation is the growth of simulation capabilities and related technologies. These new technologies are rapidly changing the manner in which the U.S. military trains, deploys, and executes its missions. Precision munitions, satellite-based surveillance and communication systems, and computer-based mission planning systems are but a few examples that are dramatically increasing the information processing capabilities and have served to expedite decision making and execution on the battlefield. The rapid growth in computer capabilities,

including advances in computer-based graphics and communication technologies, have enabled the use of networks of interactive simulators to distribute training over great distances [Ref. 10: p. 14-15]. Today's simulators can realistically model military entities, environments, and combat against synthetic opposing forces. Once individuals and units have been trained on the real weapons systems and tactics, further training can be conducted on such current systems as the Army's SIMNET (Simulator Networking) using the emerging communication systems such as the Distributed Interactive Simulation (DIS) network to link simulators. Such networked simulators are designed for unit and joint training in large scale, two-sided engagements with various weapons types and command and control groups. Networked, interactive simulation systems currently being developed and fielded include both British and German versions of SIMNET, the Close Combat Tactical Trainer (CCTT), and the Synthetic Theater of War (STOW) demonstration project. [Ref. 1: Chap. I, p. 10]

a. Distributed Interactive Simulation

DIS is a follow-on development of SIMNET technology. Once fully developed, DIS will support real time communications between networks of various types of simulators, in multiple locations, to create a realistic synthetic environment to perform interactive training, design and prototyping, war gaming, and other applications. The infrastructure will be designed to allow interactive sessions between simulation systems from all the services, built for separate purposes, with different technologies, and from different vendors. DIS exercises will incorporate a mixture of live, virtual, and constructive entities and allow units of all sizes to engage in two-sided combat whether in a simulator or using actual equipment on an instrumented range. Interoperability in DIS is established through the use of standard protocols, communication architectures, interface standards, and other standardized elements necessary to link the various simulators into a seamless synthetic environment. [Ref. 12: p. 1-7]

With DIS, the military will not only retain the use of stand alone simulators, but will be able to conduct "Total Force" training without requiring units to leave their home bases. As such, a cost savings will be gained from avoiding the transportation of personnel and equipment that would normally be required to facilitate an operation and the reduction

of wear and tear on the equipment. Additionally, DIS provides a safe environment where operation and contingency plans can be developed, tested, and evaluated in a realistic simulated environment. Fielding of deployable simulators aboard ship and at forward locations, and the use of satellite communications, will enable exercising Marine Air-Ground Task Forces (MAGTF) though the use of simulation. Feedback from real simulations into virtual simulators will be accomplished through the continued development of instrumented ranges that instrument personnel, weapons, and targets to provide data on events in both time and space, between opposing sides in simulated combat. [Ref. 7: Chap. 1, p. 5]

If real time interaction between simulated crewed platforms is to be achieved, many issues must be resolved that are not addressed in the commercial market. To enable DIS to operate in real time, a dedicated, high capacity communication network with transfer rates higher than 155 megabytes/second will be required, and must include land sea and air connectivity [Ref. 7: p. 3-35]. The network must be capable of conveying data to interested simulation nodes with low latency of 100-300 milliseconds and low latency variance. The latency standard refers to the maximum allowed time for data to travel from the transmitting application to the receiving application. DIS requires that each simulated entity inform all other simulated entities of its activities without knowing who or what the capabilities of the other entities are. To handle this many to many communication, the network must support multicast addressing rather than point to point addressing. The Defense Advanced Research Projects Agency (DARPA) has sponsored the development of the Defense Simulation Internet (DSI) as a high capacity, general purpose, packet switching Wide Area Network (WAN) to achieve this goal. Another challenge is handling the immense amount of data arriving at each node and separating only the data pertinent to that node from the data stream for processing at that node. [Ref 12: p. 23-29]

Technological developments critical to simulation and training that are associated with DIS include networks, semi-autonomous forces (SAFOR), terrain and environment databases and display, range instrumentation, and individual combatants [Ref. 1: Chap. 6, p. 2-19]. Infrastructure developments required to support these efforts include developing hardware suites for data processing and display for the instrumented ranges and

developing hardware suites for mission preview capability [Ref. 6: p. 3-9]. User interface development for virtual simulation will focus on three dimensional displays, SAFOR that correctly model personnel and weapon capabilities, and SAFOR construction tools capable of rapidly building synthetic environments to promote rapid scenario and mission generation. [Ref. 7: Sec.2, p. 9-17]

D. THESIS OUTLINE

Chapter II, Military Simulation Systems, provides an overview of military simulations efforts within both the DoD and the U.S. Marine Corps. Major modeling and simulation (M&S) initiatives from both organizations are discussed to provide a background on the major simulation developments, challenges, and objectives. Finally, the LeatherNet project is described to provide an overview of its purpose, the development strategy, and the expected benefits of the system.

In Chapter III, the methods for conducting training and cost effectiveness analysis of simulation systems are examined. The challenges to performing such analysis are discussed to provide an explanation of how the methodology for evaluating LeatherNet was developed.

Chapter IV, Methodology, explains the purpose and methodology for evaluating LeatherNet. The methodology for data collection and analysis is described for both the user survey and the user performance evaluation. The test constraints and environment, to include the threats to the validity of the experiment, are also examined.

The results of the data analysis are discussed in Chapter V. The results are displayed graphically in bar charts and further explained in the text. Various data analysis techniques are used to analyze the user survey and user performance evaluation results.

In the final chapter, Conclusions and Recommendations, the meaning of the data analysis results and their implication on the LeatherNet system are discussed. Recommendations for future research in evaluating LeatherNet and similar simulation systems that are used for collective training are presented. Additionally, suggestions are made regarding steps the Marine Corps can take to promote the use of M&S technologies

and to ensure the Marine Corps remains a relevant participant in M&S development.

II. MILITARY SIMULATION SYSTEMS

A. ASSESSMENT OF MODELING AND SIMULATION IN DOD

1. Background

The M&S developments prior to 1990 were characterized by fragmentation and limited coordination across the Services and functional communities. In recognition of these deficiencies, the DoD created the Defense Simulation Management Office (DMSO) to facilitate the coordination of M&S activities within and across the different communities. Additionally, many of the DoD components established their own M&S organizations to coordinate their efforts within their own component and with the other services. These steps have fostered advances in architecture, standards, and protocols; representation of the environment, weapons systems, and human behavior; and the fielding of M&S systems and associated infrastructure. [Ref. 13: Chap. 3]

2. Architectures, Standards, and Protocols

Interoperability and reuse of simulation systems are limited within the DoD due to the lack of a common framework for simulation architectures. It is widely recognized that a common framework must be established to facilitate the interoperability of all the various simulators. To meet this objective, DIS protocols and standards have been implemented to establish a common data exchange environment, and they continue to be refined. There remains the need to significantly expand DIS and develop its architecture to support a broader range of capabilities such as representing command and control more realistically, supporting simulations with different time management methods, and reducting the computational and communication bandwidth demands.

The Aggregate Level Simulation Protocol (ALSP) confederation of models currently in use will remain the primary tool for simulation for joint level training until the Joint Simulation System (JSIMS) reaches its Initial Operating Capability (IOC). ALSP has been critical for constructing "federations" of existing models for connecting theater-level tactical simulators supporting a wide spectrum of joint and combined exercises, such as REFORGER. This confederation of models, however, has only limited interoperability, takes

a long time to set up, and requires many personnel to operate. DIS, as a part of JSIMS, will replace ALSP. [Ref. 14: p. 1147]

3. Representation of the Environment, Systems, and Human Behavior

The simulated terrain representations achieved to date are impressive, but they are resource intensive to produce and are largely non-reusable by different simulators. The DoD continues to conduct research and development for reusable terrain and environmental databases, but is impeded by a lack of clear understanding of the modeling and simulation community's requirements for environmental data.

The DoD is also researching the development of authoritative models for representing military systems and units as a means of enhancing interoperability and reuse. Efforts are underway to develop a joint simulation object library and develop common approaches for representing threat forces and systems. Currently, however, there are no broadly accepted standards to represent military systems and units, which causes incompatibility among the different models.

The representation of friendly and threat humans and groups of humans under the stress of combat is an extremely challenging task. The U.S. Army Modular Semi-Automated Forces (ModSAF) program is attempting to provide a baseline, standardized, modular software structure in which the model components have a well-documented and defined interface. This program is seeking to develop more sophisticated, generalized representations of behaviors, missions, and behavior control mechanisms. Other efforts are focused on representing command and control in entity-based simulations, but there are few efforts, to date, to represent tactical human behavior authoritatively, particularly threat forces, their doctrine, and tactics.

4. Fielding M&S Systems and Associated Infrastructure

To fully realize the benefits of widespread modeling and simulation use, attention must be paid to fielding M&S systems that are interoperable, reusable, support operational needs, and address the full range of defense missions. The fielding must be in adequate numbers to meet DoD-wide end user needs. To be accepted, modeling and simulation needs to have established credibility. Procedures for verification, validation, and accreditation

(VV&A) need to better defined and refined. Furthermore, VV&A must begin much earlier in model development and become a part of the M&S life cycle. A reusable communications infrastructure with the capacity to adequately support modeling and simulation does not exist but efforts are ongoing in this area. The DSI has been implemented to support geographically distributed users. Plans also exist to merge DSI with the Defense Research and Engineering Network (DREN) to enhance capability and reliability. The long term objective is to use commercial services and operational communications capabilities to meet M&S needs, but challenges such as bandwidth reduction and security must be met to make this objective feasible.

In summary, modeling and simulation today is resource intensive and tends to be comprised of narrowly focused systems that cannot interoperate among user communities, and the systems that do exist have not been properly validated, verified, and accredited. The issues are being addressed and significant effort is being made to implement DoD-wide architecture, standards, and protocols to promote interoperability and software reuse. [Ref. 13: Chap 3]

B. DOD MODELING AND SIMULATION OBJECTIVES

The DoD has adopted six modeling and simulation objectives to improve its ability to more efficiently develop simulation systems and promote simulator interoperability. The objectives are as follows:

- Provide a common modeling and simulation architecture
- Provide timely and authoritative environmental representations
- Provide authoritative representations of systems
- Provide authoritative representations of human behavior
- Provide a modeling and simulation infrastructure to meet the developer and end user needs
- Share modeling and simulation benefits with other government agencies, industry, and allied nations [Ref. 15]

C. DOD INITIATIVES

1. SIMNET and CCTT

In 1983, the U.S. Army and DARPA began the development of the SIMNET training system to link various units over large scale computer networks in a common synthetic environment. Numerous simulators configured around a mock up of the interior of an armored vehicle allowed the participants to see a simplistic three-dimensional landscape and other simulated vehicles participating in the exercise. The simulated armored vehicles could maneuver over the simulated terrain and engage enemy targets in concert with other friendly forces. SIMNET made use of SAFOR, both friendly and enemy, that performed automatically according to specified doctrine and tactics after being tasked by the computer operator. Use of SAFOR added realism and computer generated forces without the use of additional simulators that were normally required to generate and control a simulated entity. [Ref. 16: p. 10-12]

For those tasks that are fully represented in SIMNET, training with SIMNET is more effective than additional field training. SIMNET has the capability to train tank crews in 35% of the tasks specified in the Army Training Evaluation Program and many studies have shown a positive transfer of tactical training with SIMNET to field training [Ref. 9]. Research has shown that platoons trained with SIMNET improved there scores on Situational Training Exercises, designed to evaluate a tank platoon in both individual and collective tasks, by an average of 13% while platoons receiving only addition field training, improved there scores by only 6%. Additionally, platoons with more battle runs on SIMNET produce higher scores in competition for the Canadian Armor Trophy. Although SIMNET has been assessed as providing positive training benefits, those benefits have never been fully quantified. Tests of the system have tended to be subjective, failed to use control groups, and have even been altered as a cost saving measure due to the high cost of testing. [Ref. 9]

Several limitations of SIMNET, which included unrealistic behaviors and modeling only two ground combat vehicles, led to the development of the Close Combat Tactical

Trainer (CCTT). The design for CCTT began in 1992 as a simulator for training armor and mechanized forces. CCTT is the first in a series of the envisioned Combined Arms Tactical Trainer (CATT) systems which will eventually include simulators to train artillery, aviation, air defense, and engineer forces.

