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Virtual Simulation Support to the 1996 Defense Science Board Summer Study "Tactics and Technology for 21st Century Military Superiority"

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PREFACE

The Small Team Engagements on the 21st Century Battlefield project was performed for the 1996 Defense Science Board (DSB) Summer Study, "Tactics and Technology for 21st Century Military Superiority." The Institute for Defense Analyses (IDA) accomplished the work, with funding provided by the Defense Advanced Research Projects Agency (DARPA) and the Defense Modeling and Simulation Office (DMSO).

The Army's Simulation, Training and Instrumentation Command (STRICOM) provided some of the equipment and systems integration services and coordinated contractor support for the project. The Army Research Institute (ARI) developed the human performance evaluation criteria, provided observers to evaluate the human behavior of the players, and assisted in analyzing the data from the exercises. The U.S. Marine Corps and U.S. Army National Guard provided player participants. In addition, the U.S. Marine Corps provided fire controllers as part of the exercise control cell.

Margaret S. Salter and Robert L. Clover provided a critical review of this document and made valuable suggestions for improving or clarifying the report.

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SUMMARY

Through the virtual simulation of small, specially equipped and trained teams on the 21st Century battlefield at the Institute for Defense Analyses (IDA) Simulation Center, doctrinal concepts and technologies considered by the 1996 Defense Science Board (DSB) were evaluated and the value of human-in-the-loop simulations was demonstrated. The exercise was divided into trials designed to investigate parametric variations in small team size and composition, mission, organic sensor capabilities, and remote sensor suites.

The battlefield for this virtual simulation exercise portrayed the targeting elements of two small teams of two to three men each plus an intermediate headquarters and a task force headquarters. Army and Marine officers served as the participants. In some trials, teams were assigned missions to control an area of 5-km in radius. In other trials, the players were formed into subelements of a team and operated together in one control area, effectively halving the size of their mission. Sensor capabilities varied from providing rudimentary information to providing ground truth.

The geophysical aspects of this battlefield were created by digital terrain databases (TDBs). One TDB provided a desert-like environment, and the other TDB provided a European (mixed) environment with numerous tree lines and rolling hills. These databases also provided Global Positioning System (GPS) data corresponding to the terrain being portrayed. Modular semi-automated forces (ModSAFs) and adjunct models provided remote fires and sensors and also provided the enemy forces that included opposing tank, armored vehicle, truck-mounted, and dismounted platoons.

Individuals and subelements of the team were placed in portals that provided interfaces with the virtual environment. These interfaces enabled the individual(s) to walk, run, crawl, see, hear, and talk on the virtual battlefield in a near-transparent manner. The portals also had surrogate equipment interfaces for the items of individual and small team equipment that were depicted. The surrogate Personal Data Assistants (PDAs) and Maps of the Future (MOFs) were interfaced with associated digital radios and GPS receivers. These surrogates were employed in various combinations to assess their contribution to the team's combat capability.

The teams conducted seven combat operations, ranging in duration from 1 to 3 hours. During these battles, the teams received over 200 sensor reports and requested and controlled over 150 remote fire missions. Throughout the approximately 14 hours of combat, the teams were opposed by 48 tank, 55 Bronevaya Machina Piekhotas (BMPs)[1], 5 truck, and 68 dismounted platoons. This varied terrain, advanced technological capability, and opposing force (OPFOR) provided a data-rich environment for assessing small-team combat capabilities and limitations. Tactical and behavioral experts observed the trials, monitored participant activity, and evaluated mission performance. Data collection sources included the ModSAF datalogger, which recorded all the simulated events; observer observations and interviews; voice loggers; and a fire direction center (FDC) emulator that tracked fire support time lines.

A. CONCEPTS EXPLORED

The small teams' exercises compared two types of teams:

1. Teams of individuals who were assigned the same duties and the same technologically enhanced equipment
2. Teams of two- to three-man subelements, with each subelement member assigned specific duties and provided with the appropriate equipment.

The work load that the team could handle successfully also was assessed.

B. EQUIPMENT

During some of the small team combat operations, each team member was issued a surrogate PDA. During most of the operations, larger, laptop-size MOFs were issued to the team and element leaders to assess the utility of each type of equipment and the type of data and displays that were most useful and effective.

One team was placed in a simulated vehicular-mounted portal, and the other team was placed in a foot-mounted portal (treadport) to evaluate the effectiveness and ability of mounted and dismounted teams to accomplish assigned tasks.

The relative effectiveness of a laser range finder, which incorporated binoculars and an electronic compass, was compared with a similar piece of equipment that was integrated with a data entry device/radio and software that predicted the target's location at the projected time of impact of indirect fire based on the target's direction and speed. Fire

1 A BMP is a Russian infantry fighting vehicle.

request and fire control procedures between the team and the task force headquarters also were evaluated.

To compare the effectiveness of observations from the ground with observations from the air, surrogate tethered sensor platforms hosted optical sensors that allowed an assessment of the team's ability to observe the enemy, to direct fires, and to control its area with these elevated devices.

C. CONCEPT EXPLORATION METHODOLOGY

During each combat operation, operational and behavioral observers were positioned behind each portal to observe and record the team's activities. The team and OPFOR locations on the synthetic battlefield and the outcomes of remote fire missions were recorded automatically on a data logger. Following each combat operation, each team member completed a questionnaire and then participated in a systematic and comprehensive after action review (AAR) with the observers, subject matter experts, and the PDA and MOF software designers.

From insights gained during these AARs, team doctrine was modified and, periodically, the PDA and MOF functionality was enhanced. Insights about the doctrine and technology employed by the small teams were then developed for the DSB.

D. ANALYTICAL INSIGHTS

The STP21 Exercises provided insights in the following areas:

- General
  - The roles and responsibilities of the team and task force headquarters must be apportioned to optimize combat effectiveness.
  - While individual situational awareness should be enhanced, combat power is derived through teamwork.
  - A dismounted team was not effective in moving to a new location in a timely manner. The team needs a vehicle that can move quickly in restrictive terrain.
- Sensor Management
  - The key functions of dismounted teams were to detect and classify enemy forces that other sensor systems could not observe and to determine enemy intent.

- Battle damage assessment (BDA) should be provided by the remote sensor system, not the small team.
- In restrictive terrain, the stationary hovercraft with an optical sensor had reduced effectiveness beyond 2 km.

- Data Management
  - Distributed databases and a multicast communications system would enhance situational awareness and command and control (C2) by providing the right information when it is needed.
  - The team can validate a target and request fires, but the "system" should track and complete the engagement at the most appropriate time.
- Weapons Management
  - Small teams must have confidence in the fire support system. Without proper feedback, the C2 system becomes clogged with redundant requests for fire and information.
  - If targets are not tagged and tracked, weapons must engage within 2 to 5 minutes of the fire request; otherwise, the predicted target location may no longer be accurate.
  - The team had difficulty handling more than two targets at the same time.
  - Returning to a previous target to update location or to provide lasing may result in the loss of other targeting opportunities.
- Data Presentation
  - Near-real-time improvements to display and message formats were implemented during the design and runs of the virtual simulation. Immediate interaction between the players and the software designer enabled these improvements.
  - Control of large areas requires digital, scaleable maps of appropriate size that can perform distributed, automated battle management and terrain analysis.
  - Three different data entry and display devices were needed to produce a full capability for acquiring and engaging targets. These capabilities should be consolidated into one device that is optimized to support the conceptual doctrine.

E. THE UTILITY OF VIRTUAL SIMULATION

The virtual simulation employed in these exercises was useful in the following areas:

- Concept Exploration
  - Virtual simulation provides an environment for creating and experimenting with new doctrine, tactics, and techniques.
- Human Performance
  - Virtual simulation enables the investigation of individual work load (e.g., task management, skill definition, information management) and roles (e.g., sensor, shooter, fighter tradeoffs).
- Process Analysis
  - Virtual simulation is an appropriate technique for assessing new battlefield processes, such as sensor and weapons management. Sound process analysis ensures that new technology is used for developing new processes rather than for automating obsolete processes.
- System Specification
  - Development of the virtual simulation design requires an understanding of included processes, such as fire support, to the degree necessary to specify accurately the requirements for system design.

I. BACKGROUND

The 1996 Defense Science Board (DSB) Summer Study Task Force on Tactics and Technology for 21st Century Military Superiority[1] was formed to focus on the concept of enabling relatively small and rapidly deployable forces (or teams)—specially equipped and trained and supported by remote sensors and weapons—to accomplish missions that were until now only possible with much larger and massed forces.[2]

Current efforts on battlefield digitization use current doctrine to solve difficulties when conducting operations. Exploring new doctrine that digitization might enable has been given only modest thought because the digitization initiative—which focuses on communications, information processing, and data display—is considered too narrow. However, new technology thrusts are needed to support 21st Century doctrine, such as the Army's "Army After Next" and the Marine Corps' "Sea Dragon" concepts. Two of these technology thrusts address improvements in indirect fire support (IFS) and indirect sensor support (ISS).[3]

The problems that digitization is addressing are the same problems so aptly described by S.L.A. Marshall in his book *Men Against Fire*, which presents the travails of World War II infantry warfare. These problems included the universal lack of knowledge by troops in contact. Typically, engaged troops had no information about the disposition of either enemy or friendly forces in their vicinity. In modern parlance, virtually no *situational awareness* existed. These troops also had little knowledge of what is now called the *commander's intent*. Marshall described the consequences of this information deficit, and his revelations inspired major changes in Army training and doctrine in the post World War II era. At that time, the available solution was not to solve the information gaps but to

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[1] Many of the following thoughts were extracted from a White Paper prepared by Major General Jasper Welch (USAF-retired), who chaired the Modeling and Analysis Panel of the referenced 1996 DSB Summer Study.

[2] OUSD(AT) Memorandum, Subject: Terms of Reference -- Defense Science Board Summer Study Task Force on Tactics and Technology for 21st Century Military Superiority, 15 March 1996.

[3] Coined by Major General Jasper Welch (USAF-retired).

work around them with tactics, training, and doctrine. Only now can computation and communications technology be used to solve these situational awareness issues.

Understanding one other concept is necessary. This concept is generally called *empowerment.* In this context, empowerment means that every soldier is authorized to request and receive whatever information he thinks can help him follow his commander's intent. Given digitization, empowerment, and extremely effective and efficient IFS and ISS, entirely new doctrine and tactics can be supported.

Major technical advances still largely unexploited in land warfare fall into the following areas:

- Precision, lightweight, target-specific weapons and munitions
- High-resolution, lightweight, all- or most-weather sensors
- Digital processing and the transfer and storage of massive amounts of data
- User friendly graphical user interfaces (GUIs)
- Wide-band, interoperable, portable communications
- Commercial practices and protocols for networking.

A. ANALYSIS AND MODELING SUPPORT

The 1996 DSB Summer Study was unique in three different ways:

1. It was the largest study of its kind ever conducted. Over 150 people participated.
2. It focused on operational concepts and technology for the small unit and for the individual combatant. Past studies tended to focus on operational or strategic concepts at higher levels.
3. It looked beyond the technology that it addressed directly to recognize that current modeling and analysis capabilities were deficient for addressing the concepts enabled by information technologies. A special panel on modeling and analysis was formed within the study to investigate how new concepts should be analyzed.

Several analyses provided insight into the analyses of 21st Century warfighting concepts. Table I-1 lists these analyses.

Table I-1. Analyses of 21st Century Warfighting Concepts

Project	Lead
Impact of leading teams and managing indirect fires	Institute for Defense Analyses (IDA)
Required time lines for direct fires	Joint Precision Strike Demonstration
Base case and effect of expanding situational awareness and creating tracks between teams	Gama Corporation
Effect of direct control of sensor [unmanned aerial vehicle (UAV)] by teams	McDonnell-Douglas Corporation
Impact of mobility and sensor capabilities on team performance	Joint Warfighting Center
Mobility impact on team effectiveness; helicopter survivability	U.S. Army Training and Doctrine Command (TRADOC) Analysis Center
Effect of better situational awareness on weapons mix, kills, and losses	RAND Corporation

B. VIRTUAL SIMULATION

The analysis conducted at IDA's Simulation Center used virtual simulation and immersed small teams onto a 21st Century battlefield. The project was called Small Team Portal into the 21st Century (Virtual) Battlefield (STP21). The simulation excursions investigated the efficacy of the small team concept on a 2015 battlefield.

C. THE SMALL TEAM CONCEPT FOR STP21

The small team concept envisions groups of 4 to 12 soldiers that operate semi-autonomously on the battlefield by gathering information on enemy forces and managing attacks on these forces with remote sensors and remote fires. The teams can deploy clandestinely into positions as the only force in country (before the arrival of a larger force) or as a force far forward of the main force. They avoid direct combat because they have little self-defense capability. Mobility is by foot or light, wheeled vehicles. The small team employs limited organic sensors and air- or artillery-delivered remote sensors. The latter provide digital input to the small team via data entry and display devices. Long-range missiles, overhead orbiting platforms, tactical air, artillery, or naval gun fire (if it is in range) can provide firepower. The small team's mission is to prevent enemy movement through a large area, the size of which was one of the parameters of interest of the study.

The small team concept supports a larger concept of deploying a force early in a conflict with the smallest "footprint" possible, using many small teams with combat power derived from remote sensors and long-range fires. Groups of six teams working under an intermediate leader cooperate to deny enemy operations in an area that might otherwise require a battalion-size force. A task force of 30 or more small teams, for example, might be used to deny enemy access to a beachhead during the build-up phase of an operation.

II. SIMULATION DESIGN AND IMPLEMENTATION

A. SIMULATION EXERCISE

The STP21 simulation exercise addressed part of a battlefield that portrayed only the targeting elements of two small teams plus an intermediate headquarters and a task force headquarters. The exercise was divided into trials designed to investigate parametric variations in small team size and composition, mission, organic sensor capabilities, and remote sensor suites.

The teams varied in size from two to three individuals. Sometimes a team had the intermediate leader serving as a team member, and other times the team leader was independent. For several trials, teams were assigned missions to control an area of 5 km in radius. In other trials, both teams were told to operate together in one control area, effectively halving the size of their mission. Sensor capabilities varied from those that provided rudimentary information to those that provided ground truth.

In addition to these small team variations, trials were run on two different types of geography. The Ft. Hunter-Liggett terrain database (TDB) was a desert-like environment. The Synthetic Theater of War–Europe (STOW–E) TDB area around Hohenfels, Germany, was a European (mixed) environment with numerous tree lines and rolling hills.

B. EXCURSIONS–TRIALS

Seven record excursions or trials were accomplished but were limited by available resources (i.e., time, equipment, and funds). Although these trials provided many useful insights into the value of the small team concept, not enough trials could be run to provide analytical rigor as a basis for conclusions.

Trials covered a 2-week period and included different participants each week. The week consisted of one training day, three days of trials, and a day of after action reviews (AARs). The first week produced only one record trial because of simulation start-up issues. The second week resulted in six record trials. Table II-1 shows the daily trial schedule.

Table II-1. Daily Trial Schedule

Equipment Check
Orientation Briefing
Operations Order
Mission Planning
Communications Checks
EXECUTE MISSION
Questionnaires
AAR
Controller AAR

1. Participants

Active duty Marine and Reserve Component Army officers served as the subjects in these trials. Two Reserve Component Army captains were the primary participants during the first week. They were supplemented by Simulation Center staff personnel to produce two-man teams. Although only one record trial was achieved, the other preliminary trials resulted in many simulation system refinements and insights into tactical applications of the small team concept. During the second week, six Marine lieutenants were the participants.

2. Observers

Operational and behavioral analysts observed the trials. They monitored participant activity and evaluated how the participants performed their missions. In addition, data about the simulation events were captured for subsequent analysis.

Appendix A contains a detailed list of STP21 personnel.