A task force of the Defense Science Board found that computer-based simulators offer the only practical and affordable means for joint commanders and staffs to exercise decision making skills, test war plans, and train as a joint force. Despite this finding in 1988, uncertainty remains regarding the training effectiveness of simulation and how to properly integrate computer-based simulation and field training. While technical tests provide for validation and verification as to whether CCTT can meet system requirements, user testing is necessary to evaluate the training effectiveness of CCTT and its impact on mission performance. To accomplish user testing, the Army plans the most expensive and comprehensive test of a simulation system to date, beginning late in 1996. Units will undergo pre-training evaluations, training with CCTT, and post-training evaluations that include similar training exercises to evaluate the impact of CCTT training on combat effectiveness and survivability. To determine the proper mix of simulation and field exercises, different test groups will receive different levels of CCTT training, ranging from 0 - 6 days, mixed with 4 - 10 days field training for a total of ten days training for each group. One group will receive no training as a control group. The test is designed to compare the training effectiveness of different levels of simulation training to conventional field training. [Ref. 16: p. 14-38]

2. Joint Simulation System

In the past, each of the Services has developed independent modeling and simulation systems that cannot freely interact with systems developed by the other Services. As a short term fix, linking of the various models has been achieved through the use of the multi-service Aggregate Level Simulation Protocol (ALSP). However, ALSP is a simulation protocol with known limitations and inefficiencies that make it unsuitable for long term use [Ref. 17].

In an effort to better integrate the range of missions of the Armed Forces into a

common framework, the DoD will migrate to the JSIMS as a replacement for the ALSP confederation of models. The impetus for JSIMS development is to eliminate the individual services duplication of effort in modeling and simulation development and the resulting interface difficulties, data sharing problems, and inefficient use of funds [Ref. 14]. JSIMS will provide integration of constructive, live, and virtual modeling and simulation capabilities, with C4I fully supported and interfaced using real-world equipment. The system will include man-in-the-loop capability with incorporation of decisions and simulation at all levels, including the ability to train down to the individual level. [Ref. 17]

Funding and development of JSIMS will be a cooperative effort with participation from all four Services. The Marine Corps will participate in this effort by contributing 10% of the JSIMS core funding with each of the other services contributing 30%. Besides providing funding, the Services will identify and nominate the best service applications and algorithms for use in the common framework. The Services will ensure a common, economical, and efficient development process for their prototypes. The primary development goals are reusability, portability and interoperability of object-based software components while ensuring DIS compatibility. All the Services have signed a Memorandum of Agreement outlining their commitment to JSIMS development, although the Army continues to develop their next generation model, WARSIM 2000, which parallels the JSIMS effort.

JSIMS development will initially focus on the training environment at the campaign level. Initial operational capability for Joint Task Force level training is scheduled for 1999, and by 2003, JSIMS is scheduled to have full operational capability for Service applications. [Ref. 18]

D. MARINE CORPS MODELING AND SIMULATION EFFORTS

1. Initial Efforts

The Marine Corps recognizes that the advancement in computer and M&S technologies, such as DIS, offers significant benefits in terms of improved training effectiveness and cost reduction. The ability to integrate various models and simulators, that

are geographically distributed, in a common synthetic environment, offers the opportunity for the Marine Corps to conduct Total Force training without the requirement for units to leave their home bases. Commands can conduct mission planning, rehearsal, and debriefs, and test operational and contingency plans in a synthetic environment with less cost, time, and effort. DIS also provides for the development of virtual prototyping of new systems and refinement of their designs before the investment of resources in the physical prototypes. Similarly, combat developers can harness DIS to rapidly and economically explore new operational concepts and doctrines.

To promote the employment of M&S technologies and to take advantage of these promising benefits, the Marine Corps has taken several steps. The most significant steps include:

- Establishment of the Marine Corps Modeling and Simulation Management Office (MCMSMO) as the Marine Corps focal point for modeling and simulation
- Establishment of an M&S organizational structure that parallels and interacts with the DoD M&S management structure
- Active participation in joint M&S initiatives
- Development and implementation of the Marine Air-Ground Task Force (MAGTF) Tactical Warfare Simulator (MTWS) for battle staff training
- Establishment of an Advanced Distributed Simulation (ADS) demonstration site at MCAGCC to support the Marine Corps participation in the DARPA's Synthetic Theater Of War (STOW) project
- Establishment of an ADS demonstration site and Decision making Support Center (DMSC) at Quantico, Virginia, for experimentation in the use of M&S to support analysis efforts
- Implementation of a M&S Master Plan and a M&S Investment Strategy [Ref. 7: p. 1-5]

The following sections will provide an overview of the Marine Corps modeling and simulation vision and some of the current efforts to turn that vision into a reality.

E. MARINE CORPS MODELING AND SIMULATION VISION

1. Overview

The Marine Corps M&S vision incorporates two orientations. The first is internal, focusing on the use of M&S within the Marine Corps to improve mission performance across the Total Force. The second orientation is external and focuses on Marine Corps participation in the DoD M&S initiatives.

The Marine Corps will leverage emerging M&S technologies, such as DIS, to replace and/or incorporate the current stand alone models. The objective is to augment traditional live fire training at all levels through the integration of combat systems, command and control nodes, trainers, logistics and support systems, and constructive models and war games into a common synthetic environment. Linking of the various individual, crew, and small unit simulators into a common synthetic environment will support MAGTF Battle Staff training at all levels as well as joint-level training. The end result will permit the Total Force to train as it fights whether in garrison, deployed aboard ship, or deployed in other forward areas. [Ref. 7: p. 1-9]

2. Envisioned M&S Endstates

To maximize the full potential of M&S technology, connectivity will play a critical role in the realizing the Marine Corps M&S vision. The various models and simulators used at all levels of training require interconnectivity not only within the Marine Corps, but in the joint environment as well. Developing this network of simulators on a global scale will foster Marine Corps participation in joint training and planning exercises and permits a role in development and evaluation of joint tactics and doctrine.

M&S is additionally envisioned as playing a critical role in the Marine Corps Combat Development Process. Simulated environments will be used to develop concepts, validate requirements, and conduct course of action (COA) analysis by exercising force on force and warrior-in-the-loop simulations. Acquisition costs can be reduced through the use of virtual prototyping that will replace the need for expensive physical prototyping to design and test combat system effectiveness. System designs will be refined prior to incurring the cost of physical development with the use of simulated environments to evaluate design alternatives

and analyze the performance tradeoffs. As system development matures, simulated environments will be used to evaluate and revalidate the system performance prior to full-scale development and production.

In an effort to guide the attainment of the Marine Corps M&S vision and to focus Marine Corps efforts, a set of eight M&S endstates have been laid out in the Marine Corps Modeling and Simulation Master Plan. These endstates are as follows:

- Exercise any size Total Force MAGTF as part of a combined or joint force from home bases, aboard ship, or forward deployed through the seamless integration of live, virtual, and constructive simulations
- Conduct mission planning in a distributed environment
- Conduct mission preview and rehearsal on land or at sea at all levels, from the individual Marine to a Marine Expeditionary Force (MEF), within 48 hours of tasking
- Validate Marine Corps requirements and doctrine using M&S as a primary tool
- Participate in the fundamental improvement of the acquisition process by simulating before "we buy, build, or fight"
- Merge M&S and command, control, and communications systems
- Support every major weapon system in the Marine Corps with a simulator that can be networked into a common synthetic environment
- Use M&S as a primary decision support tool [Ref. 7: p. 1-12]

F. TEAM TARGET ENGAGEMENT SYSTEM

The Team Target Engagement System (TTES) is a Marine Corps sponsored advanced technology demonstration to develop a trainer for individuals and small units. This simulator will enable users to participate in synthetic force on force combat in an urban environment and to engage interactively with Computer Controlled Hostiles (CCH). The objective is to provide the users with tactical realism and hostile reactivity to friendly force actions while avoiding the cost and use of human instructors and other simulator stations to control the simulation of other participants in the exercise.

The focus of CCH development is to create hostile entities that are realistic participants in the simulation by designing them to move exactly as humans do in an urban combat environment, suffer wounds when hit, and "see" users when they are visible and react accordingly. To accomplish this, the development must take into account the opposing force mission, available resources, acceptable losses, characteristics of the terrain and the structures, as well as the actions of the users. To achieve the objective of developing entities that will operate autonomously without the control of an operator, the individual human represented by the system will consist of a physical model level, a control level, a reactive decision level, and a reasoning level. [Ref. 19]

The physical level will describe human movement, action capabilities, simple models of weapons use, performance degradation from wounds, and audio and visual perception. The reactive decision level selects appropriate action for the immediate situation and is to be designed to have minimal computation at this level so that the decision process can be repeated frequently. The reactive decision level will also be designed to incorporate planning capabilities several seconds to several minutes into the future to provide a more realistic hostile response to friendly actions. Finally, the control level serves to govern movement and continuous low level processes.

In addition to developing the individual human entities, a major objective of TTES is developing a semantically rich representation of buildings. In doing so, it will allow the computer generated forces to reason about such issues as movement, routes, cover and concealment, and firing positions by providing information about walls, apertures, rooms, stairs, and other urban features.

TTES will be designed to be DIS compliant so that these simulators can interact with other simulators such as LeatherNet. However, since current DIS protocols do not allow simulation of individual combatants, the TTES project must propose extensions to the existing protocols. [Ref. 19]

G. LEATHERNET

1. Background

The advancement of computer and visualization technologies, specifically virtual visualization of combat scenarios, has led DARPA to apply these technologies toward the development of training and scenario analysis tools. To demonstrate the capabilities of these tools, DARPA has planned STOW-97 as a proof-of-principal demonstration with a large scale joint exercise using live, virtual, and constructive forces. The Defense Simulation Internet will be used to connect these forces comprising 50,000 entities. STOW-97 will provide a synthetic environment in which human users can interactively conduct realistic wartime scenarios involving friendly and enemy forces, with the ability to review and debrief the events, and conduct "what if" analysis. [Ref. 20: p. 1-4]

2. Overview

LeatherNet is a virtual simulation system that is being developed at MCAGCC, 29 Palms, California, under the sponsorship of DARPA. The LeatherNet project provides DARPA the opportunity to develop U.S. Marine Corps Semi-Automated Forces (MCSAF) for use in the STOW-97 demonstration. DARPA's objective is to capture the unique features and behaviors of Marine Corps systems. The objective requires development, in a distributed model, of the arbitration of battle outcomes at the entity level of detail to include portrayal of both individual weapons systems and individual combatants. Additionally, efforts are being taken to provide a realistic representation of Marine Corps command nodes, both ashore and afloat, which will portray the influences of one command level over the actions of another. The end product of the LeatherNet project is intended to represent a MEF in ground maneuver warfare, to include amphibious functions, with all the weapons systems and the various positions in the MEF organization in which humans function. [Ref. 20]

3. Project Strategy

LeatherNet development is being implemented in four builds. The first two builds were conducted during FY 1994 and 1995 and builds three and four will be completed during FYs 1996 and 1997 respectively. A brief summarization of the builds follows:

- **Build 1** Consists of developing a capability to conduct a "terrain walk" of

Range 400 at MCAGCC, 29 Palms and the ability for a Company Command Element and subordinate leaders to conduct mission planning, briefing, rehearsal, and debrief for this range in a simulated environment.

- **Build 2** Implements a capability for Company Command Elements and subordinate leaders to conduct a "terrain walk" of the Delta Corridor at 29 Palms as well as conduct mission planning, briefing, rehearsal, and debriefing for this training area in a simulated environment.

- **Build 3** Implements the same capabilities as in Build 2 except that development is focused on the Battalion Landing Team Command Element and subordinate leaders.

- **Build 4** Implements the same capabilities as in Build 2 except that development is focused on the Regimental Landing Team Command Element and subordinate leaders.

Development of LeatherNet is dependent upon the Tactical Exercise Evaluation and Control Group (TEECG) instructional staff at 29 Palms to provide feedback to ensure that the existing Range 400 and Delta Corridor training scenarios are accurately represented by the system. [Ref. 20: p. 11-16]

4. Benefits of LeatherNet

The envisioned benefits of LeatherNet are to provide the Marine Corps with lower cost and more effective training. These benefits will be derived through the capability of studying different tactical alternatives and conducting "what if" analysis without the use of field exercises. LeatherNet will enable units to conduct large-scale exercises against a hostile force without risk of casualties, expenditure of ammunition and fuel, or wear and tear on equipment. Other benefits of virtual simulation, as previously discussed, can be gained from LeatherNet's implementation as well. These benefits may be enhanced by providing LeatherNet capability to other locations in addition to the facility at MCAGCC.

III. EVALUATION OF SIMULATION SYSTEMS

A. VALIDATION AND VERIFICATION

To establish the credibility of M&S systems, the DoD is reliant upon validation and verification techniques. The validation process or the "process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model" and the verification process or the "process of determining that a model's implementation accurately represents the developers conceptual description and specification" have never been agreed upon [Ref. 21]. The techniques and how they should be applied to establish the credibility of the M&S system when used for a particular application is the subject of much debate. Many techniques exist for the developer to establish validation and verification to include mathematical proofs, design walk throughs, and code verification to name a few. However, the basic questions to be answered are; "What do we need the M&S system to do?" and "How well can the M&S system do them?" The end result must be acceptance by the end users of the M&S system. To reduce the risk of executing a M&S program that fails to meet requirements, a review of the M&S system in operation by subject matter experts (SME) as early as possible in the development is essential [Ref. 21]. Determining whether a system provides the required functions and whether those functions accurately model the real world are only some of the considerations that should be taken into account in fielding a military M&S system. The training effectiveness and cost of the system are other prominent considerations that must be considered.

B. TRAINING EFFECTIVENESS ANALYSIS

There are no well defined methods for determining military value of a training program or system, but military value is ultimately reflected in the degree of combat success that any training program or system is responsible for. Unfortunately, the degree to which a training program or system enables success in combat is difficult to assess. Military value can be empirically determined only in combat and it is obviously impractical and unwise to

wait for war to determine the effectiveness of a training system. [Ref. 22: p. 7]

As a more practical approach to assess training effectiveness, measures of effectiveness (MOE) are used as an alternative to actual combat to predict combat success. MOE are equivalent to dependent variables that are used to assess the impact of an experimental treatment condition [Ref. 22: p. 7]. MOE can be defined as "tools that assist in discriminating among a number of alternatives." They show how the alternatives compare in meeting functional objectives and mission needs. [Ref. 23: p. 8-7]

In selecting MOE, a distinction can be made between objective and subjective data. Objective data are based on observable events whose occurrence is not usually the subject of dispute. Examples include a student's test score or the number of hits scored on a gunnery range. Subjective data are based on the opinions and judgements of a SME. Subjective data is necessary to capture intangible information such as leadership, decisiveness, morale, and motivation. While the SME evaluation may carry great weight, it may be neither accurate nor valid. [Ref: 22: p. 12-14]

Selection of training MOE is dependent upon the tasks necessary to accomplish the training, the conditions under which the task will be conducted, and the standards for the tasks. Evaluation of collective training is much more difficult and subjective than evaluation of individual training. The problem is further compounded when attempting to evaluate simulators. The Government Accounting Office (GAO) has concluded that despite the Army's strategy to increase the use of simulation, the strategy lacks detailed guidance for commanders to make effective use of simulators. The major downfall is the lack of linkage between the simulation and the tasks the unit can expect to perform in wartime. The lack of guidance has resulted in the less than optimal use of simulators. That being the case, the true training value may not be realized nor evaluated. [Ref. 24: p. 2]

Deciding how to measure the training effectiveness of a training program or system is neither obvious nor simplistic. The training environment must be considered to determine whether the training is structured or unstructured. Schools tend to offer structured training and be more objective in nature. Unit training tends to be unstructured and evaluation is more difficult and subjective due to reliance upon the opinion and judgement of SME.

Further difficulty arises from the lack of understanding of the important dimensions of collective training and evaluation. Even developing the task list to determine the MOE is complicated by the fact that the tasks tend to exist in hierarchies, and separate task lists can be developed at each level in the hierarchy. As the number of levels increase, tasks are added to each level for possible interaction between that level and other levels. A comprehensive task list would be comprised of all the tasks at each level and all the tasks involving interaction among levels. No standard method of developing collective MOE exists. Many researchers stress the importance of relying upon SME's to assist in developing MOE. SME's enable researchers to identify indicators of success, interpret performance, and to ensure all relevant tasks are measured. While the SME's know best how to assess the complex training environment, objectivity may be lost as this method is reliant upon opinion and judgement. [Ref. 22: p. 10-18]

In using MOE certain assumptions must be made. In order to conduct a training effectiveness analysis of one training method over another, a MOE that predicts combat success must be selected. The MOE might be student grades or an evaluator's rating. To use these MOE, one must make a transfer assumption that student grades or an evaluation rating predict combat success. Such an assumption implies a series of assumptions that school or training performance influences training readiness which influences combat readiness. While research has provided data supporting the linkage between school performance, field performance, and combat readiness levels, these linkages remain largely unconfirmed. [Ref. 22: p. 13]

C. COST EFFECTIVENESS ANALYSIS

Cost effectiveness analysis (CEA) is a method used by the DoD to make decisions in selecting alternative courses of action when the results effect military performance. While the inputs can be measured on a cost basis, the outputs or military value, cannot be measured in monetary terms. CEA is similar to cost benefit analysis in respect to taking into account all of the associated costs of a project throughout a projected life cycle. However, CEA takes into account military value which cannot be defined in the same terms as cost due to a lack

of market value for increased readiness, improved training, and improved weapon systems. Since cost and military value have different units of measurement, selection of alternatives cannot be made on a cost basis alone. Orlansky developed a decision logic diagram for evaluating the cost and effectiveness of two training programs or systems. The diagram is shown below:

		EFFECTIVENESS		
		LESS	**SAME**	**MORE**
COST	**LESS**	**?**	+	+
	SAME	-	**?**	+
	MORE	-	-	**?**

Table 1. Cost and Effectiveness Decision Diagram [Ref. 1]

Using the diagram in Table 1, if an alternative is as effective and costs less than another, it should be adopted. Likewise, if an alternative is more effective and cost the same or less than another alternative it should be adopted. An alternative should be rejected if it is less effective and cost the same or more than the other alternative or the alternative is as effective and cost more. Finally, in those situations where the alternatives exhibit less effectiveness and less cost, equal effectiveness and equal cost, or greater effectiveness and greater cost, no logical preference can be made. [Ref. 1: p. III-2]

While Orlansky recommends acquiring simulators that are equally effective and cost less than the actual equipment, he suggests that the military should strive to acquire simulators that provide increased effectiveness at the same or lesser cost. He believes that the military should take the same approach to acquiring simulators as it does to acqiuring weapon systems with the focus on increasing effectiveness. Costs should be a secondary consideration. The end result should be the optimum combination of simulators and actual equipment that provide the most effective training at the least overall cost. [Ref. 1: p. III-11]

In a study by the M&S Benefits Task Force, DMSO reports the training applications of M&S for individual skills training are wide spread and the training benefits are positive when simulation is properly mixed with training on real equipment. Analyst have well-established theories and experimental methods for conducting analysis at this level. The same cannot be said for unit training, particularly in the higher echelons. The high cost of repeated large scale exercises and the difficulty of conducting the controlled experiments necessary preclude the collection of meaningful data. Multi-million dollar savings are reported, however, when comparing computer simulated command post exercises with conventional field training exercises. [Ref. 9: p. 2]

IV. METHODOLOGY

A. BACKGROUND

1. Purpose

The purpose of this research is to evaluate the perceived ability of LeatherNet to meet the mission planning, and to some extent, the mission preview objectives of the Marine Corps Modeling and Simulation endstates as described in the Marine Corps Modeling and Simulation Master Plan. Secondly, this research will determine if a correlation exists between the exposure to conducting mission planning and briefing with LeatherNet, and subsequent user performance in conducting live fire training.

2. Test Constraints

User testing and evaluation of LeatherNet has been constrained by several factors. All aspects of LeatherNet could not be evaluated since the system remains under development. The number of test participants has been limited by the number of units participating in the Combined Arms Exercise (CAX) Program, which are the units designated by the Commanding General of MCAGCC to conduct user testing of LeatherNet. The CAX program is an ongoing Marine Corps program to train Marine infantry battalions in all aspects of fire support coordination in a live fire and maneuver environment. CAX training cycles last approximately 30 days and are comprised of intense field training in fire support techniques and tactics at all levels of command. The training schedule allows units little or no opportunity to conduct training other than that training related directly to the CAX program. Using other, less encumbered, units to conduct the testing is not practical due to the cost of transportation to the remote test site and the cost of the training on Range 400 in terms of ammunition expenditure. During the period from April to August 1996, a total of eight groups were exposed to the system. The amount of time the users were exposed to the system was constrained by the demanding CAX training schedule that limited their exposure to three to four hours between field exercises. The time constraints further limited the functions which could be demonstrated, eliminating those which were time intensive. Some functions were not demonstrated due to incorrect behaviors and inaccurate

representation of certain entities at this stage of development. For example, hostile infantry would stand on the trench lines, rather than in them, rendering them easier to "kill." In these instances, the TEECG personnel, who are responsible for conducting the CAX program, felt the system provided "negative training" due to incorrect behavior of these entities. The TEECG thought such behavior gives a false impression of the difficulty in overcoming fortified defenses and decided against testing the system using the full wargaming capabilities until the represented behaviors become more realistic with further development.

3. Test Environment

a. User Testing Participants

The officer responsible for coordinating and conducting user testing of LeatherNet is Major Daniel Newell, the TEECG LeatherNet Representative. Major Newell ensures that two of the three rifle companies from each infantry battalion participating in the CAX program receives its Range 400 exercise brief using LeatherNet. The third company, which is the control group, is not exposed to LeatherNet and receives its brief through the use of a map study. The test participants typically consist of an infantry company's Command Element and the Platoon Leaders. The companys have the option of including other individuals in the briefs such as their Forward Observers and Machine Gun Section Leaders at their own discretion. A total of 31 participants were surveyed.

The participants come from various Marine Corps bases around the U.S. and include Marines from both reserve and active duty units. The participants had varying degrees of experience in their Military Occupational Specialty, to include prior exercises on Range 400, but none had used LeatherNet prior to the testing.

b. Functions Evaluated

As previously noted, due to the maturity of LeatherNet development, time constraints, and the willingness of test personnel to test the system, only the mission planning and mission briefing functions of the Marine Corps objectives for LeatherNet are evaluated. The system, while mature enough to conduct a mission rehearsal against an interactive hostile force, and perform "what if" COA analysis, was not used for these purposes during the course of this research. The LeatherNet mission planning and briefing

evaluation focused on using the system to conduct an estimate of the situation to include taking into consideration such elements as mission, enemy, troops and fire support available, time, space, and logistics. The test participants were led through the estimate of the situation analysis by Major Newell as part of the TEECG's Range 400 exercise brief. During the brief, the participants were allowed to use LeatherNet to "navigate" the Range 400 terrain to conduct a reconnaissance from both the friendly and enemy perspectives. In doing so, the participants were able to assess their plan's vulnerability from potential enemy positions and weapons systems along their planned maneuver routes by using LeatherNet's display of weapons range fans and deadspace. Likewise, using the same functions, they were able to evaluate the effective target coverage of friendly weapon systems from potential friendly firing positions. Additionally, the "terrain walk" of Range 400 enabled the participants to "see" the terrain, the potential enemy positions, and take into account time and space consideration for their fire support and maneuver elements.

User surveys, to measure user opinion of LeatherNet, were conducted immediately after the completion of the Range 400 field exercise to ensure minimal information loss by the participants due to a time lag between the event and the survey. The user survey can be found in Appendix A.

4. Range Performance Evaluation

The analysis conducted in this study is based on a comparative evaluation between the experimental groups, those units given a mission brief using LeatherNet prior to conducting the Range 400 exercise, and the control groups, those units given a mission brief using only a map and aerial photo study. The comparison of the two groups is made by comparing the percentage of the 31 training objectives for Range 400, as developed by the TEECG staff, that are successfully accomplished by each group. The Range 400 evaluation worksheet is included in Appendix B. Assigning scores to the evaluation worksheet was performed by a single SME, Major Newell of the TEECG. The best alternative training method is determined by the alternative with the highest average percentage of training objectives successfully accomplished. In some instances, not all 31 objectives could be measured due to the absence of certain sub-units conducting the exercise. For example, the

absence of Dragon missile teams precludes their evaluation. In these instances, the total score for the unit was based on the percentage of remaining objective successfully accomplished. The number of training objectives evaluated for the eight experimental and four control groups ranged from 28 to 31.

If the experimental groups demonstrate a higher achievement of training objectives to a statistically significant degree, it can be assumed a positive transfer of military value has occurred. However, nothing can be inferred about the transfer as a function of the amount of exposure to LeatherNet. To do so would require several different units to experience LeatherNet exposures of different time lengths and subsequent evaluation on the range. [Ref. 22: p. 30]

5. Threats to Validity

Validity refers to the extent to which the user surveys and performance evaluations actually measure the true benefits the users derive from exposure to LeatherNet. To answer the basic research questions, numerous investigate questions were considered by the author. These questions were pretested to eliminate ambiguous questions and to detect other weaknesses in the survey instrument, and refined into the questions found on the survey included in Appendix A. To enhance content validity, a review of the user survey by SME within TEECG was conducted to ensure adequate coverage of the questions under study. The performance evaluation forms for Range 400 used in this study were developed by TEECG prior to this study and are considered to be adequate to measure performance since they have been developed by the SME responsible for evaluating Range 400 exercises as part of their official duties.