C. THE SIMULATION FACILITY

The simulation facility included an exercise control area, two small team portals (STPs), and an intermediate team leader's portal. These stations were linked by digital radio, a distributed interactive simulation (DIS) network, and a separate digital communications network that supported data entry and display devices. Behind each portal were observer stations, where the observers could see and hear the participants. Figure II-1

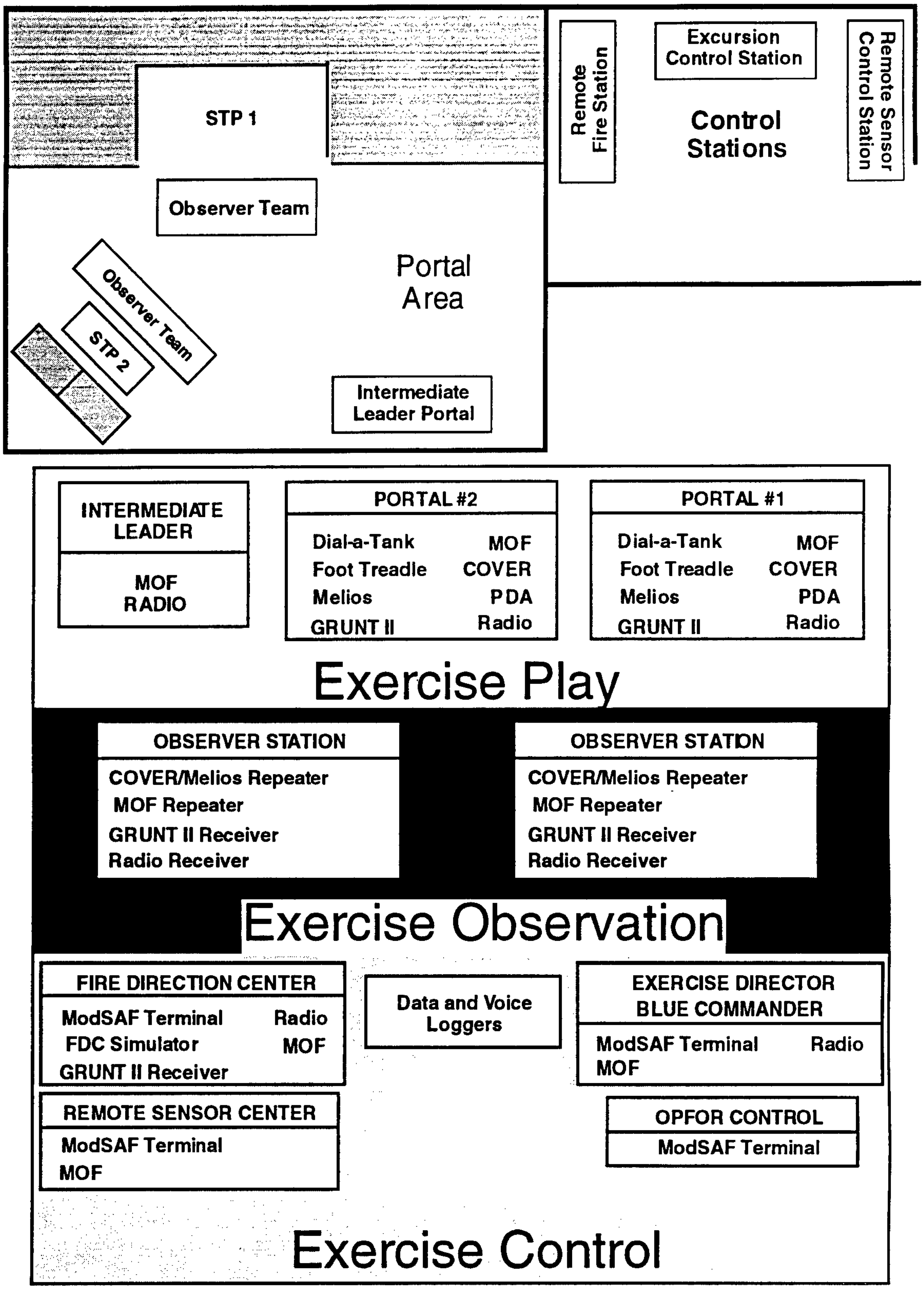

Figure II-1. Simulation Facility

shows the organization of the facility and the equipment available at each workstation. The following paragraphs describe each item. Appendix B provides a complete list of all the equipment and indicates how this equipment was used for STP21.

1. Equipment for the Small Team

The small teams had five items of equipment available to help them accomplish their mission. Each item of equipment was integrated with the simulation to enable seamless interaction by team players and the synthetic environment through the devices. All the devices were based on current technology but provided generic capabilities that could be extended in the simulation for additional capabilities, as desired. Generic capabilities included access to common databases, target acquisition and designation, navigation, and communications.

a. Personal Data Assistant (PDA)

The PDA is palm-size device that was initially issued to each team member and then only to some team members. It functions as a computer and a digital radio. A small screen provides a digital map of about 6 square kilometers of terrain. The user receives intelligence information and sends fire commands on the PDA. Communications are transmitted over the Single Channel Ground/Airborne Radio System (SINCGARS).

b. Melios

Melios is a hand-held binocular with an embedded laser range finder. It is capable of lazing on a target and returning range and azimuth. This information is transmitted automatically to the GRUNT II, where it is integrated into the call for fire (CFF). For this exercise, the Melios laser range finder also was assumed to be capable of designating targets for terminal guidance of certain munitions.

c. GRUNT II

The GRUNT II is a hand-held computer/communicator. It receives range and azimuth data from Melios or COVER and, based on its Global Positioning System (GPS) location, computes the location of the target. The user adds other fire request information and sends the CFF automatically to the fire direction center (FDC).

d. COVER

COVER is a tethered aerial sensor that is transported in the back of a team's vehicle and can be launch when it is at the halt. The sensor raises to a maximum elevation of 100 m and provides optical and thermal views of the area. This device can be flown slightly above treetops to avoid detection or can be extended higher to get a better view. COVER has a laser range finder, azimuth indicator, and a laser designator, similar to Melios. Range and azimuth information from COVER are fed automatically into GRUNT II. A technical limitation of the simulation would not allow COVER and Melios to operate at the same time.

e. Map of the Future (MOF)

MOF is a laptop emulation of a futuristic fold-up electronic map, with input and output communications. It presents a scaleable map overlayed with graphics and menus that support communications over a digital network. The user can place MOF in his pocket when it is not in use. (For this study, a laptop computer served as a surrogate for an MOF.) MOF receives information from the Remote Sensor Control Station (see Figure II-2). The small teams use this information as cues to search for targets. They also can submit CCFs with MOF.

2. Exercise Control

Exercise control included functions required to ensure that the objectives of the exercise would be accomplished. These functions included activities to control the movement of enemy forces and remote sensors, the control of remote fires, and the functioning of higher headquarters. At a higher level, exercise control provided the means for the exercise director to influence the simulation scenario and to capture all the data required to assess the simulation's results. The exercise control room had five major components.

a. Blue Force Commander and Excursion Control Station (see Figure II-2)

A Blue force commander's station consisted of a modular semi-automated force (ModSAF) terminal for maintaining situational awareness of the battle, an MOF, and a radio networked with the teams and the fire support officers (FSOs). This station also was used by the Exercise Controller.

Other Simulation Control Stations

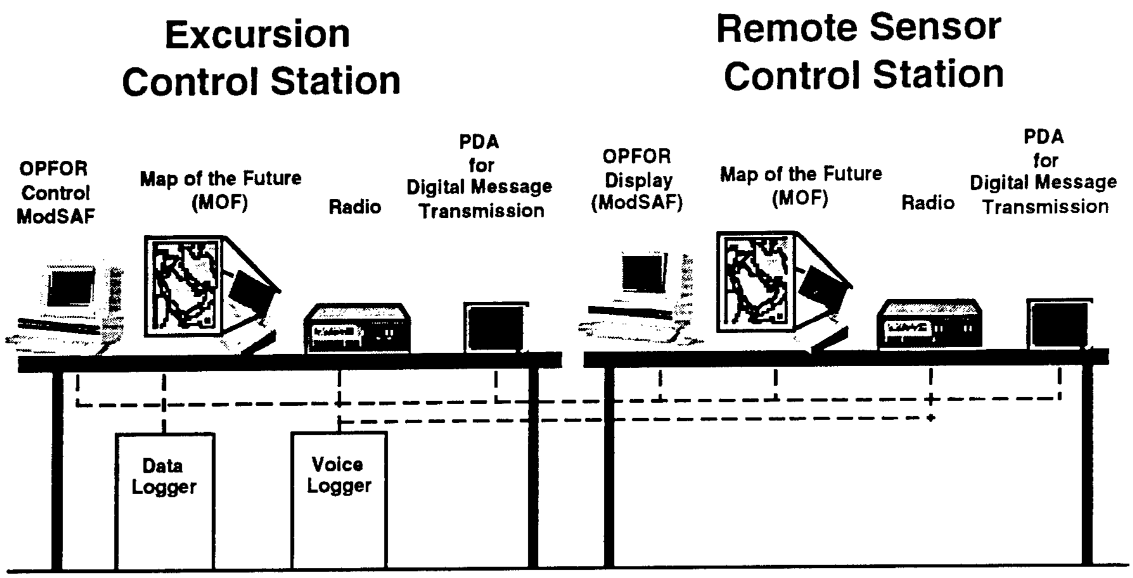

Figure II-2. Control Stations

b. Opposing Forces (OPFOR) Workstation (see Figure II-2)

An OPFOR workstation generated all the enemy forces. A ModSAF v 1.5.1 terminal capable of generating about 40 entities provided this service. Scenarios were preloaded with infiltrating elements comprised of either three vehicles [tanks, Bronevaya Machina Piekhota (BMP)[4] or trucks] or three dismounted infantry platoons. The ModSAF operator initiated some reactive play, but most of the infiltrations proceeded as planned.

c. Remote Sensor Control Station (see Figure II-2)

The Remote Sensor Control Station consisted of a ground truth view (ModSAF terminal) and a swivel chair interface to an MOF. The operator used templates to represent various sensors. As the enemy forces moved through the templated areas, he reported the appropriate information to the teams via the MOF in near-real time. He also had a ModSAF UAV that reported targets dynamically. Table C-1 in Appendix C lists the sensor suite available for the trials.

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4 A BMP is a Russian infantry fighting vehicle.

d. Fire Support Workstation (see Figure II-3)

Fires were managed by the Fire Support Workstation. The station received CFFs from the small teams via an MOF or GRUNT II and entered coordinates into a locally built FDC emulator. The FDC computed impact times and location based on the type of weapons selected by the FSOs (two Marine artillery captains). At the computed time, the FSOs used the "bomb button" on their ModSAF terminal to place the ordnance at the computed target location. This technique permitted precise control of munitions' effects. The weapons available to the FSO—unclassified hypothetical weapons that represented what might be available in the timeframe of interest—were postulated specifically for this exercise. Appendix C, Table C-2 describes the weapon suite available for the trials.

Remote Fire Station

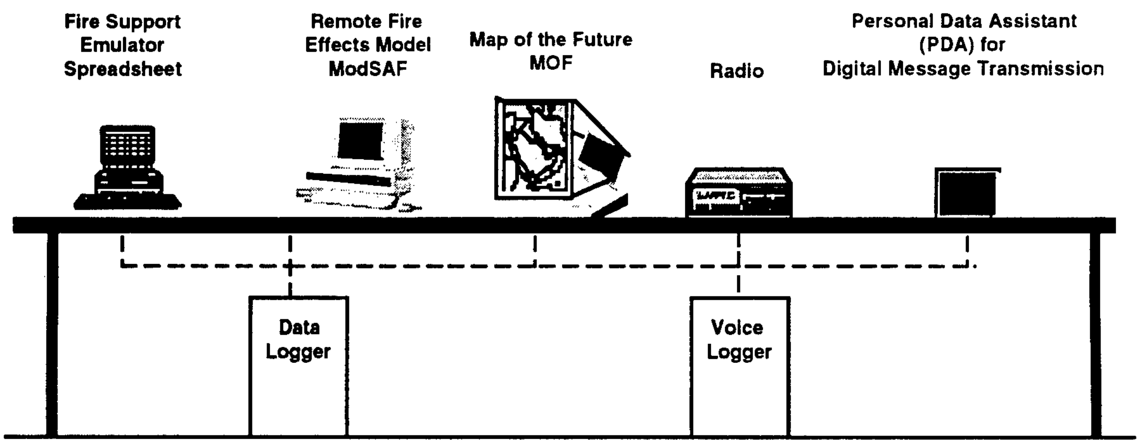

Figure II-3. Remote Fire Station

e. Data Capture Workstation

For analysis of the simulation exercises, a data logger captured all the Advanced Distributed Simulation (ADS) traffic, and a voice logger captured all the voice traffic.

3. STPs

The small teams interfaced with the simulation through three portals.

a. Vehicular-Mounted Portal (see Figure II-4)

One STP consisted of a Dial-a-Tank station with vehicle controls and an out-the-window view of the virtual terrain. It also had a foot pedal for ground movement when the vehicle was stopped. The crew had a Melios and GRUNT II. As an alternative to the Melios, the team could use COVER. For communications, the STP had a radio, an MOF, a GRUNT II, and a PDA.

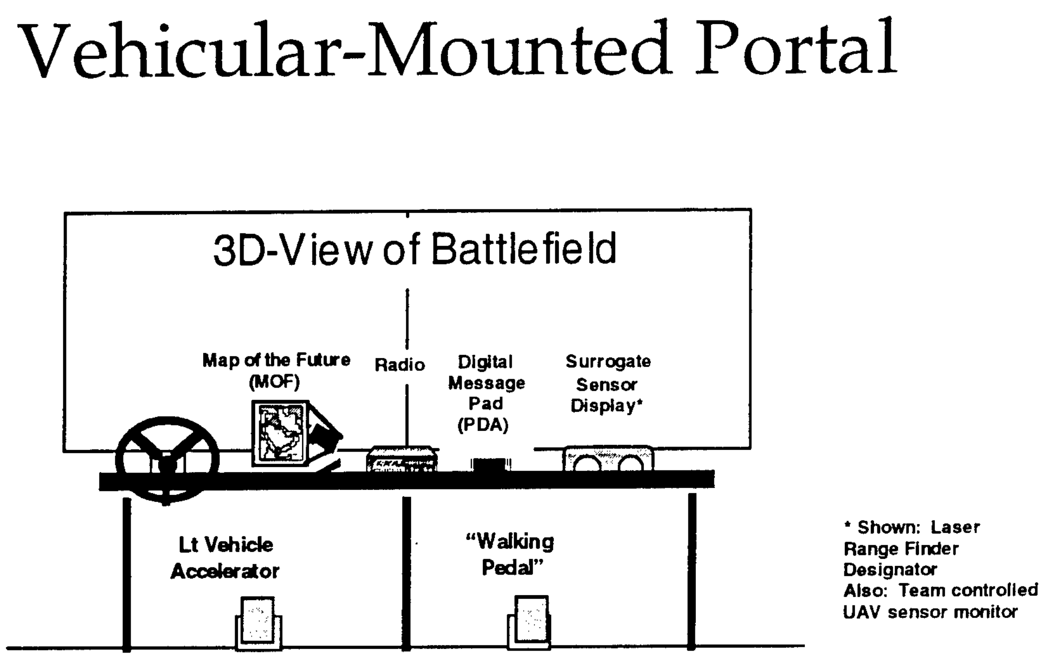

Figure II-4. Vehicular-Mounted Portal

b. Foot-Mounted Portal (Treadport) (see Figure II-5)

The other STP had a similar driver's portal. However, for dismounted operations, it had a treadport where the participant could run, walk, or crawl through the virtual environment. In the treadport, the team's movement was generated by one man while the other man waited (only one man could be on the treadport at a time). At the halt, the individual in the treadport could use his Melios while his partner operated the communications gear.

c. Intermediate Leader Station

The intermediate leader station supported one man with a radio and an MOF. His station was physically next to the vehicular-mounted portal where he could use the out-the-window view. He had no mobility. He was assumed to be collocated with and dependent on the small team in the vehicle-mounted portal for mobility.