The study consists of a post-test only control group experiment. No performance pretest was conducted with either group. The control and experimental groups, consisting of infantry company command elements and subordinate platoon and section leaders, were determined by random selection. In a post-test only control group study, normally the internal threats to validity from history, maturation, selection, and statistical regression are adequately controlled by random assignment of groups. [Ref. 25: p. 359-364]

Despite efforts to promote internal validity, the test environment experienced during

this research presented certain threats to the validity of the experiment used to measure the benefits of LeatherNet. Ideally, neither group would be exposed to any information source concerning the Range 400 exercise than that which is normally available to company-sized units prior to an attack upon enemy held territory. Typically, this information would consist only of intelligence summaries from higher headquarters, aerial photos, and map studies. Both groups received all of these types of information with the experimental group receiving additional information available through the use of LeatherNet. There were, however, no effective means to control access to information sources not normally available in a hostile environment. Prior to conducting the exercise, units could, and in many instances did, gain additional information through physical reconnaissance of Range 400, observing other units conducting the Range 400 exercise, and receiving advice from individuals and units that had previously run the range. If the control units chose to exploit these sources of information, it could negate the ability to measure the benefits of using LeatherNet since this information is similar to the information LeatherNet provides.

The manner in which the TEECG conducts its mission briefs for all units prior to the exercise effectively reduces the possibility of critical errors by the exercising units, and therefore, tends to diminish disparity that might normally be observed between the exercise and control groups. The TEECG's purpose is to assist and evaluate unit training and their efforts are often focused on helping units train correctly, rather than allowing units to fail due to lack of experience and simply giving them an evaluation of their shortcomings. As such, training exercise briefs often includes instruction that is prescriptive in nature, causing units to execute very similar plans with little variation due to the suggestive remarks. For example, supporting weapons such as mortars and heavy machine guns are employed from essentially the same positions on Range 400 by nearly every unit. The reasons for this are not only due to suggestive remarks, but suggestive names for terrain features such as Machine Gun Hill. Specific instructions for weapons employment were also given that left little room for variance, due to training safety considerations. Under these circumstances, the ability of LeatherNet to influence performance tends to be reduced.

Other influences upon unit performance evaluation that could not be controlled

include the amount of ammunition available to the units and the personnel used to conduct the evaluation. When ammunition availability is limited, planning is essential to performance to ensure that ammunition remains available in adequate amounts at critical moments of the exercise to ensure fire support is available. However, the author observed some units conducting the range with up to three times the normal allotment of some ammunition types. Such abundant supplies of ammunition give the units a performance edge that enables them overcome the lack of information and planning prior to the exercise. An internal validity threat also exists in the fact that the performance evaluations were conducted by a single individual. The evaluator's boredom, experience, anticipation, bias, and fatigue all have the potential to influence results.

It is acknowledged that it is difficult to conduct an experimental test in an operational setting. The problems include difficulty in establishing experimental control in manipulating the events for experimental purposes. In order to achieve this objective, the cost becomes prohibitive as it requires using units that are solely dedicated to the test process, as well as the expenditure of large amounts of ammunition to replicate a combat scenario. To do this for the single purpose of testing LeatherNet was considered impractical for a system still under development.

B. DATA COLLECTION

1. Questionnaire Development

A user survey questionnaire was developed to measure the user's perception of the value of the various aspects of LeatherNet as a mission planning and mission briefing tool. Many of the specific questions were developed from a questionnaire previously used by Major Newell to conduct user opinion surveys regarding the use of LeatherNet to conduct an estimate of the situation. This questionnaire was revised, reformatted, and expanded to cover other aspects of this research. The user survey was pretested at the Naval Postgraduate School using Marine personnel, several of whom had previous Range 400 experience, and with the TEECG personnel. Pretesting was necessary to ensure the questions were understandable, unambiguous, and in an easily readable format. Numerous revisions

were necessary before the final version could be made.

2. Types of Data Collected

Questions 1 - 34, 39, and 41 - 44 provide ordinal data using five point Likert scales to record the respondent's answers. The respondents are asked to rank their degree of agreement with the question statements, ranking from strongly disagree to strongly agree. Question 38 also provides ordinal data but does so by asking the respondents to rank, by order of importance, various potential capabilities of LeatherNet. The remainder of the survey, questions 35 -37 and 40, provide nominal data. These questions require the respondents to list LeatherNet characteristics that they found most useful, least useful or thought should be developed for the system. Nominal data was derived by grouping the characteristics that the respondents listed by category. The following subsections describe the purpose for the specific questions used in the user survey.

3. Determine the User's Experience Level with Range 400.

Questions 1 - 8 ask the user to indicate his professional experience level, the tactical proficiency of his unit, and his familiarity with Range 400. The purpose for these questions is to test the hypothesis that LeatherNet is most useful as a mission planning tool to those personnel whom are the least experienced and familiar with Range 400. In order to obtain an overall rating for an individual respondent's experience and familiarity, the various questions are weighted according to their relevance to professional experience and Range 400 familiarity. The weights were assigned through the use of the author's and the TEECG SME's judgement after using pairwise comparisons between the criteria to determine their relative importance as it relates to experience To obtain the overall experience and familiarity of the user, the scores of all the questions were summed to provide an aggregate experience and familiarity score. The possible scoring range for experience and familiarity ranges from 1, for least experienced; to 100, for most experienced. Table 2, on the following page, indicates how questions 1-8 of the user survey were weighted according to the respondent's answers.

Question 1	**> 12**	**9 - 12**	**6 - 9**	**3 - 6**	**< 3**
Scores	**5**	**4**	**3**	**2**	**1**
Question 2	**>24**	**18 - 24**	**12 - 18**	**6 -12**	**<6**
Scores	**10**	**8**	**6**	**3**	**0**
Question 3	**Yes**	**No**			
Scores	**20**	**0**			
Question 4	**> 10**	**7 - 10**	**4 - 6**	**1 - 3**	**<1**
Scores	**15**	**12**	**8**	**4**	**0**
Question 5	**Far Above**	**Above Ave.**	**Average**	**Below Ave.**	**Far Below**
Scores	**15**	**12**	**8**	**4**	**0**
Question 6	**Yes**	**No**			
Scores	**15**	**0**			
Question 7	**Yes**	**No**			
Scores	**10**	**0**			
Question 8	**Yes**	**No**			
Scores	**10**	**0**			

Table 2. Determination of User Experience Through Assignment of Experience Scores (Bottom number in each cell) to Possible Responses (Top portion of each cell) to Survey Questions 1-8

The top portion of each cell represents a possible response to each question and the bottom number reflects the experience score assigned to the respondent if he selected that particular answer. A sum of all responses to questions 1-8 is used to assign an overall experience score for each respondent.

Admittedly, these questions are not all inclusive in determining experience and familiarity but represent those factors which SME feel have the greatest degree of influence

on experience as it relates to performance on Range 400. Additionally, while this method of assigning weights to the experience and familiarity criteria is subjective, it is used due to a lack of a suitable alternative.

4. Determine the Ability of LeatherNet to Conduct an Estimate of the Situation

Questions 9 -23 ask the respondent his opinion of the degree to which LeatherNet helped his understanding of the enemy situation, terrain, fire support, time and space issues, and logistical considerations.

5. Determine the Realism of the LeatherNet Terrain

The users are asked in question 24 to indicate how closely the LeatherNet terrain represents the real terrain on Range 400.

6. Determine How the Information Provided by LeatherNet is Used by the Test Participants

Questions 25, 26, 41, and 42 ask if critical information was provided by LeatherNet and if that information influenced the respondent's plan of attack. Questions 41 and 42 were added to the end of the survey because they might be considered "hot button" issues. The questions ask the respondent to indicate if they failed to change their plan of attack despite the fact that LeatherNet provided information indicating they should do so. The purpose for the questions is to gauge the level of trust users place in the information LeatherNet provides.

7. Determine the Potential of LeatherNet to be a Mission Planning and Rehearsal Tool

The respondents are asked, in questions 27 - 30, to indicate the degree to which LeatherNet demonstrates the potential to be an effective training tool for Marines to evaluate tactical alternatives, conduct mission planning, and mission rehearsal.

8. Determine the Value of LeatherNet Under Different Circumstances of Use

The respondents are asked their opinion of LeatherNet's value, in questions 31 - 34, if they had no other source of information regarding Range 400, if they had the opportunity to expose more of their own Marines to the system, and if they were allowed to use LeatherNet at their home base prior to CAX.

9. Determine the Most and Least Useful Features of LeatherNet and What Features and Changes can be Implemented to Make LeatherNet More Useful

The respondents are asked in questions 35 - 37 and 40 to provide written comments concerning what features they felt were the most and least useful, what features should be added, and what changes should be made to LeatherNet to make the system more useful.

10. Determine the Ranking, in Order of Importance, of the Perceived Abilities of LeatherNet to Overcome the Limitations of Live Fire Training

Question 38 asks the respondent to rank, in order of importance, eight perceived abilities of LeatherNet to overcome the limitations of live fire training. The perceived ability of LeatherNet to overcome the limitations of live fire training were determined through previous research on the system. The perceived limitations of live fire training include lack of realistic and interactive enemy forces, limited feedback on weapons employment, safety constraints, lack of adequate range facilities and limited ability to reconstruct exercises. [Ref. 26: p. 48]

11. Determine the Respondents Attitude Toward LeatherNet

Questions 43 and 44 ask the respondent to indicate his attitude toward LeatherNet prior to using the system and whether his attitude is more positive after exposure. The purpose of these questions is to determine if there is an existing bias towards using simulators for training and to determine LeatherNet's degree of acceptance among its users.

C. ANALYSIS PLAN

1. Survey Data

The data collected through user surveys in most cases are ordinal data. The questions in the survey rely upon opinion scales to register the participants level of agreement to various statements. To determine the central tendency of all respondents the median value is used and is presented in bar graphs to show the various levels of agreement with the statements in the questionnaire. The median is the most appropriate measure to determine the center for ordinal data and provides resistance to extreme scores. In some cases, the percentages of respondents giving particular answers is given to further clarify the distribution of responses and levels of agreement.

The level of experience, as calculated from survey questions 1 - 8, is further analyzed through the use of Spearman's Rho, to determine if there is a correlation between the level of experience of a user and the perceived benefits of using LeatherNet. Spearman's Rho is used to test the null hypothesis, that there is no difference between a participant's experience and the degree to which LeatherNet provides critical information and influences the user's plan of attack [Ref. 25: p. 507-509]. The user's experience score is correlated with his responses to questions 25 and 26 to make this determination.

2. User Performance Data

Performance scores for the units using LeatherNet and the control units are compared to determine if there is a quantitative performance differential between the units using LeatherNet to conduct mission planning and the control groups, units with no LeatherNet exposure. The comparison of the two groups is made by comparing the percentage of the 31 training objectives for Range 400, as developed by the TEECG staff, that are successfully accomplished by each group. The evaluation sheet for Range 400 is included in Appendix B.

Due to the small sample sizes involved, an n of four for the control group and an n of eight for the experimental group, the t test is used to test for a statistically significant difference in the mean percentage of training objectives successfully completed by each group. The t test is chosen because the data, or performance scores, are interval level data and the samples are independent. Use of the t test assumes normally distributed populations and equal population variances [Ref. 25: p. 449-451]. This test is designed to test the null hypothesis, that there is no difference in performance on the Range 400 exercise for the units using LeatherNet as compared to the units without LeatherNet exposure. The alternative hypothesis is that using LeatherNet does make a difference in performance.

V. DATA ANALYSIS

A. USER PERCEPTIONS

1. Description of the Chart Data

The bar charts used in this chapter use numbers 1 - 5 to represent the user's level of agreement with the survey questions. The numbers translate as follows: 1 - Strongly Disagree, 2 - Disagree, 3 - Neither Agree nor Disagree, 4 - Agree, 5 - Strongly Agree. Some charts do not display bars for all five numbers which indicates that no test participants selected the response category represented by the missing number.

2. Assessment of LeatherNet as a Tool to Conduct an Estimate of the Situation.

The user's perception of using LeatherNet as a tool to conduct an estimate of the situation is generally positive. The median value of all responses to survey questions 9 - 23 are displayed in Chart 1.

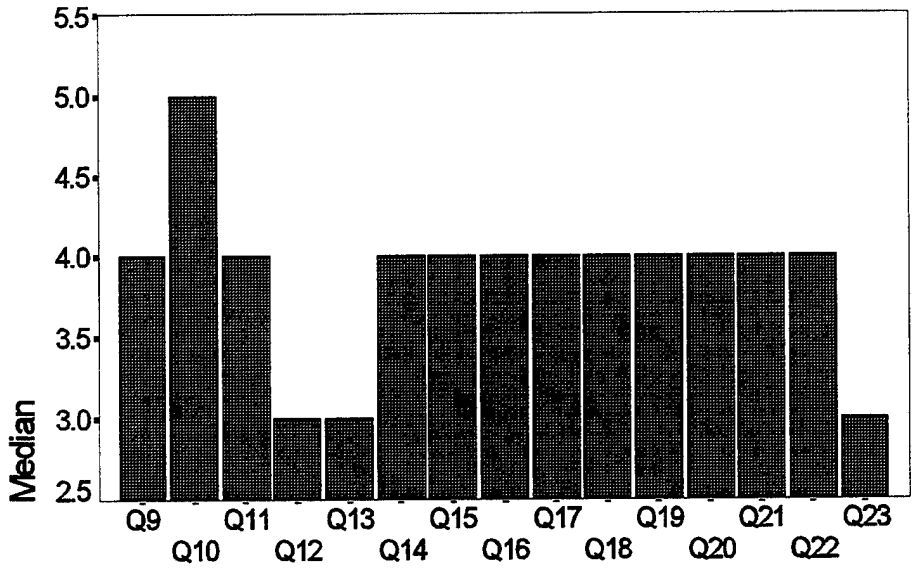

Chart 1. Assessment of LeatherNet for Conducting an Estimate of the Situation

Of all the elements of conducting an estimate of the situation, the users agreed most strongly that LeatherNet improves their understanding of the enemies fields of fire (question 10) with 67% of all respondents answering "strongly agree." The bar for question 10, as

shown in Chart 1, indicates the median value was 5 The respondents tended to "agree" that LeatherNet improved their understanding of most of the other aspects of conducting an estimate of the situation, particularly friendly avenues of approach (question 11) , friendly fields of fire (question 15), and shift/cease fire points (question 19). For these three aspects, over 80% of all test participants agreed or strongly agreed that LeatherNet improved their understanding of them. The test participants had a generally neutral opinion regarding an improved understanding of obstacles (question 12), enemy avenues of approach for counterattacks (question 13), and ammunition requirements (qustion 23) as indicted by the median values of three to each of these questions.

3. Assessment of LeatherNet Terrain

When asked if the LeatherNet terrain closely matched the Range 400 terrain (question 24), 81% of all the respondents either agreed or strongly agreed that it closely matched the real terrain. The median value was 4 or "agree." Only one respondent disagreed. However, it should be noted that several respondents thought that the best way to improve LeatherNet would be to refine the terrain resolution to better show the microterrain. Many test participants thought that the terrain tended to look "cartoonish" up close and that it was not possible to determine the type of ground material such as soil, sand, or rock.

4. Assessment of LeatherNet Information Usage

Charts 2-5 show the distribution of the responses to survey questions 25, 26, 41, and 42. An assessment of whether critical information was provided by LeatherNet will be made followed by an assessment of whether that information influenced the final attck plan. The questions were in inverse order on the questionnaire which is why question 26 is addressed here first. The distribution of responses to question 26 regarding whether LeatherNet provides critical information is shown in Chart 2. The fact that 65% of all responses were greater than or equal to the median value of four, indicates there is general agreement that LeatherNet provided the respondents with critical information that was previously unknown to them. The claim that they were able to gain critical information is important, particularly in light of the fact that the respondents had ample alternative sources of information regarding the exercise. Despite the use of map studies, aerial photo studies, and in many

cases, gathering information from fellow commanders who had previously run the range and even physically walking the ground prior to the exercise, they were still able to obtain previously unknown information from LeatherNet. The reason for the knowledge gain is probably due to the systems ability to present visually that information normally obtained by one's imagination, such as weapons fire fans.

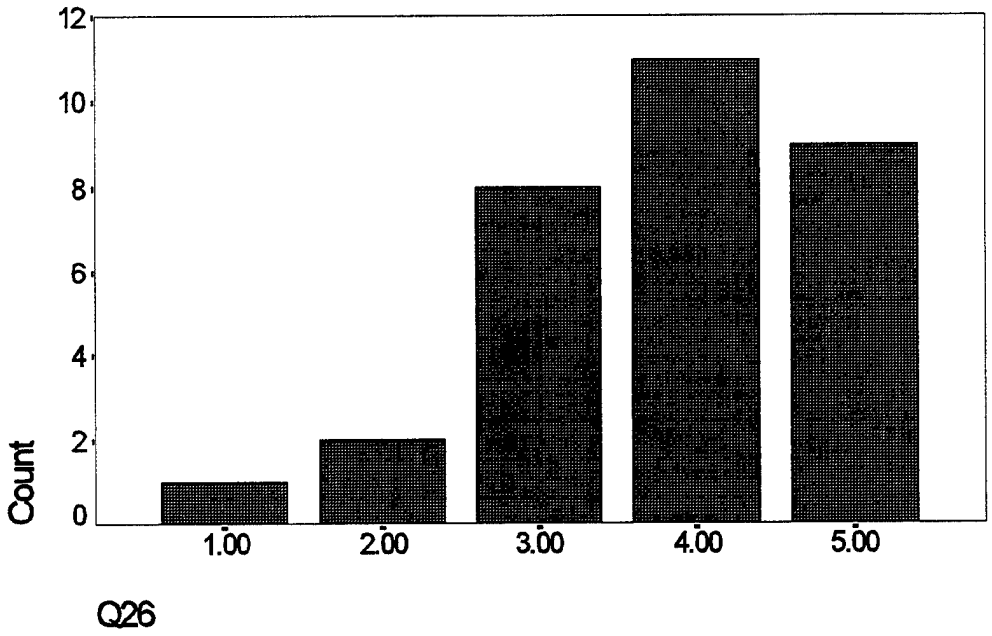

Chart 2. Assessment of Whether LeatherNet Provides Critical Information

The responses to question 25 shown in Chart 3, however, indicate that there was only moderate tendency for the additional information provided by LeatherNet to influence the final plan of attack.The median value was four, with 52% of respondents claiming LeatherNet influenced their plans. The fact that more respondents claimed to have gained critical information than changed their plans based on that information may be explained in part by the lack of freedom to alter plans due to range regulations and other constraints placed upon the participants. An alternate explanation would be some lack of user confidence in the system, but responses to questions 41, 42, and 44 fail to support this idea.

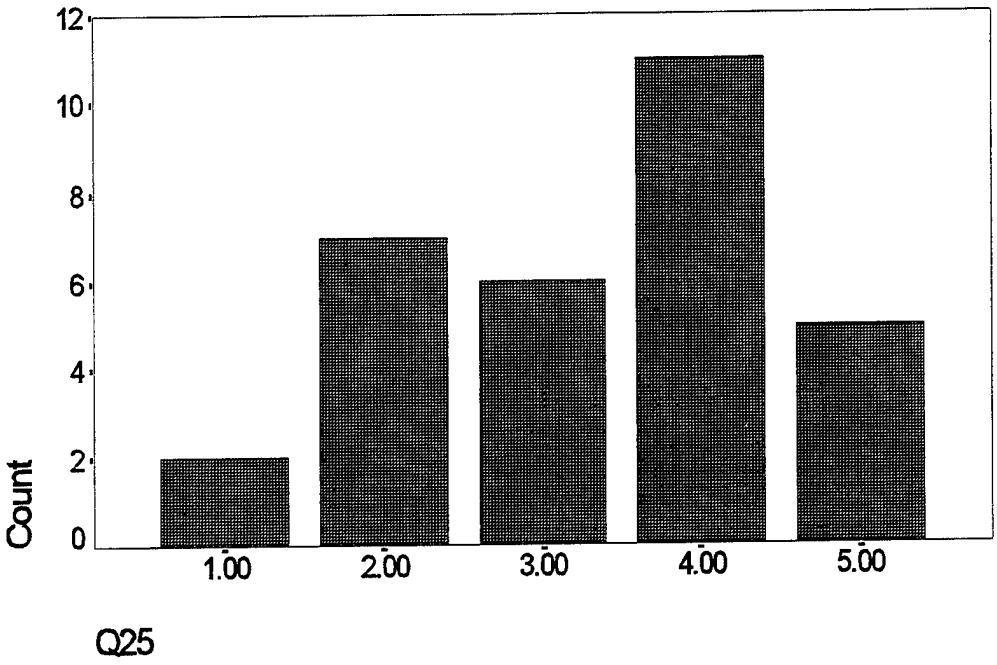

Chart 3. Assessment of LeatherNet's Influence on the Final Plan of Attack

The distribution of responses for question 41, shown in Chart 4, indicates some respondent discomfort in relying upon LeatherNet to evaluate their plan of attack because they were unfamiliar with the system. While the median response of three indicates neither comfort nor discomfort as the central tendency, 19% of the respondents indicated they did have some degree of discomfort. However, the responses to question 42, shown in Chart 5, indicate that nearly all respondents disagree or express neither agreement nor disagreement with the statement that they "did not change their plan of attack because they felt they could not trust LeatherNet results for use in a real exercise." Only one respondent agreed that he did not alter his plan of attack because he felt he could not trust LeatherNet, and none strongly agreed. The assumption here could be that, while the system was unfamiliar to the users, the presentation of information appears to be authoritative and reliable enough for planning purposes. Before reaching this conclusion, however, it would be wise to consider that Marine officers may not desire to reveal that they did not change a plan of attack in the face of information indicating that that was the proper course of action.

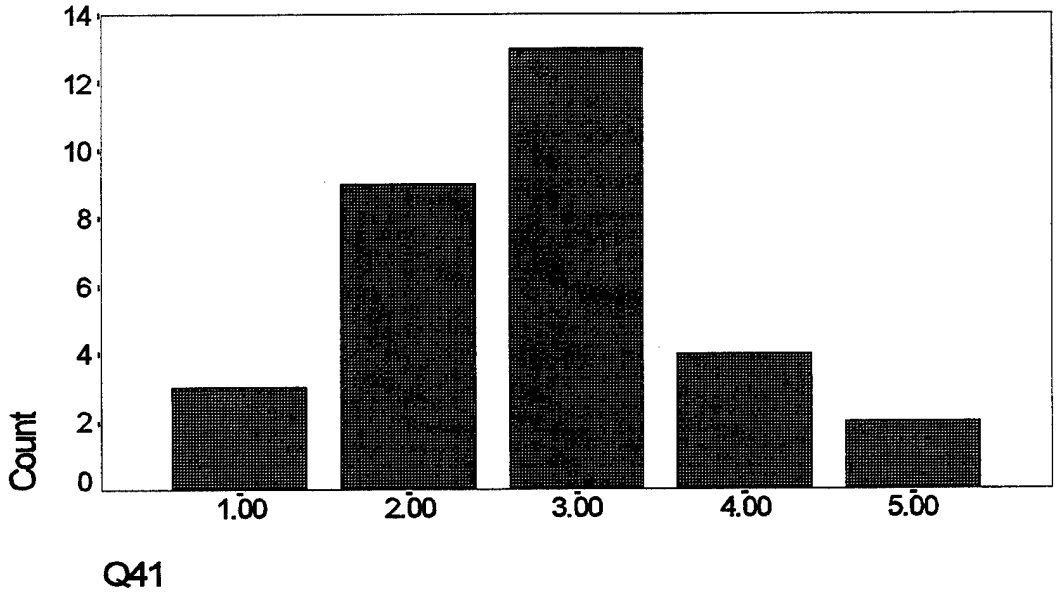

Chart 4. Responses to Question 41 Regarding Whether the Respondents Felt Uncomfortable Using LeatherNet to Evalauate a Plan of Attack

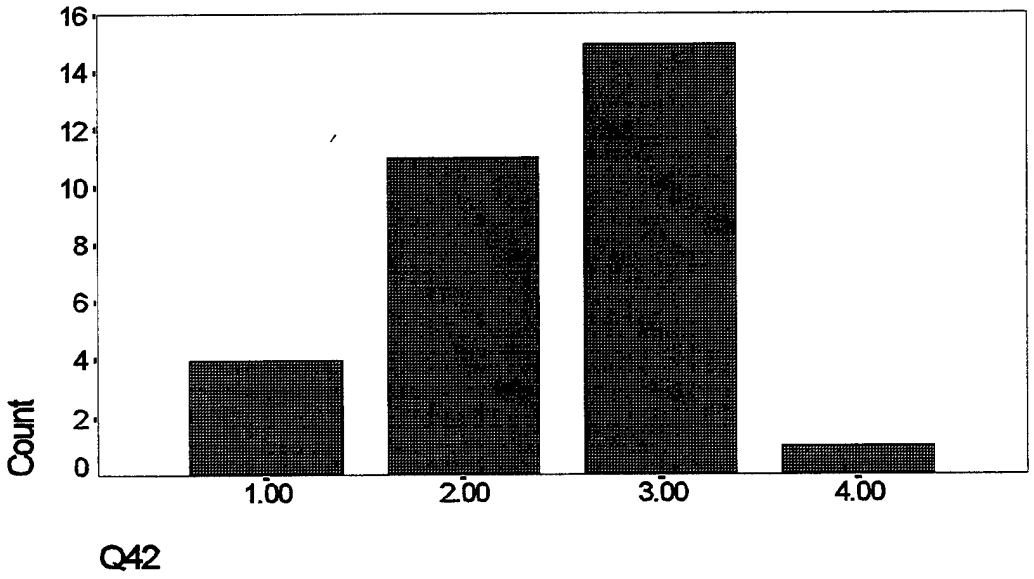

Chart 5. Responses to Question 42 Concerning Whether the Respondents Failed to Use LeatherNet Information in the Final Plan of Attack Due to Lack of Trust in the System

Spearman's Rho was used to determine if a correlation exists between the user's experience level and the degree to which LeatherNet influenced the user's final attack plan and provided previously unknown critical information. Spearman's Rho is used to test the null hypothesis, that there is no relationship between a participant's experience and the degree to which LeatherNet provides critical information and influences the user's plan of attack. It was expected that the alternative hypothesis, that there is a relationship between a user's experience and the degree to which LeatherNet influences the plan of attack and provides critical information, would prove to be true. This expectation was based on the typical tendency for more experienced personnel to rely upon their own skills and methods rather than adopt a planning tool of unknown value. Upon conducting the test, Spearman's Rho values of .0287 and -.1302 were calculated for questions 25 and 26 respectively. A Spearman's Rho of 0 signifies no correlation between variables, whereas a Spearman's Rho of plus or minus 1 signifies total correlation. It can easily be seen that no significant correlation exists between a user's experience and LeatherNet's ability to influence the his final attack plan and provide critical information to him. Therefore, we fail to reject the null hypothesis. In fact, to be 95 % confident that the null hypothesis is rejected only when it is indeed false, a P-value of .05 or smaller must be attained. The P-values of the calculated Spearman's Rho were .878 and .485 respectively.