Foot-Mounted Portal

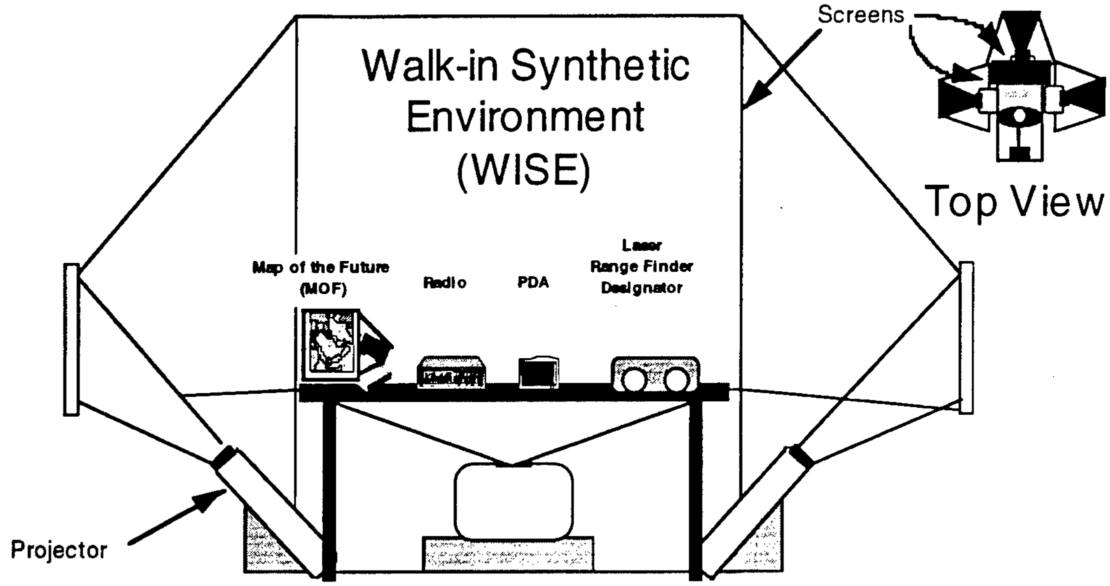

Figure II-5. Foot-Mounted Portal

D. DOCTRINE FOR SMALL TEAM OPERATIONS

Before conducting the exercise, establishing a doctrinal foundation for small team operations was necessary. Army subject matter experts created the conceptual doctrine, which represented a starting point for the exercise. The basic tenants of the initial conceptual doctrine were as follows:

- Small teams control areas of 5 or more kilometers in radius.
- A task force headquarters controls six or more intermediate leaders. Intermediate leaders control up to six small teams.
- Small teams operate semi-autonomously. They exercise decision authority to attack targets within their control area, subject to the rules of engagement (ROE). They employ organic sensors (hand-emplaced) and determine areas in which to focus remote sensors based on their intelligence preparation of the battlefield (IPB).
- The task force manages remote sensors and allocates resources to the small teams, depending on priorities it has established.
- Small teams operate in a stealth mode. They avoid direct combat and move only when necessary for self-protection or target servicing.

- The small team's battlefield functions are to identify targets and decide whether they are valid (per the ROE) for engagement, prioritize targets for engagement, assist in terminal guidance of munitions, and assess battle damage.

E. ASSESSMENT PLAN

The objective of the evaluation was to develop insights into the nature of small team operations on the 2015 battlefield and to assess the value of the STP21 simulation as a tool for studying future battlefields. A plan was developed to formulate a list of essential elements of analysis (EEA) or hypothetical questions that, when answered, would achieve these objectives. The EEA were used to develop a list of measures of effectiveness (MOEs), which measured functional objectives of system performance, and measures of performance (MOPs), which measured technical parameters of system behavior. A Data Collection and Analysis Plan was formulated in support of the Assessment Plan that related EEA, MOEs, and MOPs with collection methods and techniques. The data collection scheme was integrated within the simulation design.

1. EEA

The evaluation plan had three EEA:

1. What is the utility of sensors and PDAs in enhancing the small team's situational awareness?
2. What is the utility of remote fires in increasing the small team's combat effectiveness?
3. How suitable is virtual simulation as a concept exploration tool?

2. Data Collection

Two general types of data were collected: operational and behavioral. They are divided into six categories, as shown in Table II-2, with different collection methods and functions for assessment.

Operational and behavior analysts observed each team during the trials. They manually recorded events such as detection of enemy forces and the initiation of a CFF. They also recorded their impressions of how the team was operating and how the simulation was functioning. Exercise control personnel also recorded their observations and judgments. Questionnaires and interviews were used to supplement analysts'

Table II-2. Data Collection

Category	Method	Function
Behavior	Direct observation Questionnaire Interviews	Human interface Human work load Human performance
Doctrine	Observation Questionnaire Interviews	Roles and responsibilities Organization Operations
Equipment	The methods above plus automatic data collection	Data presentation and use Sensor performance Database management
Procedures	The methods above plus voice log	Communication procedures Managing targets and tasks Battle damage assessment (BDA)
Tactics	All the methods above	Family of scatterable mines (FASCAM) fires Mobility Sectors Situational awareness
Training	All the methods above	Target acquisition, tracking, and engagement Communications Managing sensors CFF Situational awareness

observations. These observations were entered into a database (see Appendix D) that can be sorted in several different ways. Event-specific data were collected to assist in the reconstruction of engagement time lines, as discussed below.

Data collected automatically came from the ADS network and the records maintained by several of the devices used in the simulation:

- The data logger provided information about target visibility, which defines when a target would have been visible [line-of-sight (LOS)] to the team, when and where targets were attacked, and whether these targets were killed. It also provided records of all vehicle and dismounted infantry movements.

- The FDC emulator maintained a complete record of all engagements, including the time of the request, the weapons used, the delays encountered, and the time and location of impact.
- The MOF maintained a record of all digital record traffic in an internal database. This record assisted in reconstructing engagement time lines. Data from observers also contributed to the reconstruction by providing a time reference for correlating the data from several different sources. GRUNT II data were unusable since it provided only event times, not event descriptions.
- The Voice Logger recorded all voice traffic. However, the digital equipment was the primary source of communication. The voice traffic was minimal during the exercise.

The simulation system had no formal data collection architecture. Therefore, software tools that could read the collected data and structure it for subsequent analysis had to be designed and built. For future exercises, the entire data collection process should be redesigned and built into the simulation system. Much of the collected data could not be used because of time correlation problems.

F. ASSESSMENTS

1. Engagement Time Lines

The data necessary for reconstructing time lines for each engagement were an important data set. Data from all sources contributed to building time intervals between each step in an engagement. Figure II-6 shows the time line structure. (Time line reconstruction required extensive effort because of the difficulty in correlating the data from several different sources. Only a few example time lines were actually constructed.) These time lines were intended to provide an understanding of how long it takes to engage targets, where compression of time intervals was seen as a measure of goodness of parametric change (e.g., equipment, doctrine, or organization).

2. Area of Situational Awareness and Control

A significant issue in defining the doctrine for small team operations is the size of the area that a small team can effectively control or dominate. This issue has two components:

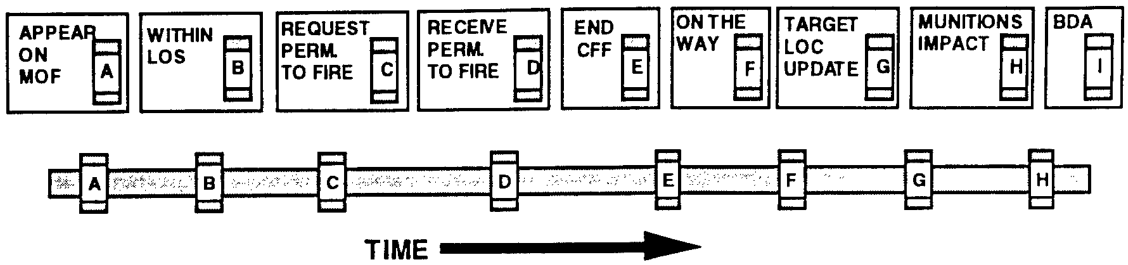

Figure II-6. Notional Time Line Structure

Legend for Figure II-6:

(A) **APPEAR ON MOF.** Target cued by remote sensor.
(B) **WITHIN LOS.** First instance of LOS between target and observer.
(C) **REQUEST PERM. TO FIRE.** Team leader cannot determine if a target is within range and requests approval from higher headquarters.
(D) **RECEIVE PERM. TO FIRE.** Higher headquarters approves request.
(E) **END CFF.** Last key stroke or voice command of the CFF.
(F) **ON THE WAY.** FDC acknowledgment, with impact time and munitions type.
(G) **TARGET LOC UPDATE.** Team reports updated location of target before missile impact [required for Navy Tactical Missile Systems (NTACMS) and tactical air (TAC AIR) only].
(H) **MUNITIONS IMPACT.** Munitions land on target.
(I) **BDA.** Team reports target damage.

1. The area in which the small team has situational awareness (i.e., it knows what the enemy is doing in that area) defines its intelligence gathering utility. Situational awareness was measured by determining the closest enemy probe that passed the small team without being detected.

2. The area that the small team controls (i.e., it can dominate that area with effective fires) defines the team's combat effectiveness. The control area was measured by determining the closest enemy probe that passed a small team without being damaged or destroyed.

G. SCENARIOS

Each trial represented one battlefield configuration (scenario). Parameters were varied from trial to trial to ensure coverage of relevant situations. Each trial lasted about 2 hours. Appendix E, Tables E-1 and E-2, outline the configurations.

The STP21 exercises used two basic scenarios. Figure II-7 (Hunter-Liggett terrain) and Figure II-8 (Hohenfels terrain) show the operations overlays for both friendly and enemy forces.

The scenarios were simple. The U.S. forces had established a beachhead that had to be protected for several days until the buildup was complete. A task force of small teams

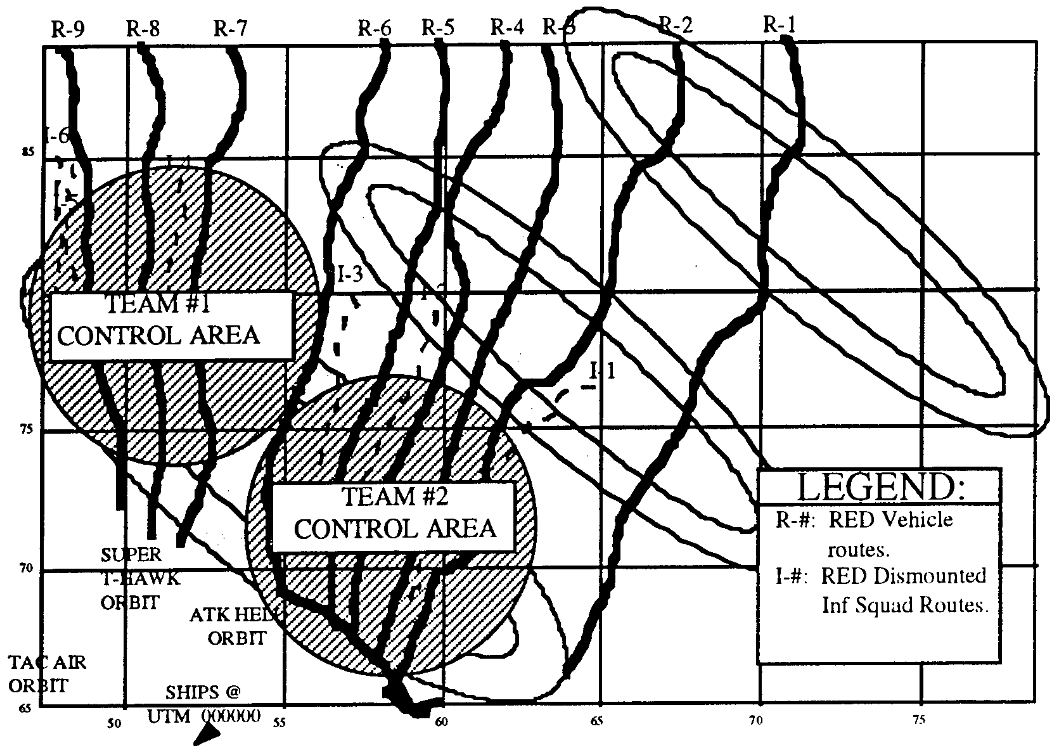

Figure II-7. Hunter-Liggett Scenario – Operations Overlay

was positioned about 70 km forward of the beachhead to deny enemy penetration into the area surrounding the beachhead. The enemy forces had dispersed into platoon- and squad-size elements because any large concentrations of forces were immediately attacked by U.S. long-range weapons. These smaller elements were attempting to infiltrate through the U.S. screen to disrupt the beachhead. Each trial portrayed two small teams and the enemy infiltrations that would come near their control area.

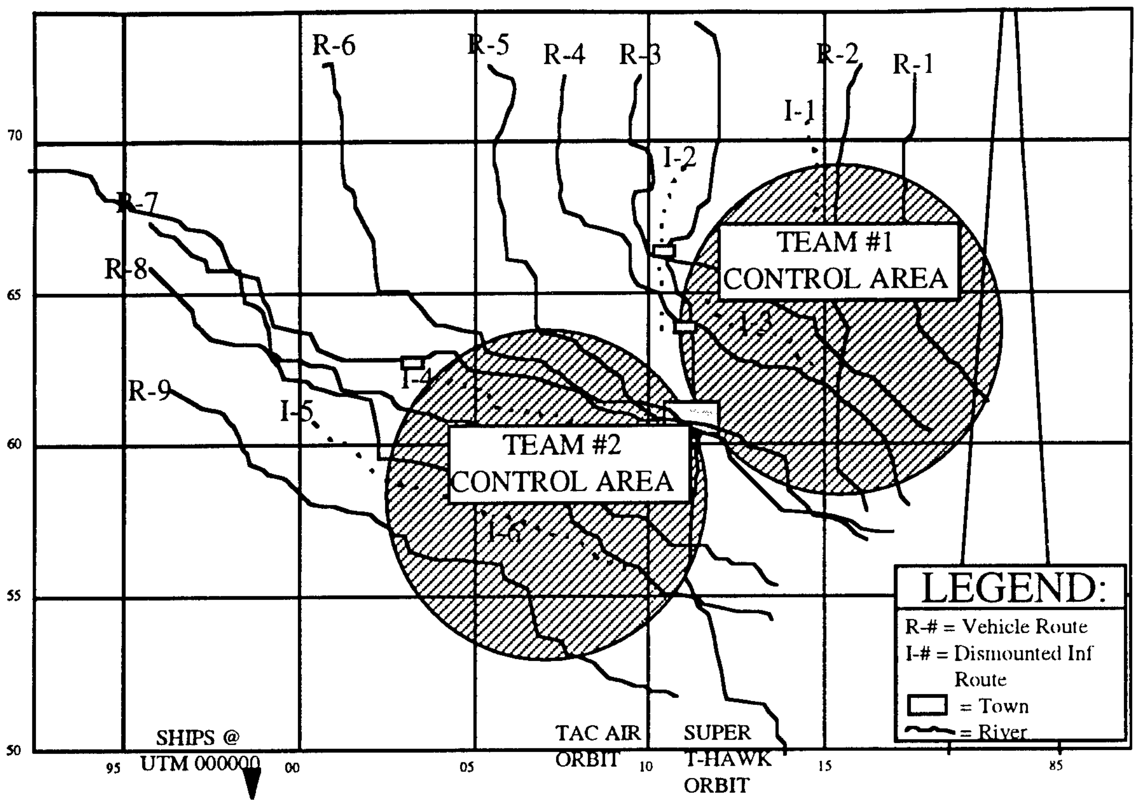

Figure II-8. Hohenfels Scenario – Operations Overlay

III. INSIGHTS

The STP21 exercises revealed many details about how small teams should operate, how their equipment should be designed, how the teams should function internally, and how the simulation should be improved (see Appendix D). Section III consolidates these insights.

A. SITUATIONAL AWARENESS OF SMALL TEAMS

1. Control Area: Sector Size

A small team could not handle more than a 90-degree sector with the equipment provided in this exercise. Scanning a wider sector for targets resulted in loss of orientation. Returning to a previous target required excessive time, during which other targeting opportunities were lost. With a more flexible observation device, such as an untethered UAV and an integrated command and control (C2) system, a larger sector could be managed. However, the problem of monitoring too many targets at once would become the limiting factor.