The implication of these findings is that LeatherNet, as used in these tests, has value as a mission planning tool to the test participants regardless of their experience level and familiarity with Range 400. For training purposes, the indications are that company level staffs, of a wide range of experience levels, can improve their understanding of an exercise through simulation, and that LeatherNet training adds value to the CAX training program.

5. Assessment of LeatherNet as a Mission Planning and Rehearsal Tool

Charts 6-9 on the following pages display the distribution of responses to questions 27-30 of the user survey.

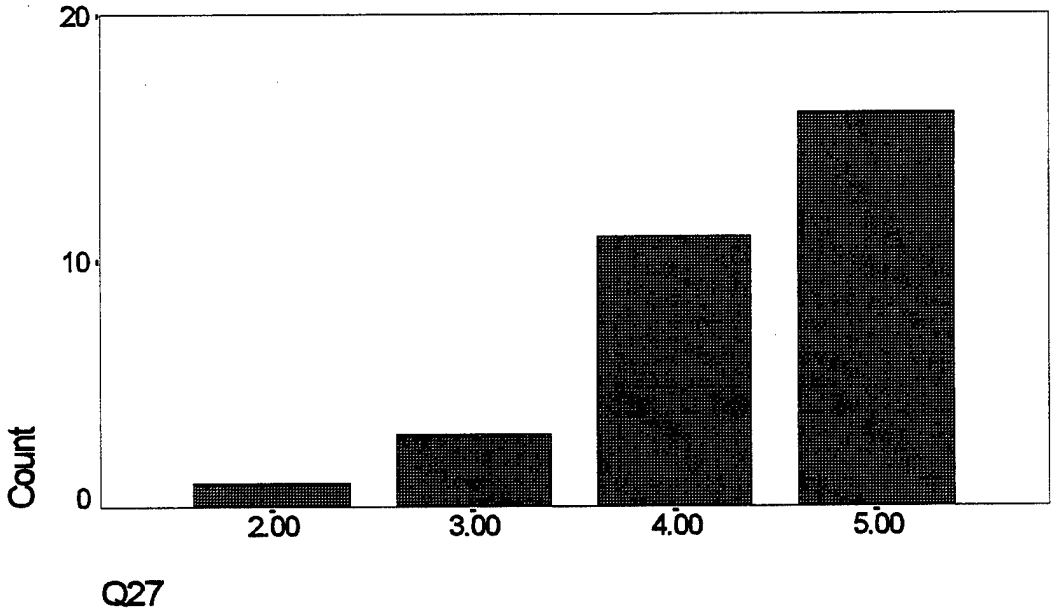

Chart 6. Assessment of LeatherNet's Potential as an Effective Mission Planning Tool

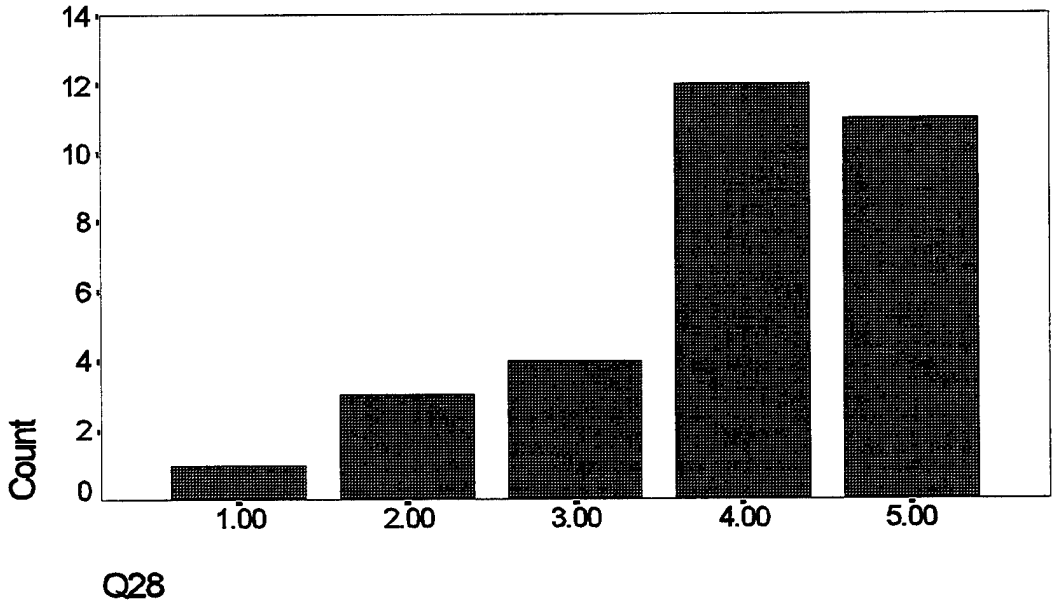

Chart 7. Assessment of LeatherNet's Potential to be an Effective Mission Rehearsal Tool

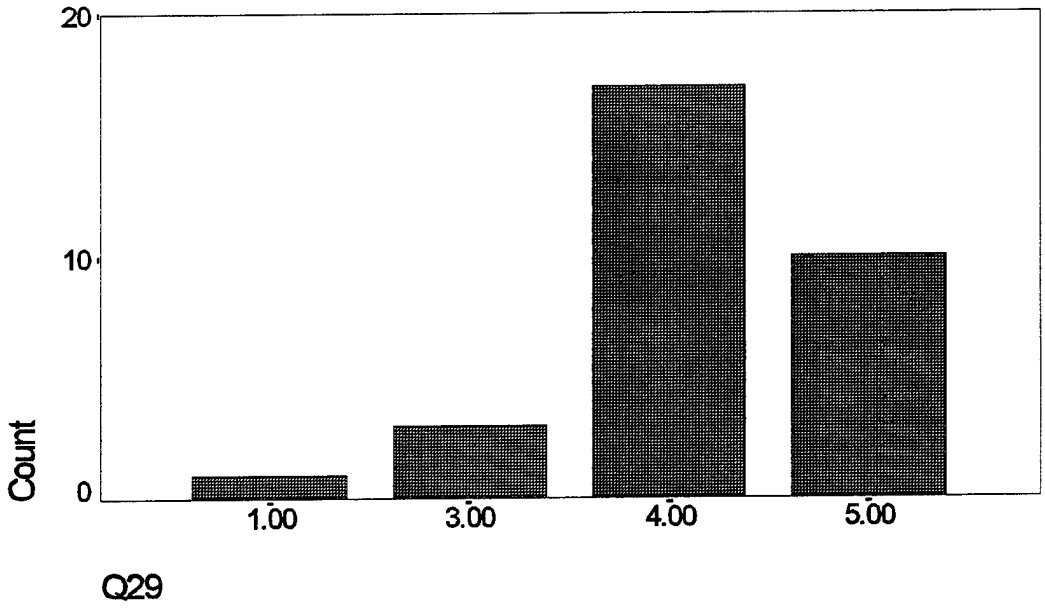

Chart 8. Assessment of Whether LeatherNet Provides Vital Information in Evaluating Tactical Alternatives

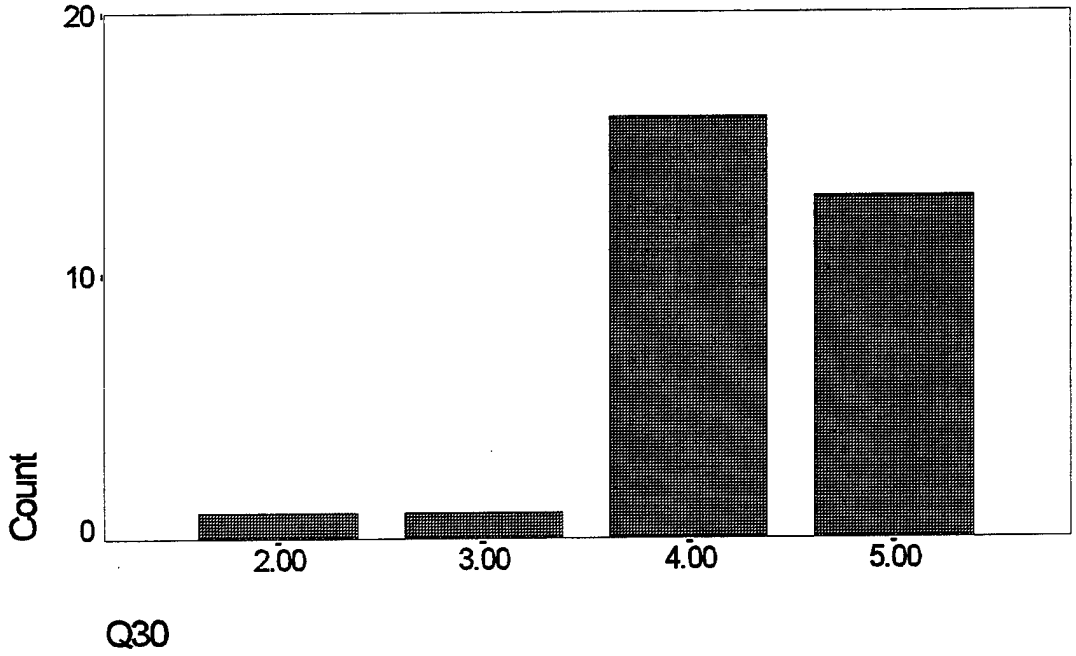

Chart 9. Assessment of LeatherNet's Potential to be an Effective Tool for Training Company Commanders and Their Staffs

Overall, the test participants believe that LeatherNet demonstrates the potential to be an effective mission planning and rehearsal tool, that it is effective for training company commanders and their staffs, and that it provides vital information for evaluating tactical alternatives. Less than 10% of all respondents expressed a negative or neutral response to questions 27, 29, and 30. The highest number of neutral and negative responses, totaling 25% of all responses, were given to question 28 regarding LeatherNet's potential to be an effective mission planning tool. This is probably due to the fact the participants did not rehearse their plans with the system, and were therefore only speculating about the systems potential in this regard based on the credibility of the other functions they observed.

6. Assessment of Possible Alternate Uses for LeatherNet

The respondents answers to questions 31 -34 indicate wide agreement that use of LeatherNet at their home bases, with more time to use the system, and with more of their personnel exposed to the system, would be beneficial. Furthermore, they agree that LeatherNet would be of more value if other sources of information concerning Range 400 were not available, such as having the ability to physically walk the range and get advice from other personnel who had completed a Range 400 exercise. Only 3-6% of all respondents disagreed with any of these four statements.

7. Assessment of the Most and Least Useful Aspects of LeatherNet

The most useful features of LeatherNet, according to the respondents answers to question 36 are listed below. The features are listed in decreasing order of importance as determined by the number of respondents listing each feature. The number of respondents listing each feature is given in parenthesis. It is important to remember that the users were not exposed to the full functionality of the system.