2. Control Area: Range

For this exercise, the small teams with the most powerful set of sensor assets were able to detect targets at 5 km when they had LOS, which was infrequent. They saw most targets that came within 2 km. Even with COVER at 100-m altitude, target sightings were limited beyond 2 km. LOS was the limiting factor. The team needs a free flying aerial platform—a platform that can maneuver to see around tree lines and hilltops—under its direct control.

3. Reading the Battlefield

The participants' energies were consumed with the task of finding and servicing targets. On several occasions, they detected the enemy's overall scheme or plan, but the task of reading the battlefield did not receive much attention. This lack of attention to reading the battlefield may have been caused by the inexperience of the operators and the difficulty of keeping up with the work load. In this type of exercise, the participants need to be well-schooled in IPB, and this skill cannot be learned in one day of training. Small teams of the future will require IPB training so they can detect patterns of enemy activity in fleeting glimpses.

4. Information Management

Data entry and display devices need to be designed from the soldier up and integrated with the other command, control, communications, computers, and intelligence (C4I) systems. This was not the case with the devices used in this exercise. For example, one team leader used his pencil and pad to keep notes on which targets had been requested, engaged, designated, or assessed or were waiting engagement. The devices should have been able to keep track of this information automatically and display it on demand. Designers of new information management equipment should be required to observe exercises like these so they develop an appreciation for what the soldier really needs.

5. Elevated Tethered Sensor (COVER)

An elevated platform tethered to a ground vehicle does not provide adequate visibility in either European or desert terrain. Some observations follow:

- Because of forests and hills, the soldiers were seldom able to find targets (cued targets) beyond 2 km even though the optics were capable of viewing to a range of over 5 km. In these types of terrain, an untethered UAV is essential. The small team should have control of the untethered UAV but not the responsibility for maintaining or flying it.
- The operator had difficulty orienting COVER on a target that had been reported on the MOF. A team member must read the azimuth and range to a suspected target based on information from the MOF, and then the operator must try to align the optics accordingly. This process is laborious. Ideally, the MOF should automatically cue COVER to a spot on the ground and move the optics to this spot without any assistance from the operator.
- The soldiers developed a search technique in which the observer aims at the ground in the direction of a suspected target and then elevates the system lazing frequently to determine range. They used this approach to lock on a cued target. They did not have time to develop optimum search patterns. Search techniques need to be developed by proponents, in conjunction with system developers, and provided as input to the simulation exercise.

6. Magnification

COVER and Melios need multiple magnification choices (i.e., 1x, 5x, 10x). A better solution would be a continuous variable optical device. The soldiers need to scan at low power and then go to high power to lock on the target.

7. Terrain Analysis

The small team armed with an MOF needs the capability to perform automated terrain analysis from a digital TDB. The teams made good use of this feature on ModSAF when they were allowed to use the terrain profiler to conduct mission planning. They also used it to determine if COVER could see a target that had been identified on the MOF. Then, they could tell the COVER operator where a target would be seen and avoid wasting time looking for a target that he could not possibly see.

B. COMBAT EFFECTIVENESS OF SMALL TEAMS

1. Small Targets at Long Range

The combination of advanced sensor systems and long-range precision weapons will cause opposing forces to present smaller targets. Mass assaults and mass movements will be very dangerous. Confronted with accurate, long-range fires and near-ground-truth sensor capabilities, enemy units will disperse and travel in small groups. This scenario argues for a low-cost, accurate, long-range weapon that can attack single targets. A long-range, top attack system with precision guidance may be the solution.

2. Windows for Target Engagement

Engagement windows have two forms. As a general rule, vehicular targets came into view and went out of view over a period of approximately 20 minutes (10 km at 30 kph). These targets, during their movement, would be visible for fleeting periods of about 1 to 2 minutes each. Dismounted targets remain within the range of visibility longer, but they are more fleeting, exposing themselves for only seconds at a time. In either case, attacking these targets with a weapon that arrives 10 or more minutes after the CFF is ineffective.

3. Target Engagement Time Line

A limited set of engagement time lines was computed from the trials, as shown in Figure III-1. These time lines are typical of the engagements during the seven record trials.

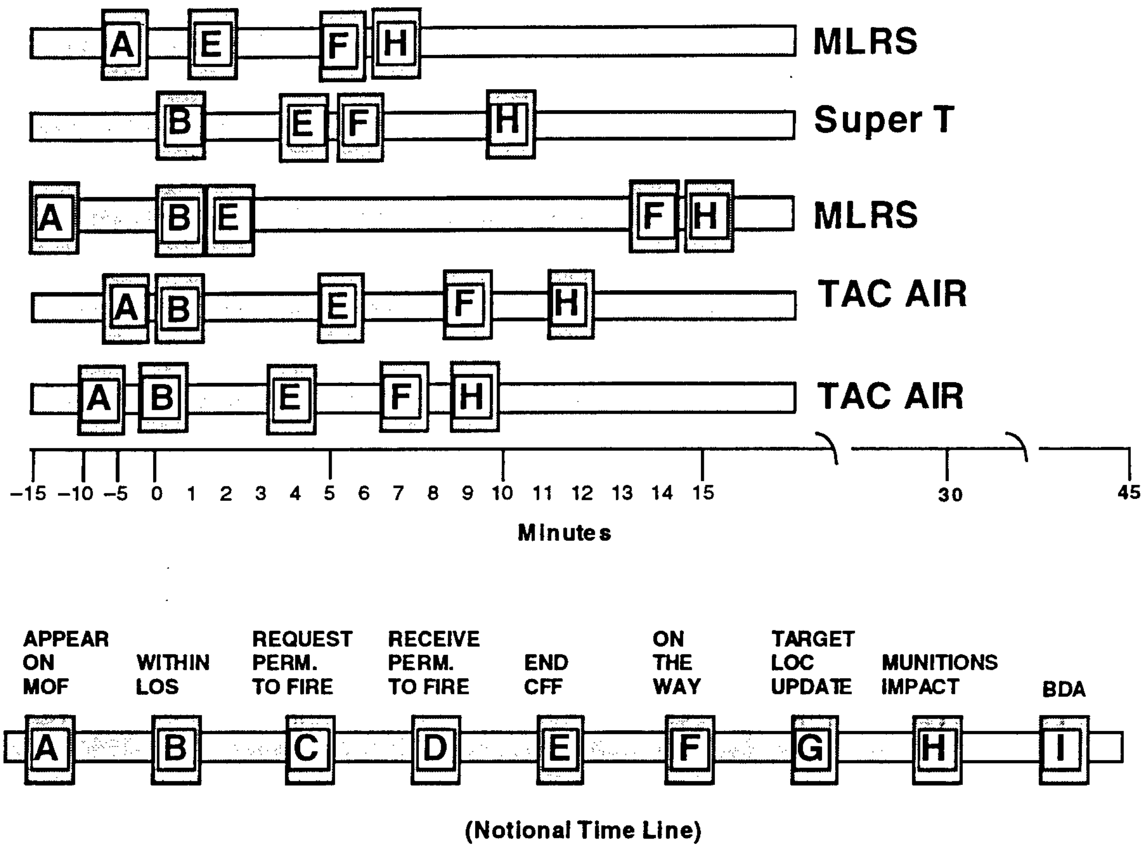

Figure III-1. Typical Target Engagement Time Lines

Notes for Figure III-1:

1. *The time scale is different on each side of the baseline.*
2. *Under "minutes scale," missing markers indicate that the event was not observed.*
3. *For the notional time line, see Figure II-6 for a definition of the terms (e.g., "Appear on MOF").*

Most engagements took on the order of 20 minutes from the time a target was first spotted until it was attacked. Although no attempt was made to develop a definitive analysis of the time lines because the manual process is time consuming, it was apparent that these types of data can be generated from the simulation given better data collection and analysis tools.

4. Small Team Work Load: Equipment Improvements

Team members could manage two targets simultaneously. With current equipment capabilities, a third target caused an overload. The limiting factor was the requirement to find the targets with Melios or COVER. The general sequence of engagements was to find a target, place a CFF, look for other targets, return to the original target for designation, and assess damage. Shifting from one target to another took time and demanded the concentration of the whole team. The manageable number of targets could be improved significantly by automating the orientation process. If these devices were connected to the MOF, automated controls could bring COVER to a desired orientation. For Melios, these controls could translate into arrows in the field of view that tell the operator which way to turn to find the target.

5. Small Team Work Load: Doctrinal Improvements

Another aspect of the work load problem is the requirement to participate in the terminal phase of an engagement. The remote sensor and fire capabilities postulated for the future would be adequate to track a target accurately and control the strike of the munitions so that the small team would not have to participate. Without the requirement for terminal control, the small team could concentrate on finding, discriminating, and setting priorities for targets. Once they have decided that a target should be attacked, the target engagement system should execute the strike at the time and place of its choosing. This approach could result in more efficient weapon choices. For example, the FDC could launch a long-range missile with multiple warheads to attack a "quarry" of targets instead of using one missile for each target.

6. Message Feedback

The communications devices used in this exercise were designed primarily as input devices. The small team needs feedback from the target engagement system. They also need efficient mechanisms for providing results and receiving confirmation from higher headquarters. Some suggestions for improvement are as follows:

- The operator should have an alert mechanism to inform him that a message has been received. A soldier who is running or driving would have difficulty monitoring his data entry device. He should have a buzzer, light, or vibrator that alerts him to look at the device.

- Message formats need to be developed for responses from higher or adjacent headquarters. For example, a menu item is needed in the MOF for a BDA report on the remote sensors.
- The soldier also needs to know that the system is working. If he enters a request or message, he needs to receive acknowledgment that the message has been received. In addition, he needs to know what the recipient is doing about it. The small teams tended to repeat fire requests or messages because they were not sure that an earlier message had been addressed. This problem tended to overload the small team and the fire support element (FSE).

7. Mobility

A soldier cannot walk fast enough to meet the time lines of the target engagement system. Engagements take approximately 10 to 20 minutes from target detection until warhead impact. During this time, a soldier can walk about 1 km under the best circumstances. If he needs to get somewhere to observe the impact, designate a target, or assess battle damage, his range is very limited. A vehicle is essential. The soldier must be able to travel quickly in restricted terrain and hide the vehicle on short notice. A motorcycle or dune buggy may be the answer.

8. Target Movement Prediction

The technique of using a double laze to predict future target location is ineffective. It assumes linearity over time, and targets do not move that way. If the delay from target prediction to impact is only 5 minutes (typical for artillery), a 20-kph target can move 1.7 km. A military vehicle will not move that far in a straight line anywhere on the map (ground). Missile and air targeting takes longer. After 20 minutes, the target could be anywhere within a 7-km radius but probably not at the end of a linear projection. Therefore, a different method is needed. The intelligence system must be accurate enough to track the target to impact or at least be able to make a prediction based on terrain analysis. Sensor platforms must provide real-time position data on targets and be cued to track tagged targets.

9. Target Attack

The FDC frequently used the attack helicopter instead of other weapons because of the greater flexibility in finding the target several minutes after the helicopter had been requested. From a logistical viewpoint, the attack helicopter is probably not an efficient choice. However, for responsiveness and accuracy, it should be the model for the capabilities of a 2015 engagement system. A micro-cruise missile with attack helicopter responsiveness and loiter time might be a useful concept if the missile could be designed to attack a single vehicle platform or small dismounted units.

10. Data Entry and Display Devices

In these exercises, three different data entry and display devices were needed to produce a full capability. This number of devices is too many for a two- or three-man team. All the capabilities should be consolidated and integrated into one device that is optimized to support the conceptual doctrine. Differences in menu structures, function, and human interface among the devices detracted from the combat effectiveness of the small team—as represented in these exercises—by imposing an artificial work load.

11. Adjustment of Fires

The current adjustment of fires technique (i.e., refinement of the target location after first impact) is not viable with the small team concept. The delay times between original target identification and munitions delivery is typically more than 10 to 15 minutes. In that time, the target has moved significantly. With another delay of the same duration until the next round lands, location of the target at first impact becomes irrelevant. A better approach would be to treat each shot as a new engagement, using predictive methods of determining where the target will be when the next warhead arrives.

C. SUITABILITY OF THE STP21 SIMULATION

Even though the simulation was immature, it demonstrated great potential for addressing the complex issues associated with developing the Small Unit Operations (SUO) concept.

1. General Capabilities

Some general capabilities include the following:

- Exercise control
  - Remote indirect fires. ModSAF provided the mechanism for efficiently providing indirect fire support to player participants.
  - Remote sensors. ModSAF provided the mechanism for integrating intelligent or semi-intelligent sensors with the battlefield. Postulated sensors

that have characteristics beyond what currently existed in ModSAF could be programmed into the environment or could be integrated manually.

  – Friendly and enemy force management. ModSAF provided the mechanism to monitor friendly and enemy force activity and to modify this activity as required.

- 3D player-battlefield simulation interface
  – Fields of view. Fields of view were constrained by vegetation and terrain variations, as would be expected in live combat. However, the *Stealth* or 3D view of the battlefield enabled a human member of a small team to be immersed realistically into a battlefield. This characteristic was important because it became apparent that sensor management would be an important new function on the future battlefield.
  – Combat interactions. The 3D-view enabled realistic combat interactions between players and enemy combat entities.
- Concept development (new entity design). The synthetic battlespace enables the postulation of future equipment (e.g., sensors and indirect fire) capabilities, which allows experimentation with how these new capabilities will impact doctrine.
- Data collection. ModSAF's entity-based property enables data collection by event, and these data have a level of detail that is not replicated in any other simulation environment. This capability is important for analysis purposes since it enables data to be viewed from various perspectives at a high level of fidelity.

2. Simulation Hardware and Software Integration

The hardware and software were assembled over a 4-week period preceding the start of the exercise. During the first week of the exercise, hardware and software problems and challenges caused the interruption of many trials. However, through the concerted efforts of the technical staff and contractors, everything came together by the last trial of the first week.

The process of building the simulation was a valuable learning experience. Software in the communications devices had to be modified to fit the conceptual doctrine. This process required many decisions about the form of the communications needed to support the concept. The need for these decisions became apparent this early in the developmental cycle only because of the simulation environment. This process also required the development of procedures to facilitate the exercise, such as construction of an FDC surrogate and manual methods of managing remote sensors. All these steps led to a clearer understanding of the concept. The final configuration of these devices is the record of what was learned about them.

3. Battlefield Functions

In this exercise, only the intelligence and fires functions were examined. Results from such a limited battlefield environment are tenuous at best. As a minimum, the simulation needs to address these functions plus logistics, maneuver, communications, electronic warfare, and air defense.

4. Moving Models

The visual systems could portray only tanks, BMPs, and trucks, and this limited capability was insufficient for a challenging battlefield environment. Discrimination of targets was simple, and no civilian vehicles were present to make demands on the teams' decisions to engage. The system needs to display the full suite of ADS models to enable a realistic evaluation of the SUO concept.

5. Visual Fidelity

Without the possibility of a direct fire fight, the out-the-window view had limited value in this exercise. The small teams fought the enemy beyond ranges that they could see out-the-window. Looking at the screens provided little information that the teams could use, and there was minimal need for considering that view of the battlefield.

6. Data Capture

Capturing behavioral and performance data and making changes based on performance is much easier in a controlled environment than in the field. The development cycle was repeated several times in the 6 weeks of setup and trials in the facility. Developers and contractors could observe the action and interact with the participants to derive solutions quickly and evaluate these solutions almost immediately.

7. New Doctrine

New concepts and equipment may result in new doctrine. Before attempting to conduct an exercise with soldiers, some experimentation should be done in a series of trials to establish reasonable tactics, techniques, and procedures (TT&P) to go with the new concepts and equipment used in subsequent experimentation. The participants in scored trials should not develop the doctrine as part of the trial.

8. Analytical Tools

The simulation needs analytical tools to help generate and control an exercise. Particularly important is the need to extract data more efficiently for analysis. All the elements of the simulation should operate over the ADS network (i.e., GRUNT, PDA, MOF, ModSAF) so that data can be extracted efficiently. The simulation system should have a formal data collection architecture, and all new devices must be integrated into it.

9. Representation of Future Operational Equipment

Current equipment inhibits the simulation of the future because it forces the use of current technology. Devices like GRUNT II or the 1996 version of a PDA are limiting. Old systems must be replaced by new approaches. For example, instead of trying to make the GRUNT II work in the simulation, new fire control techniques should have been developed to match the postulated technology.

10. ModSAF Enhancements

ModSAF needs to be enhanced so that it can simulate an FDC with reconfigurable weapon platforms. It also needs an automated Remote Sensor center capable of analyzing ground truth and reporting appropriate information from the postulated sensor suite. An editor function within these devices should allow a researcher (not a technician) to create futuristic weapons and the fire control procedures and sensors to complement these weapons. Similarly, an editor function is needed to adjust the parameters of any vehicle and aircraft to facilitate simulation of future capabilities (e.g., robots and enhanced infantrymen).

11. Dynamic Terrain and Environments

The simulation needs to be able to portray dynamic terrain (e.g., changes caused by minefields, craters, building destruction, barrier construction, and so forth) and dynamic environments (e.g., wind, rain, fog, smoke, clouds, and diurnal effects). The latter must be implemented correctly in the visual, thermal, radar, and microwave spectrums.

12. TDBs

Assembling and integrating various simulation systems and displays and various developmental C2 devices for this simulation support effort highlighted the fundamental problem with standard TDBs operating on multiple platforms. Much of the delay associated with becoming operational revolved around this issue. In the end, the exercises were possible only by using work-arounds or by accepting some terrain limitations. Data and points of origin among simulation and C2 maps and databases were not congruent, and this incongruity resulted in grid coordinates that did not correspond to the same point on the earth. Resolving this problem is essential to future simulation and real-world C2.

D. GENERAL OBSERVATIONS

1. Digital C2 System

The metaphor for a digital C2 system is a ModSAF or JANUS terminal. Graphical functions that ModSAF and JANUS operators use to initiate CFFs, move units, and so forth are useful models for developing a C2 system. Pre-formatted messages, while useful, are not sufficient. Many developmental C2 systems are merely embedding old, manual procedures and tasks into an automated system. The technology postulated in this exercise permits and demands new tasks, new procedures, and new information methods. Concept and task development efforts must parallel technology development to realize the full potential of the technology.

2. Embedded Simulation Capability

All future C2 systems should include an embedded simulation capability. This capability would facilitate simulations like STP21 and would enable the immersion of soldiers into a future warfighting environment for concept development and exploration. It also would enable training, mission planning, and mission rehearsal with new concepts.

3. Simulation of New Battlefield Capabilities

The Defense Advanced Research Projects Agency (DARPA) and Service program managers who are developing new weapons, sensor platforms, communication devices, and so forth should include a requirement for their systems to be developed with hardware and software that permits evaluation in a simulation throughout the development process.

Then, the program managers and others could use the synthetic battlefield for concept development, systems integration, force design, and training.

4. Simulation Improvement

Synthetic environments can be useful in concept and material development, but an initial investment must be made to enhance the synthetic battlespace. Image generators, ModSAF behaviors, TDBs, and other features of STP21 need to be advanced and integrated to establish an efficient and effective tool for evaluating future concepts. The tools need to be built before the requirement to use them. After a requirement is generated, it is too late to start building the simulation facility.

IV. FINDINGS ABOUT FUTURE BATTLEFIELD CONCEPTS

A. GENERAL

Doctrinally, the team was responsible for most aspects of requesting and controlling indirect fires; employing organic sensors; determining areas for remote sensor focus; and conducting BDA. However, the exercises showed that the team had limitations. The team could be more effective and the overall mission could be more successful if some portions of the team's tasks were handled by the task force headquarters.

Initially, considerable attention was given to empowering the individual combatant, but the exercises showed that more effort should be focused on empowering the team. Forming the team into subelements, assigning each member of a subelement a narrow range of tasks, and equipping each team for its collective mission were more effective than assigning each member a wide range of tasks and the same equipment. Determining optimal team functions, size, and composition for all battlefield systems will require more study since these exercises examined only intelligence and fire support systems.

The team's combat effectiveness was enhanced when it had transportation to move around on the battlefield. The dismounted infantrymen could not move fast enough to accomplish some assigned missions and ensure their survivability. With many teams widely dispersed and large areas for each team to control, the teams must be capable of moving rapidly in a light vehicle that can be easily deployed by helicopter. Further assessment is needed to evaluate the tradeoff between increased capability and the added logistic requirement that would be imposed.

B. SENSOR MANAGEMENT

These exercises helped answer the question about why the small team is needed on the battlefield. Teams were able to gather and provide unique information about the enemy, which included verification about the characteristics of enemy targets and intent. Positive identification of dismounted enemy or enemy using civilian-type transport was often possible only by visual means. The exercises also illustrated that the teams functioned as sensors and were effective where other sensors were not.

The small team could detect targets out to 5 km, with an elevated, tethered video sensor platform, but it had difficulty detecting targets in restrictive terrain beyond 2 km because its LOS was blocked. A taskable, tactical UAV that could look in difficult places would enhance the situational awareness of the team and task force.

C. WEAPONS MANAGEMENT

The teams occasionally submitted multiple fire requests for the same target because they did not receive any feedback on action being taken to track or engage the target. This lack of knowledge about the target detracted from their ability to continue locating and validating other targets.

The concepts employed in the exercises required the team to monitor target engagement from start to finish, which was possible if the target could be engaged within 2 to 5 minutes. However, most engagements that used long-range, indirect precision fires required about 20 minutes. Thus, the team needed to stop locating and evaluating other targets to provide location updates and terminal guidance for previous target requests. The system should be capable of tagging, tracking, and engaging the target and conducting BDA.

BDA is not an effective mission for teams since it detracts from more effective primary roles (e.g., requesting and controlling indirect fires; employing organic sensors; determining areas for remote sensor focus). The "macro sensor system" should be capable of performing most BDAs, with the team contributing only when the remote sensors are incapable of performing that task.

D. DATA MANAGEMENT

The team should be provided only the information it needs when it needs this information, and this information should be presented in a user friendly format. Distributed databases and multicast communication systems would facilitate this requirement. Items of equipment [e.g., the Forward Observer, Forward Air Controller (FOFAC) and GRUNT II] should be combined and integrated to expedite the transmission of information. For example, a remote sensor sighting transmitted to the MOF should automatically slue the hovercraft sensor platform to the location of the sighting, without requiring the operator to scan for the target.

Once the team has requested CFFs on a target, the Fire Control System (FCS) should determine when to strike. For example, waiting until multiple targets infiltrating an area converge or until a target leads to a more lucrative target, such as a command post or a supply depot, may be more appropriate. The task force commander can make this determination better than the team because of additional resources and information. However, the team must know what action is being taken to have confidence that a target is no longer its concern.

E. DATA PRESENTATION

Improvements in display and message formats will permit the team to have better situational awareness and will expedite information processing and dissemination. Automating current manual message formats is not sufficient. Software designers should work closely with the equipment developer and user to optimize data presentation. This type of simulation enables near-immediate system modification and evaluation and ideally results in reduced development time and lower costs.

Scaleable MOFs were much more effective than the map on the PDA, which only presented a small size (3 × 3 km) map. The user of the smaller presentation had difficulty orienting himself on the battlefield and understanding the tactical situation. Future digital maps and information should be manipulated by voice, touch pad, and so forth rather than by a key pad. A terrain profiling capability should be built-in to facilitate mission analysis and planning.

APPENDIX A.
STP21 PERSONNEL

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STP21 PERSONNEL

Players

July 15–19, 1996	**National Guard Bureau** CPT Greg Pickell 1LT Peter Clark **IDA** Mr. Rick Wright Mr. Chris Turrell
July 22–26, 1996	**TSB, Quantico MCB, Virginia** 2LT Robert Parks 2LT Anhee Hong 2LT Robert Hubbard 2LT Patrick Hodges 2LT Jeffrey Raithel 2LT Louie Sagisi

Controllers

Exercise Director	Mr. Jim Madden
Exercise Controller	Mr. Larry Mengel
Sensor Controller	Mr. Bennett Dickson
Indirect Fire Controller	CPT Chris Riggs CPT Jim Kenkel Mr. Edward Semper
ModSAF OPFOR Controller	Mr. Steve Johnson
Program/DSB Coordinator	Mr. Rick Wright
DSB Liaison/Analyst	Mr. Gary Coe

Observers/Analysts

Behavioral Observer/Analysts	Ms. Marnie Salter (1st week) Dr. Gene Fober (1st week) Dr. Bruce Knerr (2nd week) Mr. Don Lampton (2nd week) Mr. Doug Dressel (2nd week)
Operational Observer/Analysts	Mr. Doug Terrell Mr. Rick Wright Mr. Bob Clover

System Maintenance/Technical Support

Equipment Operation and Maintenance	Mr. Chris Turrell Mr. Baron Gibson Ms. Karen Luigard Mr. John Haskins
Data Collection and Analysis	Mr. Keith Green
Voice Data Collector	Mr. Tom Gioconda
Video Production	Ms. Patricia Lorenz Mr. David Potasznik Mr. Ken Ratkiewicz

Contractor Support

Lockheed-Martin	1 Full Time
Technology Systems, Inc.	3 Full Time
MAK Technologies	1 Full Time
SARCOS Research Corp.	2 Part Time
SRI International	2 Part Time

APPENDIX B.
STP21 EQUIPMENT AND UTILIZATION

APPENDIX B.
STP21 EQUIPMENT AND UTILIZATION

Equipment	Purpose	Location	IDA	GFE	G-$	Con	Avail
Apple Macintosh	Fire Control Matrix	Controller	X				I
DIS Radio	Fire Support Control	Controller	X				I
DIS Radio	Fire Support Control	Controller			X		L
IBM PC	FOFAC	Controller	X				I
IBM PC	GPS Server	Controller	X				I
IBM PC	MOF	Controller				X	
IBM PC	MOF	Controller				X	
IBM PC	MOF	Controller				X	
SGI Indigo	Data Logger	Controller	X				I
SGI Indigo	ModSAF Back End	Controller	X				I
SGI Indigo	ModSAF Back End	Controller	X				I
SGI Indigo	Voice Logger	Controller	X				I
SGI Indigo 2	ModSAF Blue Forces	Controller	X				I
SGI Indigo 2	ModSAF Front End	Controller	X				I
SGI Indigo 2	ModSAF Red Forces	Controller	X				I
DIS Radio	Radio	Int Ldr			X		L
IBM Think Pad	MOF	Int Ldr				X	
SGI Indigo 2	ModSAF Front End	Int Ldr	X				I
Earphones	Earphones	Observer # 1			X		
Electrohome Projector	3D Visual Display	Observer # 1	X				I
TV Monitor	FOFAC Back End	Observer # 1	X				I
Earphones (2)	Earphones	Observer # 2			X		
IBM Think Pad	MOF	Observer # 2				X	

Equipment	Purpose	Location	IDA	GFE	G-$	Con	Avail
IBM Think Pad	PDA	Observer # 2		X			
TV Monitor	COVER	Observer # 2	X				I
TV Monitor	FOFAC Back End	Observer # 2	X				I
DIS Radio	Radio	Portal # 1			X		
Earphones	Earphones	Portal # 1			X		
Electrohome Projector (3)	3D Visual Display	Portal # 1		X			
GRUNT II	FOFAC	Portal # 1			X		
IBM PC	GPS Server	Portal # 1	X				I
IBM PC	Mission Module	Portal # 1			X		L
IBM Think Pad	MOF	Portal # 1				X	
IBM Think Pad	PDA	Portal # 1		X			
Joy Stick and Steering Equipment	Vehicle and Sensor Controls	Portal # 1			X		
Melios Front End	Melios	Portal # 1		X			
Midi Sound Mixer	Sound Simulation	Portal # 1			X		
Projection Screens (3)	3D Visual Display	Portal # 1		X			
SGI Indigo 2	ModSAF Front End	Portal # 1	X				I
SGI Indigo 2	Sound Simulation	Portal # 1	X				I
SGI Onyx	Melios Image	Portal # 1	X				I
SGI Onyx w/MCO	Image Generator	Portal # 1	X				I
Treadport	Treadport	Portal # 1		X			
DIS Radio	Radio	Portal # 2			X		
Earphones	Earphones	Portal # 2			X		
Electrohome Projector Cabinets (2)	3D Visual Display	Portal # 2	X				I
Electrohome Projector (2)	3D Visual Display	Portal # 2	X				I
Foot Pedal	Foot Pedal	Portal # 2			X		L
GRUNT II	FOFAC	Portal # 2			X		

Equipment	Purpose	Location	IDA	GFE	G-$	Con	Avail
IBM PC	GPS Server	Portal # 2	X				I
IBM PC	Mission Module	Portal # 2			X		
IBM Think Pad	MOF	Portal # 2				X	
IBM Think Pad	PDA	Portal # 2		X			
Joy Stick and Steering Equipment	Vehicle and Sensor Controls	Portal # 2	X				I
Melios Front End	Melios	Portal # 2		X			L
Midi Sound Mixer	Sound Simulation	Portal # 2			X		
SGI Indigo 2	ModSAF Front End	Portal # 2	X				I
SGI Indigo 2	Sound Simulation	Portal # 2	X				I
SGI Onyx	Melios Image	Portal # 2		X			
SGI Onyx w/MCO	Image Generator	Portal # 2		X			

Notes:

1. *The "IDA" column indicates equipment owned by IDA.*
2. *The "GFE" (government-furnished equipment) column indicates equipment borrowed from the government (STRICOM, Ft, Benning or SARCOS).*
3. *The "G-$" column indicates equipment bought for STP21 through STRICOM. This equipment is GFE after purchase.*
4. *The "Con" column indicates equipment owned and provided/loaned by a contractor.*
5. *The "Avail" column indicates equipment that is available for future concept exploration requirements. It is either owned by IDA (I) or still on loan (L).*

APPENDIX C.
SENSOR AND WEAPONS SUITES

APPENDIX C.
SENSOR AND WEAPONS SUITES

Table C-1 shows the sensors employed in the STP21 Exercise. Table C-2 shows the weapon suite employed in the STP21 Exercise. In Appendix E, Table E-1 identifies the subset of sensors and weapons used in each trial during the first week, and Table E-2 identifies the subset of sensors and weapons used in each trial during the second week.