- The ability to display both friendly and enemy fields of fire and engagement areas (15)
- The ability to "walk the terrain" for reconnaissance purposes (12)
- The ability to visually display intelligence on the enemy (4)
- The ability to display avenues of approach (3)

The least useful features according to the respondent's answers to question 37 are as follows:

- Too many overlays and multi-color templates that are confusing (5)
- The possibility of depending on simulators for training at the expense of training in a real environment (3)
- The presentation of too much information, too fast, to be useful (2)
- Lack of details on microterrain such as resolution and surface type (2)

Below are the user's responses to question 35, listing in decreasing order of importance, the users opinions on how to improve the system. These opinion are based on having only used LeatherNet for mission planning and briefing.

- Develop an ability to war game against a realistic enemy (7)
- Refine the terrain to give more details on the microterrain and represent different types of ground material (5)
- Provide more details on the enemy forces (4)
- Expand the terrain database to cover other areas (2)
- Use at other bases (2)

It should be noted that with the exception of the microterrain issue, LeatherNet already provides, or will soon provide, all of the above listed functions.

8. Determine the Most Important LeatherNet Capabilities to Overcome the Perceived Limitations of Live Fire Training

The respondents ranking, in decreasing order of importance, of LeatherNet's perceived ability to overcome the perceived limitations of live fire training are displayed in list below.

- Ability to war game against a realistic, responsive enemy

- Ability to obtain quantitative feedback on the effectiveness of weapons employment
- Ability to train on simulated terrain in the abscence of real terrain
- Ability to reconstruct/replay an exercise for detailed debrief
- Ability to conduct the same exercise under varying conditions or to modify a plan and evaluate the outcome
- Ability to conduct "danger close' fire support
- Ability to evaluate a subordinate's performance
- Simulated casualty assessment

The order was determined by the median value of all respondent rankings. For those characteristics with the same median value, the mean value of the respondent's rankings was used to determine the order. The ability to war game against a realistic, responsive enemy was perceived to be, by a wide margin, the most important characteristic provided by LeatherNet that overcome the limitations of live fire training.

9. Assessment of the Respondent's Attitude Towards LeatherNet

Question 43 asks the test participants if they generally had a positive attitude toward LeatherNet prior to using the system and question 44 asks them if their attitude is more positive after using the system. As might be expected, the user's attitude is generally neutral towards LeatherNet prior to using the system which indicates a lack of bias for or against the system prior to use. In fact, none of the respondents disagreed with the statement that their attitude was generally positive although nearly 50% expressed a neutral opinion. The respondent's attitude towards LeatherNet was much more positive overall after exposure to the system with 77% of the test participants indicating a more positive attitude. Only one participant stated that his attitude was less positive after exposure. The attitudes expressed here tend to indicate high user acceptance of LeatherNet as a mission planning and briefing tool. The distribution of the responses to questions 43 and 44 are shown in Charts 10 and 11

respectively.

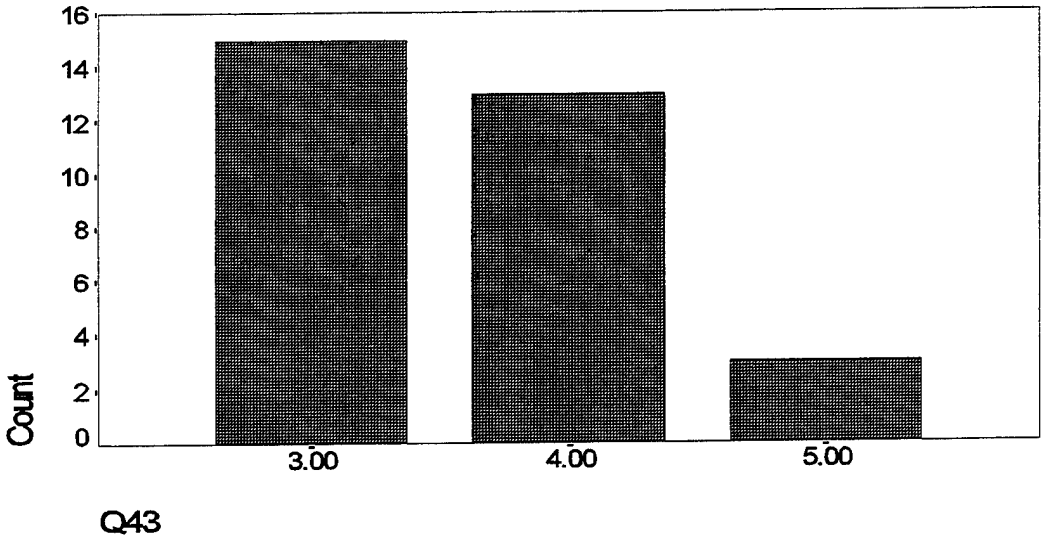

Chart 10. Assessment of the Respondents Attitude Towards LeatherNet Prior to Using the System

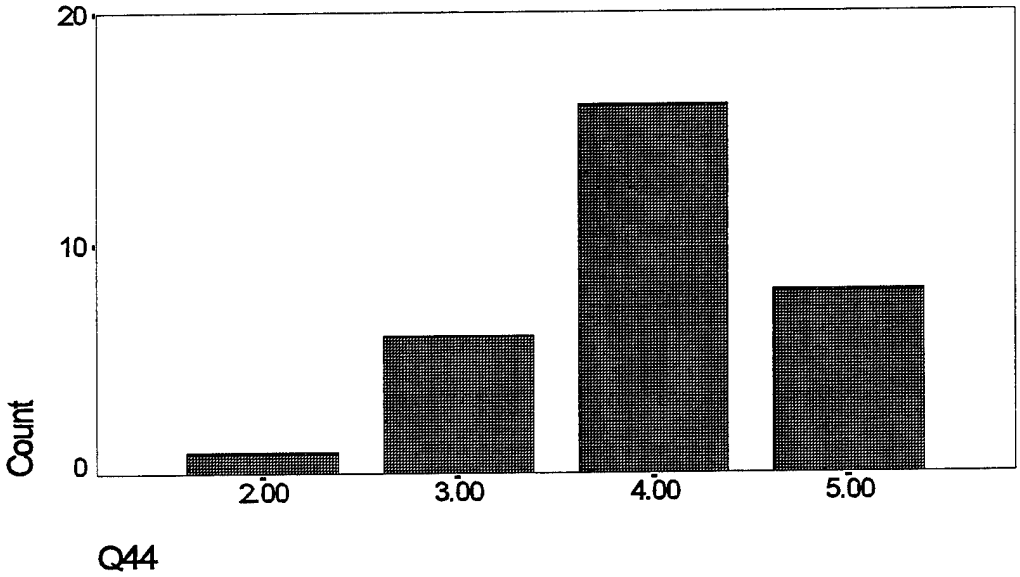

Chart 11. Assessment of Respondent's Attitude Towards LeatherNet After Exposure to the System

B. USER PERFORMANCE EVALUATION

1. Performance Testing Results

A total of 12 rifle companies from three regular infantry battalions and one reserve infantry battalion had their performance evaluated on Range 400 in connection with this evaluation of LeatherNet. One rifle company from each battalion served as the control group and received no LeatherNet training. Therefore, four control units and eight experimental units were sampled. Using the t test to test the null hypothesis, that no difference exists between the performance means of the two groups, revealed no statistically significant difference. The t value was calculated to be .179 with n - 1 degrees in each sample so that the total degrees of freedom equaled 10. Using a t distribution table, this value was compared to the critical value that ensures a 95% confidence that we reject the null hypothesis only when it is indeed false. That critical value was 2.228. The t value must be greater than the critical value to reject the null hypothesis. Therefore, we must fail to reject the null hypothesis at this level of confidence.

The control units averaged 78.5% of their objectives successfully completed while the experimental units achieved 79.6%. The small sample size can skew the results particularly in the case of the control units. Three of the control units averaged 71% of their objective achieved but the fourth control unit achieved 100%. The ability of this one unit to influence the overall results suggests the need for a larger sample size to ensure that the sample closely reflects the true characteristics of the population as a whole. If this one unit was eliminated from the study, the t test would reveal a statistically significant difference in the means at the 90% confidence level, but still not at the 95% level. Due to the fact that the performance evaluation relied upon the opinion of a single SME, the possibility also exists for the bias of the evaluator to have a profound effect on the test results as can be seen with the impact of one unit scoring 100%. While it is not being suggested that that is the case here, the possibility always exists in a subjective evaluation.

Other reasons may exist for the lack of variance between the experimental and control units performance. As mentioned earlier, lack of experimental control permitted external influences upon both the experimental and control units. Access to additional

information concerning the Range 400 exercise by the control units, such as the ability to conduct a physical reconnaissance, would tend to reduce and even negate any information advantage that the experimental units received from LeatherNet. Additionally, having more and even better information doesn't mean that the information is put to its best use. While the user surveys indicate that a large portion of the test participants gained critical information, and that the information influenced their final attack plans, the participants still must possess the necessary skills to put that information to effective use. For instance, if a test participant learned from LeatherNet that certain avenues of approach were vulnerable to enemy fires, the participant still must find a more suitable alternative and execute that alternative with skill to realize a positive effect. Major Newell, reflecting on the ability of commanders to use information presented to them during CAX training, stated; "giving a man tools doesn't make him a carpenter, but rather the skill with which he uses those tools." Having not been able to use LeatherNet to war game their plans, the test participants were left with only their normal conventional skills and imagination to finish planning and execute their plan of attack. Finally, the test participant were not free to exercise all the possible options in conducting the Range 400 exercise due to safety constraints and range regulations which limit their ability to take advantage of the information gained through LeatherNet.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. MISSION PLANNING AND BRIEFING CAPABILITIES

1. User Acceptance

The user surveys indicate that there is a high level of acceptance among the test participants for LeatherNet as a mission planning and briefing tool. The survey respondents generally agree that LeatherNet improves their ability to conduct an estimate of the situation and provides vital information. High user acceptance is supported by the large percentage of users who said the system provides critical information and that the information they received from LeatherNet influenced their final attack plan. The fact that 50% would risk altering their plan of attack based on information from a system they had no previous exposure to strongly suggests that the functionality of LeatherNet for mission planning purpose appears both authoritative and reliable. Further evidence of high user acceptance is derived from the fact that over 90% of all respondents agree that LeatherNet has the potential to be an effective mission planning tool, provides vital information in evaluating tactical alternatives, and demonstrates the potential to be an effective training tool for training company commanders and their staffs. Additionally, over 75% of the respondents had a more positive attitude toward the system after seeing it in operation.

2. Benefits Derived from LeatherNet

As mentioned, the users believe that the system provides critical information that was not known to them prior to using LeatherNet. The significance of this is that the respondents had ample opportunity to gain information concerning the Range 400 exercise from many other traditional sources, but still found that LeatherNet provided additional unknown information that was of a critical nature. The respondents indicated the ability to conduct "terrain walks" and the ability to display both enemy and friendly fire fans to be the most useful aspects of using LeatherNet to conduct an estimate of the situation. While they found LeatherNet useful for gaining information regarding most elements of an estimate of the situation they were less positive or expressed neutral sentiment that LeatherNet helped them understand obstacles, enemy avenues of approach for counterattacks, and ammunition

requirements. Finally, the test participants expressed nearly universal belief that LeatherNet has the potential to be an effective mission planning and COA analysis tool, and that it is effective for training unit leaders at the company level.

Unfortunately, no performance benefits could be quantified from using LeatherNet according to the results from the Range 400 evaluations despite the positive user appraisal of the system. It was not intended that empirical testing be conducted with a system under development and without the ability to exercise the necessary experimental control. Due to the cost, resources, and time necessary to perform this type of testing, it is neither desired nor practical at this point. It was thought, however, that early user testing prior to full completion would provide the opportunity for user feedback while the system remains under development. When this research began it was expected that a more comprehensive test could have been performed. However, developmental issues, resistance to using CAX units for more comprehensive testing, and the limited availability of CAX units to conduct the tests all combined to limit the ability to fully test the system. Several lessons, however, have been gained that can improve the quality of the test process for LeatherNet in the future.

B. RECOMMENDATIONS

1. System Testing

The Marine Corps is continuing to increase its interest and investment in the use of simulation technology to better prepare and train its forces. LeatherNet represents only a small portion of the overall effort and is primarily designed to be a demonstration project with a secondary purpose of providing an intuitively appealing training tool for CAX units. If the initial feedback from the survey conducted in conjunction with this research is any indication, LeatherNet has a good potential to successfully fulfill a role as a valuable training tool. How well LeatherNet may demonstrate its capabilities and technologies remains to be seen. While LeatherNet observers may have a qualitative feel that the system can provide effective mission planning, mission rehearsal, and "what if" COA analysis, there seems to be little or no data to quantify LeatherNet's effectiveness. Admittedly, it has proven to be a difficult task to quantify the training effectiveness of a virtual simulation system, particularly

one designed for collective training. In fact it is hard to quantify the training effectiveness of collective training alone, never mind evaluating it in combination with simulation.