Table C-1. Sensor Suite

Sensor	Type	Range	Coverage	Target	Data	IFF	Platform	Downlink
Existing Sensors (Operational and Developmental)								
REMBASS	Magnetic	3/25 m	Continuous	MTI	Digital	No	Manpack	Monitor Set
REMBASS	Acoustic	50/350 m	Continuous	MTI	Digital	No	Manpack	Monitor Set
REMBASS	IR Passive	3/50 m	Continuous		Digital	No	Manpack	Monitor Set
JSTARS	SAR	240 km	11 hrs	MTI/FTI	Imagery	No	E-8A	GSM
Predator	Radar	500 nm	24 hrs	MTI	Digital	No	UAV	GSM
Predator	E-O/IR	500 nm	24 hrs	MTI/FTI	Digital/ video	Limited	UAV	GSM
Tier II +	Radar/E-O/IR	3,000 nm	24 hrs	MTI/FTI	Multimedia	Limited	UAV	GSM
Tier III –	SAR or E-O	500 nm	8 hrs	MTI/FTI	Multimedia	Limited	UAV	GSM
Notional Sensors								
TF UAV		100 km	Continuous				UAV	MOF
	SAR			MTI/FTI	Digital	Some		
	LLTV				Video	Some		
	FLIR			MTI/FTI	Digital	Some		
REMBASS II		400 x 400m	Continuous				UGS	MOF
	Magnetic							
	Acoustic							
	IR							
Micro UAV		10 km	4 hrs				UAV	MOF
	LLTV				Video	Some		
	FLIR				Digital	Some		
COVER			Continuous				Tethered	GSM
	Radar			MTI/FTI	Digital			
	LLTV				Video			
	FLIR			MTI/FTI	Digital			

Table C-2. Weapon Suite

Characteristic	Units	Weapons: NTACMS	Super T-Hawk	TAC AIR F-16	Howitzer 155m	MLRS	Attack Helo AH-64	Naval Gun Fire
Rounds per volley	Rounds				8	8		4
Aircraft per flight	Aircraft			2	NA	NA	4	NA
Speed	kph	1,500	500	2,000	1,000	1,000	180	1,000
Maximum range	km	150	500	1,000	30	30	500	30
Launch interval	min.	2	30	0	1	1	0	1
On-station time	min.	NA	60	20	NA	NA	45	NA
Number of return passes	Number	0	0	3	NA	NA	4	NA
Interval between passes	min.	NA	NA	5	NA	NA	2	NA
Communications Intervals								
FDC to launcher	min.	10	5	5	2	2	5	8
Launcher to launcher	min.	3	0	0	2	2	0	2
Point target warhead		MP	MP	MP	Copper-head	MP	Hellfire	DPICM
Implemented in ModSAF by:		Bomb	Bomb	Bomb	155 impact	MLRS	Hellfire	Bomb
Laser-designated P_k for tracks	P_k	0.2	0.2	0.8	0.5	0.7	0.8	0.5
Laser-designated P_k for tracks	P_k	0.4	0.4	0.9	0.2	0.7	1	0.5
Laser-designated P_k for troops	P_k	0.4	0.4	NA	NA	NA	NA	NA
Area Target Warhead								
Implemented in ModSAF by:		Bomb	Bomb	Bomb	155 prox	MLRS	Bomb	Bomb
Footprint against tracks	m x m	400 x 400	200 x 200	200 x 200	200 x 200	200 x 200	100 x 100	400 x 400
P_k against tracks in footprint	P_k	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Footprint against wheels	m x m	400 x 400	200 x 200	200 x 200	200 x 200	200 x 200	100 x 100	400 x 400
P_k against wheels in footprint	P_k	0.4	0.4	0.3	0.2	0.2	0.4	0.2
Footprint against troops	m x m	400 x 400	200 x 200	200 x 200	200 x 200	200 x 200	100 x 100	400 x 400
P_k against troops in footprint	P_k	0.5	0.5	0.6	0.4	0.4	0.8	0.4

Table C-2. Weapon Suite (Continued)

Characteristic	Units	NTACMS	Super T-Hawk	TAC AIR F-16	Howitzer 155m	MLRS	Attack Helo. AH-64	Naval Gun Fire
		Weapons						
FASCAM								
Mines installed by ModSAF								
Footprint	m x m	400 x 400		400 x 400	100 x 100	100 x 100		
Density (mines per footprint/pass or volley		400		500	65	100		
Target Location Update								
Update window (before impact)	sec.	120–60	120–60	300–240	NA	NA	60–30	NA
Correction envelope	km	3	NA	10	NA	NA	2	NA
Laser designate (impact minus X)	sec.	NA	7	7	7	7	NA	NA
Unattended Ground Sensor (UGS)								
Number per sortie	Number	0	0	0	0	0	4	0

Notes for Table C-2:

1. *Launch interval of "0" indicates continuous availability.*
2. *P_k is the probability of kill given an attack/per pass or vehicle.*
3. *MP means multipurpose.*

APPENDIX D.
OBSERVER AND PLAYER INSIGHTS

APPENDIX D.
OBSERVER AND PLAYER INSIGHTS

Appendix D is a collection of the significant comments by players and observers during the 2 weeks of trials conducted for STP21 Study. Comments were collected from observer data sheets, player input during the exercises, and AARs. These comments have been entered into a database and edited, evaluated, and sorted. The list below is sorted as follows:

- First, according to category
- Second, according to function
- Third, according to importance (*).

In Table D-1, the column headings are identified as follows:

- **Trial.** Trials took place in half-day sessions. Each comment is identified according to the session of origin. The trial number (e.g., 26AM) refers to the date of the trial in July 1996 and time during which the trial was conducted (AM or PM). This information is useful for relating to the raw data and for understanding the utility of the information. Before 18PM, all the trials were contaminated by technical problems within the simulation. In those early trials, the teams were learning how to use the equipment (MOF and COVER), and the software and the interfaces for all the equipment were being improved on an hourly basis. After that one good trial, the players changed and a new group (six Marine Lieutenants) began training on 22 July (22PM). They ran six trials from 23–25 July. The last day, 26 July, was dedicated to interviews and a comprehensive AAR. The most valid trials were 18PM, 24AM, 24PM, 25AM, and 25PM. These trials were conducted when the players were fully trained and the equipment worked well.
- **Category** and **Function.** Category and function are used as key words to sort the comments. They are generally self explanatory. Clearly, the comments are applicable to multiple categories and functions, but this breakdown was helpful in analyzing the data.
- ***.** The asterisk signifies the importance of the comment, which was determined by evaluating when the comment was made relative to the more valid trials and its applicability to the evolution of the small team concept.

- **Comments.** Comments about the design of specific items of equipment were not included in this report, in recognition of the fact that many of the problems with the equipment were fixed by the ongoing software updates.

In Table D-1, some of the terms are identified as follows:

- BDA (Battle Damage Assessment). BDAs are reports by the players or the intelligence system about the results of an attack on a target.
- BMP (Bronevaya Machina Piekhota). BMPs are Russian infantry fighting vehicles.
- COVER. COVER is a tethered UAV that raises Melios to a maximum elevation of 100 m above a team's Heavy Multipurpose Mobility Wheeled Vehicle (HMMWV).
- Driving Portal. A driving portal is a work station that allows the player to enter the simulation as the driver of an HMMWV. It includes COVER, Melios, GRUNT, and MOF.
- FASCAM (Family of Scatterable Mines). FASCAM is a minefield that is fired into position by artillery or delivered by tactical air.
- FDC (fire direction center). FDC is the facility where fire requests are received and instructions are sent to weapon systems.
- GEN. GEN, which appears under the **Trial** column, indicates a general observation that is not related to a specific trial
- GRUNT. GRUNT is a hand-held personal data assistant (PDA) that collects data from Melios and computes the coordinates of the target. The operator adds the other information needed in the CFF and transmits it digitally to the FDC.
- Melios. Melios is a hand-held binocular with a laser range finder. The observer aims at a target and lazes to determine the range and azimuth. These data are then fed automatically to GRUNT. The binocular has two magnification levels. Some trials were conducted with 1x–3x. Other trials were conducted with 1x–6x, and the last trial (25PM) was conducted with 1x–10x.
- ModSAF. ModSAF is the software system that manages virtual forces on the battlefield. In these trials, ModSAF provided the enemy forces. The players in 25PM used the display terminal of ModSAF as their intelligence source. In effect, they knew ground truth.

- MOF (Map of the Future). MOF is an electronic map and communications device capable of automatically portraying information reported from sensors. It also has menus for sending spot reports, fire requests, and e-mail.

- SA (Situational Awareness). Situational awareness is being aware of what is happening on the battlefield. It includes the physical presence of objects and a "read" of what they are doing.

- Treadport. Treadport is a work station that allows the player to enter the simulation as a dismounted infantryman. On it, he can walk and run, turn, and maneuver across the terrain. The station includes Melios, GRUNT, and MOF.

- UAV (Unmanned Aerial Vehicle). UAV is a drone. It is controlled from a ground station and provides intelligence about the area it overflies.

Table D-1. Observations About the STP21 Study

Trial	Category	Function	*	Comment
			*	1 = HIGH importance, 2 = MODERATE importance, 3 = LOW importance
GEN	Behaviors	Attention span	1	Each of the soldiers tended to become complacent when action was slow. Although they could become overloaded, they were not happy with little to do.
GEN	Behaviors	CFF	2	Many multiple requests were issued for the same target. The equipment did not provide the information needed to be confident that a request had been processed and was being acted upon.
GEN	Behaviors	Commo	1	Use of the radio increased markedly as the week went on. Troops found it more efficient and faster, and it probably had fewer errors.
GEN	Behaviors	Commo	2	Communications devices need an alert to advise the receiver of urgent messages.
GEN	Behaviors	Commo	3	Even though radio was down-played, radio transmission procedures (RTPs) were weak and counterproductive. More training is needed in this area.
GEN	Behaviors	COVER/Melios	1	The magnification needs to be changeable to avoid tunnel vision syndrome and job burnout.
GEN	Behaviors	COVER/MOF	2	COVER/Melios should be linked directly to the MOF. Having different systems with different keystrokes to do the same thing does not make sense.
GEN	Behaviors	Equipment	1	Soldier's comment: "Everything I had to do distracted from the mission I had to do."
GEN	Behaviors	Equipment	2	The soldiers tended to accept the small team concept but had little confidence in the equipment. (This feeling was truer during week 1 than week 2.)
GEN	Behaviors	Equipment	2	Participants were engrossed in device screens and not looking at the larger view.
GEN	Behaviors	GRUNT	2	Using the second laze to predict future target location was ineffective. A better way is needed.
GEN	Behaviors	MOF	1	Before using tools like GRUNT or MOF, soldiers need to be given standard operating procedures (SOPs) and taught specific procedures (e.g., brevity codes) that everyone will follow. Well-defined SOPs would have improved performance with these devices.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
GEN	Behaviors	MOF	1	The MOF screens should be analyzed by a graphics layout expert to determine the best colors. The current configuration makes it difficult to discriminate information from the background.
GEN	Behaviors	MOF	2	The MOF was too slow. It took too much time to update the screens and process input.
GEN	Behaviors	MOF	3	All three team members should have MOFs, with adequate map size, so that they can help each other.
GEN	Behaviors	Observers	1	GRUNT and MOF repeater screens did not provide an indication of what the soldier was doing. The observer only got to see the final product. He could not tell when he started working on a new CFF.
GEN	Behaviors	Personality	1	Personality heavily influenced performance. Differences were obvious between those who can sit still and those who cannot, between groups who chattered a lot and those that did not, and between groups that cooperated internally and those that did not. Work load issues are also, to some extent, personality driven. Future participant populations will have to be based on some selection issues.
GEN	Behaviors	Searching	1	The soldiers did not have good search/ scan techniques. Consequently, they did not make the best use of their time. (Training and player selection were problems.)
GEN	Behaviors	Task load	3	Because of the awkwardness of the equipment, the soldiers reached overload very quickly.
GEN	Behaviors	Task loading	1	Having one or two people to do all three tasks (sensor, shooter, fighter) presents difficulties. Three people, as a minimum, are needed for these roles.
GEN	Behaviors	Target tracking	2	The team needs a way to designate/tag/ identify/spot a potential target and follow it over time. Each time a soldier took his eyes away from the field of view to look at a device, information was lost.
GEN	Behaviors	Treadport	1	The treadport walker is an unrealistic concept. The soldier cannot get LOS on the ground in heavy vegetation.
25AM	Doctrine	Minefields	1	Minefields were the most effective weapon on the battlefield.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
25AM	Doctrine	Organization	2	Roving observer groups need three people dedicated to the engagement function. Adding a team leader to the group detracts from the group because he uses the equipment (MOF) to perform the lead function and takes this equipment away from the group for that time.
26AM	Doctrine	Roles	2	In response to the question "What do you think a man can do here that a computer cannot?", the Marines responded: provide spot reports, determine friend/foe/neutral, perform BDA, drive/walk/run, provide on-the-ground intelligence (i.e., Are those real tanks, or decoys, and so forth?), recognize patterns in movement.
26AM	Doctrine	Target hand-off	1	The concept needs to be adjusted so that the team is responsible for "discriminating" the target, (i.e., Is it a valid target?) and is then able to assist in tagging it. After the decision to attack the target is made, the soldier should be able to hand it off to the "system" for attack. He cannot keep his eyes on the target long enough to participate in the terminal phase of the attack.
26AM	Doctrine	Target tracking	1	The "system" needs to predict the direction and movement of the target.
25AM	Doctrine	Weapons	2	The troops wanted helicopters in the weapons suite because helos could hunt for a target even though the troops could no longer see it. (While we may not want to put helicopters into the 2010 environment, the functionality of a helo is what will be needed in the weapons systems that support this concept.
24AM	Equipment	BDA	1	No convenient way (graphical interface) exists to send BDA. BDA was sent via MOF e-mail as free-text messages. This process is very time consuming.
22PM	Equipment	COVER	1	The COVER operator cannot find the targets easily using verbal instructions from the MOF operator. He should have an automatic target hand-off capability.
23AM	Equipment	COVER	1	It was very difficult for the troops to go back and find a target several minutes after a CFF, when it was time to designate or update the target location. Correlating a fleeting target with a 10-minute-old CFF is a nearly impossible task, but one that could be done well by the Intel system if a target tagging technology were employed.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
25PM	Equipment	COVER	1	COVER should be slaved to the Intel reporting system (i.e., MOF). That way, the operator of MOF could point to a target and orient COVER automatically on the desired target.
26AM	Equipment	COVER	1	The hardest task, among all tasks, was tracking multiple targets on COVER.
23PM	Equipment	COVER	2	A tank was positively identified at 3,800 m with COVER.
22AM	Equipment	COVER	2	Infantry was detected at 3 km with COVER at 6x magnification
26AM	Equipment	COVER	2	The joystick was difficult to use. Keeping the view on the target was hard.
22PM	Equipment	COVER	3	COVER needs an auto-slew capability, slaved to MOF, to help orient on the target.
18AM	Equipment	COVER	3	Even at 100-m elevation, COVER is severely restricted in its ability to see at long distances. The same can be said for short distances. Hills and trees around any location block LOS. A higher magnification does not yield equivalent increases in utility. An untethered system would be much more useful.
18PM	Equipment	COVER	3	Even though COVER was fully deployed at 100 m, the visibility in most places was limited to 2,500 m because of tree lines. Occasionally, it could see beyond 8 km.
18PM	Equipment	COVER	3	The media for tasking a UAV should be "voice." The same media should be the interface with these input devices. Keypunching should be replaced with a voice recognition system.
18PM	Equipment	COVER	3	COVER should be an untethered UAV that allows the team to simply task it. Some remote or automated system should fly it. However, it should be dedicated to the small team.
25PM	Equipment	COVER	3	The operator must be able to store a target and later slew to the old location as a starting point for finding the target again.
24AM	Equipment	COVER/ GRUNT	3	COVER and GRUNT should be operated by two different people.
25PM	Equipment	COVER/MOF	1	COVER and MOF need to be interactive so that COVER can auto-slew to a cued target location.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
25PM	Equipment	Ground truth	1	With perfect knowledge and an MOF, the team was able to request fires very rapidly.
24PM	Equipment	GRUNT	2	Operator could not keep two missions going at once on the GRUNT.
26AM	Equipment	GRUNT	2	Lack of training and lack of feedback on the GRUNT resulted in confusion. Marine's comment was as follows : "Sit and wait, no feedback. Did message transfer? Do I need to re-laze? Call in second mission on same target? Need automated feedback, need automated feedback on everything!"
23PM	Equipment	GRUNT	3	The GRUNT provided no feedback to the operator. It should at least acknowledge that the recipient has read the message.
24PM	Equipment	Interfaces	1	Hardware interfaces need to be system engineered. Joysticks and keyboards are awkward in a heavy task-loaded situation, not to mention mud.
24PM	Equipment	Internal commo	1	Observers and MOF/GRUNT operators experienced a great deal of interaction. These interactions need to be automated so that the tasks of orienting the viewer onto a cued target is less time consuming.
24PM	Equipment	Melios	1	Melios' view is limited by tree lines on STOW-E TDB.
24PM	Equipment	Melios	2	The GRUNT/MOF operators need to be able to see what the Melios operator is seeing. Otherwise, they cannot help with target tracking.
23PM	Equipment	Melios	3	It is difficult to hold Melios and aim it for any length of time because it is too heavy.
23PM	Equipment	Melios	3	It is difficult to find and locate a target with Melios.
22PM	Equipment	Melios	3	The Melios is too unstable. It needs a tripod.
23AM	Equipment	MOF	1	The MOF should report the reliability and accuracy of the information provided by the Intel system. Without this, the soldier cannot properly prioritize his work load. He should not waste his time chasing a low accuracy report when other reports are more likely to yield a target.
22PM	Equipment	MOF	1	The unit leader could not see the big picture on the MOF and still see the detail he needed to see about the terrain. The system needs a display with finer resolution.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
26AM	Equipment	MOF	1	MOF needs the capability to do LOS determination. This would help the team make much better use of its time. All future C2 devices need a Terrabase (2D)-like capability as a minimum. 3D visualization of the battlefield with fly-through capability would be better.
26AM	Equipment	MOF	1	Ground truth from ModSAF was "very nice," but the lack of integration with the MOF made it difficult to keep up with the work load. Too much manual data work.
22PM	Equipment	MOF	2	The team leader could not see enough of the battlefield when he zoomed in to see the detail. He could not see enough detail when he zoomed out to see his whole area of responsibility (i.e., 5-km radius).
25PM	Equipment	MOF	2	In this trail, the teams had a ModSAF terminal, which gave them ground truth, as their Intel picture. The troops quickly learned that the range arrow was the perfect tool for determining range and azimuth to the target. They could then pass this information verbally to the COVER operator to get him oriented. MOF needs this capability.
25PM	Equipment	MOF	2	The terrain profiling capability on ModSAF enabled the team to determine if a target was within the LOS of COVER and, if not, when it would be. This information allowed the team leader to maximize the value of COVER because it was not searching for targets that it would not have been able to see anyhow.
22PM	Equipment	MOF	2	Resolution at the big-picture level on MOF is not good enough.
22PM	Equipment	MOF	2	A mouse interface on the MOF is not good for soldiers.
25PM	Equipment	MOF	2	MOF screen update cycle is too long.
25PM	Equipment	MOF/GRUNT	3	MOF/GRUNT users talked in universal transverse mercator (UTM). COVER operator needed information in azimuth and range. This made it difficult for COVER to find targets.
22PM	Equipment	MOF	3	Screen organization and menu structure were poor. (Many fixes occurred hereafter.)
22PM	Equipment	MOF	3	MOF needs contour lines and a map legend.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
22PM	Equipment	MOF	3	MOF operator could not save a message and go to something else (a training problem)
25PM	Equipment	MOF	3	When targets were not posted on the MOF by the remote sensor, the troops had to create their own target symbols before initiating a fire command. This requirement added considerably to their time lines. (This situation occurred when ground truth was provided via ModSAF in lieu of sending remote sensor information via MOF.)
25PM	Equipment	MOF	3	The MOF screen updates too slowly. A lot of "finger tapping" occurred while the troops were waiting for the screen to repaint.
22PM	Equipment	MOF/COVER	1	Two-man teams had trouble handling COVER and MOF at the same time. One Marine said, "Hard to do it all at once."
22PM	Equipment	MOF/GRUNT	2	Need to have all systems working on the same coordinate and azimuth system. We had a mix of mils and degrees, UTM and latitude/longitude, miles and kilometers, and feet and meters.
24AM	Equipment	MOF/GRUNT	3	MOF and GRUNT should be combined into one piece of equipment. Melios or COVER data should be fed directly into the MOF just like it goes into GRUNT.
22PM	Equipment	MOF/GRUNT	3	Early in the training cycle, the troops were totally focused on the equipment. They did not see the battlefield.
23PM	Equipment	MOF/GRUNT	3	Digital communicators should provide a silent alert to key the operator to the fact that a message is waiting to be read.
GEN	Equipment	Prediction of location	1	The feature of GRUNT that predicts future target location based on a linear function is inadequate for this context. It takes 5 to 15 minutes to service a target. In that time, a vehicle can move 2 to 5 miles. An infantry group can move 1 km. Only the inexperienced move in straight lines on a battlefield. The targeting system needs a higher order method of prediction.
22AM	Equipment	Sensors	1	COVER and Melios are inadequate for detecting infantry in mixed terrain.
25AM	Equipment	Terrain analysis	2	The troops got to use ModSAF, with its terrain profiling capability, in their mission analysis. It was very useful. This capability is needed in the MOF.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
18AM	Equipment	UAV	1	A small team needs a dedicated UAV that it can task to cover areas of its choosing. It does not need to maintain the UAV but should have tasking authority. The UAV should be immediately available to the team.
24AM	Exercise management	Observers	3	Observers need to be trained and briefed on the specifics of the exercises and their note-taking/reporting requirements.
23AM	Procedures	Task allocation	2	The driver used COVER while an observer used MOF and GRUNT. GRUNT was used for most CFFs, which left the MOF screen free to use as a map.
23PM	Procedures	BDA	1	It was difficult to make BDAs. If the target was observed and it burned, no problem. If it was simply a mobility or firepower kill, it was hard to determine, given the simulation display (also true in real combat). Unobserved targets could not be evaluated by the team, and the Intel system did not provide much information.
23PM	Procedures	BDA	2	It is difficult to match a vehicle on the battlefield with a CFF that may be 10 or 15 minutes old. Consequently, many engagements were never closed with a valid BDA. Database tagging of the target is required.
24PM	Procedures	BDA	2	Lack of BDA caused confusion about whether the target had been engaged.
24PM	Procedures	BDA	3	Trooper had BDA but did not transmit.
24AM	Procedures	Commo	1	It was difficult for the roving observers to keep the unit leader informed when more than two targets were coming at them.
23PM	Procedures	Commo	2	Communications—even digital—still require brevity codes to prevent wasted time with unnecessary words.
22AM	Procedures	Commo	2	Radio was the medium of choice for local coordination among observers and leader.
23PM	Procedures	COVER	1	Moving between targets was awkward. Trooper was observing target 19, but needed to get onto target 13. "How do you know where 13 is now?"
24AM	Procedures	COVER	2	The COVER operator has to stay with the target. It is difficult to track multiple targets simultaneously because once the operator goes to a different target, it is nearly impossible to get back to the first one on time.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
22PM	Procedures	COVER	2	Trooper had developed an excellent search pattern technique.
26AM	Procedures	COVER	3	The best technique for finding a cued target is to pan to the suspected azimuth and then start from close-in lazing frequently to find the suspected range.
26AM	Procedures	COVER	3	The best technique for searching is to scan with the horizon at the top of the screen.
24PM	Procedures	Engage cycle	1	Getting rounds on target take too long. Troops were frustrated because the targets disappeared before they could be killed.
25AM	Procedures	Engage cycle	2	CFFs based only on MOF information are ineffective. The locations are too old—approximately 1 to 3 minutes—by the time the information gets to the team. This situation was driven by the limitations of the Remote Sensor Station swivel chair interface, which only permitted a near-real-time input. This situation shows the need for a direct link with the intelligence platforms to provide real-time data.
24AM	Procedures	Fire request	1	A moving target was spotted. However, by the time artillery was ready to arrive and the crew was ready to laze, the target had disappeared into the trees.
26PM	Procedures	Fires	3	A Marine said, "Smart weapons cannot do everything."
23PM	Procedures	GRUNT	3	If the observer needs to call up a previous target on the GRUNT so that he can designate it, the GRUNT interface does this very poorly.
23AM	Procedures	GRUNT/ COVER	2	Troops felt that GRUNT and COVER should be operated by different people. COVER operator must stay focused. If the COVER operator drops off to work GRUNT, he looses his orientation.
23PM	Procedures	Leader	2	The intermediate leader needs to be forward, with the teams, seeing the battlefield.
22PM	Procedures	Melios	3	Missed target in Melios, late in the day. Fatigue? Boredom?

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
23AM	Procedures	MOF	1	Operations orders and overlays were issued by the Blue Commander on the MOF. Teams then did their mission planning and communicated their plan back to Blue Commander on the MOF. This approach worked well and was used for the rest of the trials. However, the MOF graphical interface is inefficient for this purpose.
24AM	Procedures	MOF	2	"How do you update a previous fire request?" (a training problem)
16PM	Procedures	MOF	2	MOF needs an indicator of target's disposition. Has it been serviced, waiting for initial action, waiting for second action, or killed? The response has to be visual so the operator can see it. He cannot remember it.
25PM	Procedures	MOF/ModSAF	2	The ModSAF and COVER operators had to do a lot of talking to correlate targets on the two devices.
22PM	Procedures	Remote Sensor	3	Remote sensor information is old when it arrives to the team. In some instances, this was a function of the work-around swivel chair interface. In other cases, it replicated a gap in continuous sensor coverage.
24AM	Procedures	Search	2	COVER operator identified a target before it appeared on the MOF. (**Note:** *Given the sensor coverage, it is entirely possible that UAVs may not have been on station at the time.)*
23AM	Procedures	Sectors	2	Unit leader assigned roving observer responsibilities by sector, dividing at the river that went through the control area. The leader set up aiming points to mark sector boundaries, similar to the way range cards are used today. Roving observers were responsible for eyes-on targets, and the team leader took care of the beyond-visual-range (BVR) targets, doing the CFF on the MOF.
24PM	Procedures	SA	1	Enemy infantry walked within 10 ft of the team. Because of their fixation on the equipment, they missed the enemy.
GEN	Procedures	SOP	2	Internal team procedures should be laid out ahead of time. A language for target management is needed along with drills for target hand-off, CFF, and so forth.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
26AM	Procedures	System	1	The target engagement/Intel system needs to provide feedback to the team and team members. They need to know that a message has been received, that a request is being acted upon, and when something is going to happen. They also need BDA from the system about those targets that they cannot directly observe.
26AM	Procedures	Task allocation	2	Divide targets into two sets: visible and non-visible. Leader takes the non-visible, and the observer takes the visible.
18AM	Procedures	Task assign-ments	2	Organizing the team around a target manager system may be useful. One person would take responsibility for a target and handle it throughout the engagement. The next target would go to somebody else. This idea is worth developing and evaluating.
24AM	Procedures	Task loading	1	When too many targets started coming in, the leader lost control of the tactical situation. Too much was going on. Because of the confusion, he double-engaged some targets.
26AM	Procedures	Task loading	1	Comment by player: "This mentally wears you out. I could not do this 8 to 10 hours a day. Using the joystick and staring at the screen are frustrating."
26AM	Procedures	Task manage-ment	2	After redistribution of tasks, a three-man team worked well. If COVER had auto-tracking, a two-man team could do it.
26AM	Procedures	Tasks	2	A three-man team is best. Driver operates COVER. Team leader operates MOF. Assistant operates GRUNT and provides "extra eyes" for COVER. Extra eyes are important to relieve stress on COVER operator and to improve chance of spotting a target. Can target recog-nition software be put in COVER?
24AM	Procedures	Team	1	Three-man team worked well. A two-man team cannot handle the operation. The driver operates COVER, another man operates GRUNT, and the leader operates MOF. Seemed to be the best allocation of duties.
16PM	Procedures	Team leader	2	The intermediate leader needs feedback from the teams and the Remote Sensor Station on BDA. He is in the dark without it.
24PM	Procedures	Team location	2	Excellent use of MOF to find best vantage point for the team.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
16PM	Procedures	Team organization	1	When GRUNT and MOF are included at a portal, a three-man team is needed to keep up with the devices.
26PM	Procedures	Target acquisition	2	A Marine said, "It is difficult to know the value of the target without eyes-on."
24AM	Procedures	Target acquisition	3	Good coordination between MOF and COVER operators.
26AM	Procedures	Target acquisition	1	360 degrees is too much area for one team to monitor.
16AM	Procedures	Target attack	3	Teams were applying windage to their target locations. Based on their perception (not well-founded) of the target's direction of movement from the MOF screen, they would estimate a "lead" and fire on that location. This technique was totally ineffective.
22PM	Procedures	Target identification	2	Target identified at 3,080 m. Team could not validate as enemy.
25AM	Procedures	Target management	1	Group leader created a job aid in his notebook. He used paper and pencil records to help him keep track of fire missions because he could not do it on MOF or GRUNT.
15PM	Procedures	Target management	2	Cannot tell which targets have already been serviced; repetition and wasted effort are leading to frustration. Targets must be "tagged."
23PM	Procedures	Target tracking	1	Many targets drop out of sight between the CFF and impact.
22AM	Procedures	Target tracking	1	No good system exists for keeping track of older targets. For example, "What was target 07?" This situation shows the need for a target tagging capability so that the Intel system can "remember" where these targets are located.
24AM	Procedures	Target tracking	2	The team was unable to designate a target because it had moved out of sight before the weapon arrived.
24PM	Procedures	Target tracking	2	The Melios operator was able to find several targets on his own without a cue from the MOF.
25PM	Procedures	Target tracking	2	A Marine said, "Get me back on those BMPs!" COVER operator had trouble finding the BMPs and was unable to designate in time for the warhead.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
24AM	Procedures	Time management	1	Feedback from FDC is extremely important. If the team knows the impact time and the correction time for incoming warheads, it can plan its time wisely. Otherwise, it stays focused on the cued target locations at the expense of continuous scanning.
25AM	Procedures	Unit leader	1	The unit leader was part of one group of roving observers in this trial. He felt that he could not control both groups, so he told them to "do what they needed to do." He did not think that he could perform a team function and a leader function simultaneously.
25AM	Procedures	Unit leader	2	The unit leader had difficulty getting information from the two teams because the work load for each team was very heavy. They were unable to spend much time keeping him informed.
GEN	Simulation	Observers	1	Observers need to be in a position to monitor cross talk within the team, not just the radio traffic.
26AM	Simulation	COVER	3	It was hard to find geographical references to use in COVER. [This situation may have more to do with the lack of features in the TDB (i.e., telephone lines, buildings, bridges, and so forth) than with the capabilities of COVER.]
24AM	Simulation	COVER	3	COVER is perpendicular to the ground surface rather than the data plane. Consequently, when the HMMWV was on sloping ground, COVER was perpendicular to the slope. This position resulted in a tilted view of the world.
17PM	Simulation	COVER	3	At 3x, a tank was detectable at 1,800 m and recognizable at 1,200 m. At 6x, tanks were detectable at 4,500 m and recognizable at 2,200 m. This outcome resulted from a detection test run by the troops to characterize the performance of COVER.
17PM	Simulation	Driving portal	2	The vehicle should not be able to move when COVER is up. COVER should be off when the vehicle is moving. (The simulation needs to be fixed.)
16PM	Simulation	Equipment	1	Contractors were making changes to the equipment on a daily basis during the first week. They were very impressed that they could learn the problems first hand, make the fixes, and evaluate the results in an overnight cycle.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
GEN	Simulation	Excon	2	The remote sensor station and the FDC need to be automated. They are labor intensive in their current manual mode. In the 25AM scenario, the targets were slowed to 15 kph because FDC was having trouble keeping up with the work load.
GEN	Simulation	FDC	1	The FDC function needs to be automated. Manual operation was too slow.
26AM	Simulation	Lights	2	Lights for photographers were very distracting.
24PM	Simulation	Maps	1	Differences in the databases among MOF, ModSAF, and Melios caused considerable confusion for the players and for control. The MOF map must correlate with the virtual terrain. Data and points of origin also must correlate so that coordinates match. This was not the case during these trails.
17PM	Simulation	Models	2	The image generators for the portals did not have the needed models. Infantry squads had to be represented by one individual. There were no non-combatant vehicles. There were not enough vehicle types to generate a force in which the observers had to discriminate among targets and decide which ones were the most critical. For example, they did not have to choose between a BMP with a radar and a plain BMP or between a military truck and a milk truck.
24AM	Simulation	Models	2	Color of trucks vary from screen to screen.
24PM	Simulation	Observers	2	Observers need to take time to provide rationale for their comments/notes.
16PM	Simulation	Remote sensor	3	The remote sensor operator was overwhelmed by the work load. This station needs to be automated; otherwise, it will continue to be the limiting factor in the simulation. Real-world C2 devices need to be made compatible with the synthetic environment using ADS so that they can be attached directly to the simulation instead of developing a family of emulators that do the same job.
18AM	Simulation	SOP	3	For training purposes, an SOP is needed for each piece of equipment used in an exercise.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
17PM	Simulation	TDB	1	A lot of time was lost trying to correlate the TDB with COVER, MOF, ModSAF, and the image generators. The location of an entity was different in each one. The simulation needs a better architecture for dealing with this problem, and, in the future, tests need to be run from many locations on the map. In one instance, everything appeared to be correlated around one vehicle; however, when the vehicle moved to a new location, correlation was lost.
GEN	Simulation	TDB	2	The visuals in the STOW-E (Grafenfels) TDB were poor. Trees were triangular. Large blobs that were apparently rocks appeared but were not discernible as rocks. Textures were meaningless. However, the poor visuals became irrelevant after the exercises began. There was seldom a complaint about them.
22PM	Simulation	Team organization	1	Changing the composition of the teams for each trial caused a problem in ramping up for each trial. On the other hand, behavioral observers noticed that performance of the teams was heavily influenced by individual skills, talents, and personalities. Was the turmoil worth it?
GEN	Simulation	Terrain	1	The simulations allows violations of the laws of physics—excessive speeds; driving over, under, or through trees; and so forth—without consequences. These features of the simulation need to be corrected to maintain believability in the environment.
24AM	Simulation	Terrain	2	"Is that a river or a road?"
GEN	Simulation	Time keeping	3	All the components of the simulation need to be on a synchronized time system; otherwise, data collection is a nightmare.
26AM	Simulation	Training	2	Marines did not feel confident with the equipment until 24AM.
16PM	Simulation	Treadport	1	The treadport operator cannot manage an MOF or GRUNT. A second person is needed to perform these functions. Since no properly engineered place was available for this person, he sat uncomfortably on the floor. This problem needs a solution.
26AM	Simulation	Treadport	3	SAFETY: Hit the Treadport kill switch before using Melios.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
24PM	Simulation	Tree lines	1	Individual tree lines need to be somewhat transparent. A single line of trees should not totally block view.
GEN	Simulation	Preparation	1	Participants need initial instruction conventions for living in a simulator world — roads, rivers, fords, and so forth. Also, participants need training in range determination/estimation in the simulator. The simulator world is different from the real world.
24AM	Simulation	Terrain	2	In COVER, the targets are the same color as the trees.
23PM	Tactics	FASCAM	1	FASCAM was an important weapon. Teams used it to block avenues of approach. It would stop the enemy and set them up for a kill. It prevented them from disappearing before the warhead arrived.
26PM	Tactics	Fires	1	Need to make fires more responsive.
26PM	Tactics	Fires	2	A lot of rounds were wasted because of inaccurate intelligence and long engagement cycles.
18AM	Tactics	Location	2	The team leader said he had not done a good job of assigning the roving observer to the initial location. He oriented on maximizing his field of view but instead should have maximized his observation of a critical avenue of approach.
24AM	Tactics	Minefields	1	Minefields were big killers.
GEN	Tactics	Mobility	1	A foot mobile element is unable to travel fast enough to keep up with the demands of this type of operation. If he is to get to a position where he can observe targets for designation and BDA, he needs transportation. A motorcycle may be a good answer. If he is on foot, the target will be gone before he can travel very far (10 minutes = 0.5 km).
18AM	Tactics	Mobility	1	Roving observer is ineffective if he is on foot.
22PM	Tactics	Movement	2	Movement adds to vulnerability. The team moved too much. Movement needs to be kept to a minimum.
22PM	Tactics	Movement	3	The time spent moving seriously detracted from reading the battlefield.