In order to quantify the training effectiveness of virtual simulators such as LeatherNet and TTES, it is recommended that the Marine Corps follow the Army's lead in conducting user testing.. The Army is aware of the deficiency in quantifying the training effectiveness of its training simulators and has committed itself to conducting the most comprehensive test of a simulation system to date with its CCTT system. Although LeatherNet may be primarily a demonstration project, the best way to demonstrate the project is to quantify the results. The ability to say the system can save units X dollars while improving their ability to successfully complete Y training objectives by Z percent is a much more powerful promotion tool than simply saying we believe it improves training, based on user feedback. While it is recognized that the resources for testing most likely will only allow for a much scaled down version of the Army's test plans, tests can still be designed to provide quantitative data. Such data can be used to provide solid justification regarding future M&S investments.

For follow on tests, it is recommended that dedicated test units be assigned to the project during the test period, rather than using units distracted by other training and command commitments. Undedicated test units will tend to give the test process lower priority than their operational demands, and the ability to conduct the test properly will suffer accordingly. Secondly, experimental control needs to be exercised over the test units to eliminate outside sources of influence that can corrupt the results. Neither the control nor the experimental units should have access to outside information and assistance other than that information and assistance which the evaluators desire to allow each unit. Particularly, in the case of an exercise such as Range 400, neither group should be allowed to do a reconnaissance of the enemy held terrain nor collect advice from others who have just completed the exercise. Denying the control units the ability to collect intelligence not normally available on a battlefield will more likely show how much more valuable a virtual simulator can be in preparing for an exercise compared to preparing without if it is in fact more valuable. Conducting a true experiment, consisting of a pre-test to determine skill

levels, training on LeatherNet, and a post-test to determine post-training skill levels for the experimental group and a pre-test and post-test for the control group should be considered. Finally, incorporation of instrumented ranges, such as those being developed for the Emerald Light Project to assess the performance of the units in both the pre-test and post-test phases should also be considered. Instrumented ranges can provide data analysis of position and tracking of indirect fires and position and trigger-pulls of ground entities and direct fires. Developing a methodology to use this analysis to rate performance provides the possibility to eliminate, to a large degree, the subjective nature of evaluating collective training.

While this type of an experiment will most likely be expensive and time consuming to conduct, the units will be able to gain worthwhile training while providing valuable test data. Such data can also assist the Marine Corps modeling and simulation effort by providing information on how to improve our training simulators and where to focus our M&S development and procurement dollars .

2. Expansion of M&S Resources

The use of virtual simulation systems holds great promise to provide unique opportunities to overcome the current and future obstacles to training such as high cost and loss of training areas. The great majority of the test participants agreed that it would have been beneficial to have been able to use the LeatherNet system at their home base, to have been allowed more extensive use of the system, and to include more of their personnel in the simulation training. To make these desires a reality, the Marine Corps should continue to the development and implementation of both demonstration and training sites of DIS compliant simulators. Doing so will enable Fleet Marine Force (FMF) commands to train with and be exposed to what promises to be an increasingly important training alternative for combat forces. Such exposure can promote acceptance among the ranks of both our junior and senior leadership and perhaps smooth the way for further implementation.

Expansion of the terrain databases to incorporate other areas, particularly littoral areas is essential to enhancing the training value of virtual simulators such as LeatherNet for the Marine Corps. Current efforts to develop the Littoral Warfare Training Complex, including instrumented ranges, data processing and display capabilities, and the required

communication infrastructure is a step in the right direction. Without the modeling of the littoral terrain as well as the associated Marine Corps equipment, tactics, and command and control characteristics, the Marine Corps risks being left out as an effective participant in joint simulation initiatives and exercises. The only way to remain relevant in these initiatives is to devote the necessary resources to develop those systems and functionality that cannot be leveraged from the other services.

The Marine Corps faces a variety of training constraints that could potentially degrade the readiness of its forces. Investing in DIS compliant simulation systems will ensure that the FMF commands have access to world class training opportunities while preserving resources, in the long run, to conduct mission essential live fire training exercises such as those associated with the CAX program. The longer the Marine Corps takes to investigate the various simulation options and invest where the opportunities appear to be the most promising, the longer those systems will be denied to those forces that might benefit from them.

APPENDIX A. LEATHERNET USER SURVEY

7 April 96

Fellow Marine,

Your unit has been randomly selected to participate in user testing of LeatherNet. An important part of the process is a survey of your opinion toward this simulator and its value as a mission planning and mission training device. The survey is part of a study being conducted at the Naval Postgraduate School to determine the value of virtual reality simulators in helping ground units to train and prepare for combat missions.

Currently, LeatherNet represents the only operational simulator of its kind in the U.S. Marine Corps. Therefore, the results of this survey are important because they are the only data available concerning what the "Grunts" think of the system.

All responses will be kept confidential. Only the survey data will be compiled and no personal or unit data will be released from this survey.

Please answer all questions to the best of your ability. Thank you for your cooperation.

Tracy R. Hague
Major USMC

RANGE 400 / LEATHERNET LAB QUESTIONNAIRE

COMPANY:_____

BILLET:_____

RANK: _____

CAX #:_____

DATE IN LEATHERNET LAB:_____

DATE ON RANGE 400:_____

I. Experience Questions

1. How many years of active military service do you have?

   - O Fewer than 3 years
   - O 3 to 6 years
   - O 6 to 9 years
   - O 9 to 12 years
   - O More than 12 years

2. How long have you held your current billet?

   - O Fewer than 6 months
   - O 6 to 12 months
   - O 12 to 18 months
   - O 18 to 24 months
   - O Longer than 24 months

3. Have you personally run range 400 anytime prior to this CAX?

   - O Yes
   - O No

   If yes, when did you last run range 400? _____

4. How often does your company conduct live fire and maneuver exercises?

- O Fewer than once a year
- O 1 to 3 times a year
- O 4 to 6 times a year
- O 7 to 10 times a year
- O More than 10 times a year
- O Don't know

5. How would you rate your company's overall tactical proficiency?

- O Far below average
- O Below average
- O Average
- O Above average
- O Far above average

6. Did you physically walk any of the Range 400 terrain forward of Machine Gun Hill prior to the live fire exercise?

- O Yes
- O No

7. Did you receive advice on how to conduct the Range 400 exercise from other Marines in your unit who had previous experience on Range 400?

- O Yes
- O No

8. Did you observe other units conduct the Range 400 exercise during the current CAX prior to your company's Range 400 exercise?

- O Yes
- O No

II. LeatherNet User Questions

A. Ability to conduct an estimate of the situation

Questions 8 through 23 refer to the statement below.

The LeatherNet lab improved my understanding of the following information:

Enemy situation

9. Enemy positions

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

10. Enemy fields of fire

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

Terrain

11. Friendly avenues of approach

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

The LeatherNet lab improved my understanding of the following information:

12. Obstacles

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

13. Enemy avenues of approach for counterattacks

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

14. Potential friendly firing positions

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

Fire support

15. Fields of fire for friendly weapons from potential firing positions

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

16. Range fans for friendly weapons from potential firing positions

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

The LeatherNet lab improved my understanding of the following information:

17. Mortar sheaf's ability to suppress enemy positions

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

18. Machine gun target coverage

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

19. Shift/cease fire points

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

20. Weapon safety fans

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

Time/Space

21. Time exposed to enemy fire along avenues of approach

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

The LeatherNet lab improved my understanding of the following information:

22. Time required to execute movements along avenues of approach

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

Logistics

23. Ammunition requirements

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

B. Overall effectiveness of LeatherNet

24. The simulated terrain in LeatherNet closely matched the Range 400 terrain.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

25. The LeatherNet lab influenced my final attack plan.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

26. The LeatherNet lab provided critical information that was previously unknown to me.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

27. LeatherNet has the potential to be an effective mission planning tool.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

28. LeatherNet has the potential to be an effective mission rehearsal tool.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

29. LeatherNet provides vital information in evaluating tactical alternatives.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

30. LeatherNet demonstrates the potential to be an effective tool for training company commanders and their staffs.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

31. The LeatherNet lab would be more useful if we could use it at our home base just prior to CAX .

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

32. The LeatherNet lab would be more useful if we had more time to use the system to evaluate our plans.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

33. The LeatherNet lab would be more useful if more personnel in my unit had the opportunity to use the system.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

34. The LeatherNet lab would have been of more value in preparing for Range 400 if we did not have other means of obtaining information concerning the exercise such as our own reconnaissance or our fellow Marine's advice.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

35. What other changes can be made to make LeatherNet more useful?

_____
_____
_____
_____
_____
_____

36. What were the most useful features of LeatherNet?

_____
_____
_____
_____
_____
_____

37. What were the least useful features?

_____
_____
_____
_____
_____
_____

38. Please rank the following capabilities in order of importance (1 to indicate the most important, 8 to indicate the least important) Please note that you may have not been exposed to all of these capabilities. If that is the case, your ranking should reflect how important you believe it would be to have these capabilities.

A. Ability to war game against a realistic, responsive enemy ____

B. Quantitative feedback on effectiveness of weapons employment ____

C. Ability to reconstruct/replay an exercise for detailed debrief ____

D. Ability to conduct "danger close" fire support training ____

E. Ability to evaluate a subordinate's performance ____

F. Ability to train on simulated terrain in the absence of the real terrain (ie: aboard a ship) ____

G. Ability to conduct the same exercise under varying conditions or to modify a plan and evaluate its outcome ____

H. Simulated casualty assessment ____

39. It would have been beneficial to evaluate our plan of attack using all of the features listed in question 37.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

40. What other features would you like to see developed for LeatherNet?

_____
_____
_____
_____
_____
_____
_____

41. I felt uncomfortable relying on LeatherNet to evaluate my plan of attack because I was unfamiliar with computer simulators.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

42. I did not change my plan of attack because I was not sure I could trust the results of the LeatherNet lab in a real exercise.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

43. My attitude toward LeatherNet was generally positive prior to conducting the LeatherNet lab.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

44. My attitude toward LeatherNet is more positive now that I have seen it in operation.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
O	O	O	O	O

Please return this survey to Major Newell or the survey coordinator.
Thank you again for your cooperatio

APPENDIX B. RANGE 400 EVALUATION FORMS

UNIT_____ DATE_____

BASES OF FIRE/FIRING POSITION SELECTION.

Appropriate ranges to enemy positions.

Heavy machine guns YES NO

Machinegun section Y E S NO

Dragons. YES NO

Rifle platoon bases of fire. YES NO

COMMENTS:

_____
_____
_____
_____

ROUTE SELECTION.

Covered/concealed routes used to occupy Base of Fire/firing positions?

Heavy machine guns. YES NO

Machinegun section. YES NO

Dragons. YES NO

Rifle platoon bases of fire. YES NO

COMMENTS:

_____
_____
_____
_____

Covered and concealed avenue of approach used for assault element.

YES NO

COMMENTS:

_____

_____

_____

_____

SUPPORT OF MANEUVER.

Suppressive fires used in support of occupation of Base of Fire/firing positions.

Machinegun section. YES NO

Dragons. YES NO

Rifle platoon bases of fire. YES NO

COMMENTS:

_____

_____

_____

_____

Suppressive fire delivered on all enemy positions that could engage exposed movement of the assault element.

Breach of minefield and movement into wash. YES NO

Breach of wire. YES NO

Assault of western position. YES NO

Assault of center position. YES NO

Assault of CP position. YES NO

COMMENTS:

_____
_____
_____
_____

Obscuration delivered on enemy positions that could deliver fire on obstacle breaches.

Breach of minefield. YES NO

Breach of wire. YES NO

COMMENTS:

_____
_____
_____
_____

Counterfire delivered on enemy mortar position.

At beginning of attack/pre-H-Hour. YES NO

During breach of wire obstacle. YES NO

COMMENTS:

_____
_____
_____
_____

Delivery of suppressive fires effective.

Adequate coverage of enemy positions (i.e. mortar sheafs). YES NO

Appropriate machinegun gunnery techniques employed. YES NO

COMMENTS:

_____
_____
_____
_____

Fires shifted/ceased at appropriate times (by the unit, as close as possible without violating safety fans).

YES NO

COMMENTS:

_____
_____
_____
_____

No unnecessary fires (fires on enemy positions unable to engage friendlies).

YES NO

COMMENTS:

_____
_____
_____
_____

Firing units did not run out of ammunition before their mission was complete.

60mm mortars	YES NO
81mm mortars	YES NO
Machinegun section	YES NO
Heavy machine guns	YES NO
Assault platoons	YES NO

COMMENTS:

_____
_____
_____
_____

Appropriate positions were selected to observe/adjust mortar fires (STA/FST).

YES NO

COMMENTS:

_____
_____
_____
_____

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