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
25AM	Tactics	Sectors	1	A 360-degree mission is too much for one group. If the sector is over 60 degrees, the troops have to scan too widely and they loose their effectiveness. It is particularly difficult to get back onto a target on time after rotating 180 degrees away from it.
24PM	Tactics	SA	1	This scenario was a repeat of the morning scenario. About 45 minutes into the exercise, one Marine announced that he recognized it as the same scenario. This is an indication that he was able to clearly read the battlefield.
24PM	Tactics	SA	1	The observer using COVER had a much better read of the battlefield than the team leader because the team leader had only the MOF from which to see. The team leader is not able to influence the action operating from an MOF.
23PM	Tactics	SA	2	The team made a good read of the enemy operation and intent.
24AM	Tactics	SA	2	The team made a poor read of the battlefield. They had no concept of what the enemy was doing. This situation is partly caused by their inexperience but also by the difficulty of seeing complete picture with the available resources.
25AM	Tactics	SA	2	This leader had a poor read of the battlefield.
22AM	Tactics	SA	2	Team identified a target at 4 km but realized that it had already been targeted. Example of a good read of the battlefield.
24PM	Tactics	Target tracking	2	A tank platoon passed within 700 m; however, the team could not observe it because of the terrain, even though they knew from the MOF that the tank platoon was there. This was a typical problem. It suggests the need for an untethered COVER that can maneuver to a observation location quickly.
18AM	Tactics	Target acquisition	2	A small team should have multiple roving observers.
23AM	Tactics	Target tracking	2	Team could not identify targets beyond 3 km with a 6x magnification on Melios.
24PM	Tactics	Target tracking	2	Several threat vehicles got stuck in the village and could not cross the river. The team got fixated on these targets and failed to keep searching and tracking other targets. (This is also a real-world problem.)

Table D-1. Observations About the STP21 Study (Continued)

Trial	Category	Function	*	Comment
22PM	Training	Commo	3	Player communications procedures were weak. They need training in procedures, unless they come from units where Commo is used regularly.
22PM	Training	Commo	3	There was a lot of radio traffic just to check on e-mail traffic. This is partly a training problem but is also a by-product of the crude interface and design of the e-mail tool. Procedures and brevity codes are needed for e-mail traffic.
22AM	Training	COVER	2	The operator had developed good search techniques (no indication in the notes of what these techniques were). However, as a general observation, techniques need to be developed by the system designers and need to be available when the troops are being trained to use the equipment. One should not be developing techniques while operational evaluations are in progress.
24AM	Training	Equipment	3	Troops need to learn the functional capabilities of their equipment before starting an exercise. For example, in one training session, they could view targets at various ranges to see what they would look like in the simulation.
GEN	Training	General	3	Training is critical. Training for simulation should be easier because, without the real-world frame of reference, it is easier to ignore what one already knows.
22PM	Training	GRUNT	3	This was the first day of training for the Marines. At one point, they became so fixated on preparing the CFF that they did not notice a tank was overrunning their position.
18AM	Training	SA	1	The MOF, GRUNT, and COVER caused the team to focus on the equipment and not look out the window.

ANNEX E.
BATTLEFIELD CONFIGURATIONS

ANNEX E.
BATTLEFIELD CONFIGURATIONS

This annex contains the battle field configuration matrices for the trails run in week one (see Table E-1) and week two (see Table E-2).

Each day consisted of two sessions, except for 16 July, which was a single session. The trials are labeled according to the date and time of day (AM or PM).

Environments were rural. Some trials were run in the vicinity of Hohenfels on the STOW-E TDB, and others were run on the Hunter-Liggett TDB (Hunter). Participants were rotated to the extent possible, so that the learning effect was neutralized.

Appendix C, Tables C-1 and C-2, defines the sensors and weapons.

Table E-1. Battlefield Configuration: Week One

Trial	16 AM/PM	17 AM - 1	17 AM - 2	18 PM	18 PM
Environment	Rural	Rural	Rural	Rural	Rural
Terrain	STOW-E	STOW-E	STOW-E	STOW-E	STOW-E
Portal 1 (Treadport)					
Leader	Terrell	Terrell		Clark	Clark
Assistant	Clark	Wright		Terrell	Terrell
MOF	X	X	Failed	X	X
GRUNT	X	X		X	X
Melios	X	X		X	X
Magnification	1–3	1–3			
Mobility	Dismount	Dismount	Dismount	Dismount	Dismount
Portal 2 (Driving Portal)					
Leader	Pickell	Pickell	Wright	Wright	Wright
Assistant			Pickell	Pickell	Pickell
Assistant			Clark	Riggs	Riggs
MOF	X	X	Failed	X	X
GRUNT	X	X	X	X	X
Melios					
COVER	X	X	X	X	X
Magnification	1–3	1–3	1–3	1–6	1–6
Elevation Rate	50 m/s	50 m/s	50 m/s	50 m/s	50 m/s
Mobility	HMMWV	HMMWV	HMMWV	HMMWV	HMMWV
Team Leader					
Leader	Wright	Wright			
Assistant					
MOF	X	X			
Mobility	HMMWV	HMMWV			
UGS (hand-emplaced)	2	2			

Table E-1. Battlefield Configuration: Week One (Continued)

Trial	16 AM/PM	17 AM - 1	17 AM - 2	18 PM	18 PM
Environment	Rural	Rural	Rural	Rural	Rural
Terrain	STOW-E	STOW-E	STOW-E	STOW-E	STOW-E
Remote Sensors					
UAV	X	X	X	X	X
JSTARS	X	X	X	X	X
TIER II/III	X	X	X	X	X
Predator	X	X	X	X	X
Weapons					
NTACMS	X		X	X	X
Super T-HAWK	X		X	X	X
TAC AIR	X	X	X	X	X
Howitzer	X				
MLRS	X	X	X	X	X
Attack Helo	X	X			
Naval Gun Fire		X			
Red Forces					
Mission	Infiltrate	Infiltrate	Infiltrate	Infiltrate	Infiltrate
Vehicle Speeds	15 kph	15 kph	15 kph	15 kph	15 kph
Tank Probes	9	2	2	4	4
BMP Probes	11	3	3	5	5
Truck Probes	2	1	1	2	2
Dismounted Probes	19	4	4	8	8

Table E-2. Battlefield Configuration: Week Two

Trial	23 AM	23 PM	24 AM	24 PM	25 AM	25 PM
Environment	Rural	Rural	Rural	Rural	Rural	Rural
Terrain	Hunter	Hunter	Hunter	Hunter	Hunter	Hunter
Portal 2 (Driving Portal)						
Leader	Parks	Sagisi	Raithel	Hodges	Hubbard	Hong
Assistant	Hong	Parks	Sagisi	Raithel	Hodges	Hubbard
Assistant	Hubbard	Hong	Parks	Sagisi	Raithel	Hodges
MOF	X	X	X	X	X	X
GRUNT	X	X	X	X	X	X
Melios	X	X				
Magnification	1–6	1–6				
COVER	X		X	X	X	X
Magnification	1–6	1–6		1–6	1–6	10-Jan
Elevation Rate	50 m/s		50 m/s	50 m/s	100 m/s	100 m/s
Mobility	HMMWV	Dismounted	HMMWV	Dismounted	HMMWV	HMMWV
Portal 1 (Treadport)						
Leader	Hodges	Hubbard	Hong	Parks	Sagisi	Raithel
Assistant	Raithel	Hodges	Hubbard	Hong	Parks	Sagisi
MOF	X	X	X	X	X	X
GRUNT	X	X	X			
Melios		X				
Magnification		1–6				
COVER	X		X	X	X	X
Magnification	1–6	1–6		1–6	1–6	10-Jan
Elevation Rate	50 m/s		50 m/s	50 m/s	100 m/s	100 m/s
Mobility	HMMWV	Dismounted	HMMWV	Dismounted	HMMWV	HMMWV
Team Leader						
Leader	Sagisi	Rathiel	Hodges	Hubbard	Hong	Parks
MOF	X	X	X	X	X	X
Mobility	HMMWV	Dismounted	HMMWV	Dismounted	HMMWV	HMMWV
UGS (hand-emplaced)	2	2	4	4	4	4

Table E-2. Battlefield Configuration: Week Two (Continued)

Trial	23 AM	23 PM	24 AM	24 PM	25 AM	25 PM
Environment	Rural	Rural	Rural	Rural	Rural	Rural
Terrain	Hunter	Hunter	Hunter	Hunter	Hunter	Hunter
Remote Sensors						
UAV	X	X	X	X	X	
JSTARS	X	X		X	X	
TIER II/III					X	
Predator	X	X		X	X	
Ground Truth						X
Weapons						
NTACMS			X	X	X	X
Super T-HAWK			X	X	X	X
TAC AIR	X	X	X	X	X	X
Howitzer						
MLRS	X	X	X	X	X	X
Attack Helo	X	X				
Naval Gun Fire	X	X				
Red Forces						
Mission	Recon	#	Recon	#	#	#
Vehicle Speeds	15 kph	15 kph	15 kph	15 kph	29 kph	29 kph
Tank Probes	6	6	4	4	4	5
BMP Probes	6	6	4	4	5	6
Dismounted Probes	4	4	5	5	8	11

GLOSSARY

GLOSSARY

AAR	after action review
ADS	Advanced Distributed Simulation
ARI	Army Research Institute
BDA	battle damage assessment
BMP	Bronevaya Machina Piekhota (Soviet Infantry Fighting Vehicle)
BVR	beyond visual range
C2	command and control
C4I	command, control, communications, computers, and intelligence
CFF	call for fire
COVER	Name of a tethered aerial sensor
DARPA	Defense Advanced Research Projects Agency
DIS	distributed interactive simulation
DMSO	Defense Simulation and Modeling Office
DPICM	Dual-Purpose Improved Conventional Munitions
DSB	Defense Science Board
EEA	essential elements of analysis
FASCAM	Family of Scatterable Mines
FCS	Fire Control System
FDC	fire direction center
FLIR	forward-looking infrared radar
FOFAC	Forward Observer, Forward Air Controller
FSE	fire support element
FSO	Fire Support Officer
FTI	fixed target indicator
GFE	government-furnished equipment
GPS	Global Positioning System

GSM	Ground Station Monitor
GUI	graphical user interface
HMMWV	Heavy Multipurpose Mobility Wheeled Vehicle
IDA	Institute for Defense Analyses
IFF	identification friend or foe
IFS	indirect fire support
IPB	intelligence preparation of the battlefield
IR	infrared
ISS	indirect sensor support
JANUS	large combat model (constructive simulation)
JSTARS	Joint Surveillance, Target Acquisition, Reconnaissance System
km	kilometer
kph	kilometers per hour
LLTV	Low-Level Television
LOC	Location
LOS	line-of-sight
m	meter
Melios	Name of a set binoculars integrated with a laser range finder
MLRS	Multiple Launch Rocket System
ModSAF	Modular Semi-Automated Force (a constructive simulation used in this exercise)
MOE	measures of effectiveness
MOF	Map of the Future
MOP	measures of performance
MTI	moving target indicator
nm	nautical mile
NTACMS	Navy Tactical Missile System
OPFOR	opposing forces
OUSD(AT)	Office of the Under Secretary of Defense (Acquisition and Technology)

PDA	Personal Data Assistant (a hand-held commuter/ communications device)
REMBASS	Remote Battle Awareness Sensor Suite
ROE	rules of engagement
RTP	radio transmission procedures
SAR	Synthetic Aperture Radar
SINCGARS	Single Channel Ground/Airborne Radio System
SOP	standard operating procedure
STOW–E	Synthetic Theater of War–Europe
STP	small team portal
STP21	Small Team Portal into the 21st Century (Virtual) Battlefield
STRICOM	Simulation, Training, and Instrumentation Command
SUO	Small Unit Operations
TAC AIR	Tactical Air
TDB	terrain database
TF	task force
TRADOC	U.S. Army Training and Doctrine Command
TT&P	tactics, techniques, and procedures
U.S.	United States
UAV	unmanned aerial vehicle
UGS	unattended ground sensor
USAF	United States Air Force
UTM	universal transverse mercator
WISE	Walk-in Synthetic Environment

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13. ABSTRACT ***(Maximum 180 words)***

The 1996 Defense Science Board (DSB) Summer Study, "Tactics and Technology for 21st Century Military Superiority," focused on how to make relatively small and rapidly deployable forces/teams—specially equipped, trained, and supported by remote sensors and weapons—able to accomplish missions that until now were only possible with much larger and massed forces. IDA participated in the evaluation of doctrinal concepts and technologies considered by the DSB and demonstrated the value of human-in-the-loop simulations that immersed small teams onto a 21st Century battlefield. IDA profided analytical insights in the areas of team operations, sensor management, weapons management, and data management and presentation. IDA also demonstrated that virtual simulation is an appropriate technique for assessing new battlefield processes. Virtual simulation provides an environment for creating and experimenting with future doctrine, tactics, and techniques and enables the investigation of individual workload and roles.

14. SUBJECT TERMS
Defense Science Board (DSB), human-in-the-loop simulation, remote fires, Small Unit Operations (SUOs), sensor management, situational awareness, virtual simulation

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