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THE CLOSE COMBAT TACTICAL TRAINER PROGRAM

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ABSTRACT

The Close Combat Tactical Trainer (CCTT) is the first full scale development of a Distributed Interactive Simulations (DIS) training system. CCTT is being developed to support the training requirements of the U.S. Army's combined arms teams, however it also provides an entity-based battlefield which will be able to support higher level training and development activities. This paper will provide an overview of CCTT, discuss how it will use the DIS standard protocols and semi-automated forces within its architecture, the program's development methodology, and its role in future Army training. CCTT builds on the successful technology demonstration of this approach by DARPA's SIMNET project (Thorpe 1987).

1. INTRODUCTION

The Close Combat Tactical Trainer (CCTT) is a collective training system in which armor and mechanized infantry units man full-crew simulators of their weapons systems to conduct unit training in a combined arms environment. Simulated elements replicate combat vehicles, weapons systems, and command and control elements networked using DIS protocols for real-time, fully interactive collective task training on computer generated terrain. The CCTT system will initially support maneuver company commanders in planning, conducting, and reviewing their unit's training on a free play, computer-generated synthetic battlefield. Contractor personnel will provide site support and assist the training unit commander. CCTT will not be designed or fielded to completely replace field training, but rather it will augment that training. Some tasks will be better trained in CCTT, others better trained in the field. Part of the development effort will focus on supporting the training strategies for the type units that will use CCTT.

Recent performance improvements and cost reductions in computer image generation systems, networking technology, RISC processor performance, and data storage capacity allows the CCTT program to be primarily an integration of cost-effective commercial off-the-shelf (COTS) hardware. System design and software development are based on an object-oriented paradigm to insure reusability in future DIS programs.

The Close Combat Tactical Trainer (CCTT) development is following a concurrent engineering approach that organizes all engineering effort into integrated teams assigned by major system components or products. These integrated teams include industry representatives from all companies involved, the customer's engineering staff, and user representatives. CCTT development has a strong user focus because it is a complex training system with a primary product of improving human performance.

2. OVERVIEW OF THE CCTT REQUIREMENT

The Department of Army is chartered by Title 10 of the US Code to maintain a combat ready force able to protect U.S. interest at home and abroad. Maintaining forces ready to perform that mission entails equipping, fielding, and training the force. To insure an acceptable level of combat effectiveness, the Army has to resource training events and develop required training technology. This responsibility has traditionally been accomplished by providing suitable field training areas while funding operations and maintenance costs for field training, and providing commanders the time required to train units to standard levels of proficiency.

The simulation training system the Army needs will have to allow operational units to maintain their combat proficiency. CCTT will not be designed or fielded to replace field training, but rather must augment that training. Some tasks will be better trained in CCTT, others better trained in the field. Part of the CCTT development effort focuses on identifying those tasks. Understanding those tasks is key to both building the simulation and to developing the appropriate Combined Arms Training Strategies (CATS) for the type units that will use CCTT. For some tasks, CCTT will serve as a gate. Units will demonstrate task proficiency in CCTT before they can "graduate" to field training events.

Based on the evaluations of SIMNET (Alluisi 1991), it is clear that DIS-based (Miller 1991) training systems offer the potential to accommodate the Army's needs. CCTT will be the first of a family of simulations to use DIS technology. The Army will field it to all active division installations and provide the reserve component combat forces access for unit collective training drills.

Synthetic environments presented by virtual simulations systems (Beaver et al 1992) have limitations, however, they are extremely cost effective for part task training. Many collective tasks in which a unit must be proficient, as specified in their type unit Mission Training Plan, can be trained in a DIS environment. SIMNET was evaluated for training transfer with a positive outcome. Its deficiencies were identified during that and other evaluations by DARPA, Army Research Institute, and U.S. Army TRADOC. Those deficiencies were evaluated for feasible technical solutions and where made as requirements for CCTT.

Initial fielding of CCTT will be in Company-size sets of equipment; in general there is one company set per fixed site. Its primary capability is to support the training of a combat arms company team by providing a graphical image interface to the simulation for tank crews and the operators in infantry fighting vehicles.

The system design will support smooth growth to the capability to train an entire battalion task force by adding more simulators to a site. In the interim, a battalion task force will have the capability to train at a site in the Command Forces Exercise (CFX) mode. That is, the entire leadership of a battalion will be supported with appropriate simulators or workstations and the remainder of their armored systems are Semi-Automated Forces (SAF). A tank platoon leader would participate from a tank simulator as would his company commander, all other platoon leaders and company commanders in the battalion, the battalion commander, and staff. The system architecture, site design and fielding plan will support this mode as part of CCTT's initial operational capability.

The training of reserve combat forces must also be supported by the CCTT design. Because these units are located in geographically scattered national guard armories and reserve centers, the only feasible solution is to share CCTT sets among those locations using mobile configurations. Furthermore, the focus of reserve component combat units is on platoon level proficiency. Therefore, the mobile sets of CCTT will need to provide adequate training capability for a platoon of tanks or a platoon of infantry fighting vehicles as that is the manner in which they will be used within a combat arms company/team.

The CCTT System Design will conform to several constraining requirements. It must be expandable, allow varying configurations of player participation, its design must be suitable for use in a mobile configuration, its resemblance to actual equipment reasonable valid, and its design must meet prevailing government information systems standards.

The CCTT simulators in which crews train will not be full replications of their actual equipment because of cost constraints. The crew stations must, however, portray a "look and feel" that has sufficient realism so as to create the correct perceptions in the training audience and at the same time allow them to perform those tasks which are crucial to executing their unit battle tasks. Sacrifices in module fidelity must not impact task performance in such a manner that negative training occurs. All skills used in the simulators must be transferable to operational equipment.

The computer hardware and software used in CCTT will conform to emerging government standards. Operating systems standards prescribed by POSIX must be met. Inter simulator network communications must comply with the DIS protocol standards. The software environment will be the Ada programming language and any other information systems features (e.g., databases, user interfaces, etc.) will comply with prevailing government standards. CCTT is envisioned as the first of a family of simulators which will interroperate. It needs to be designed to insure the integration of future programs is feasible and affordable.

In a similar vein, the software will be developed in reusable modules. The government intends to reuse major portions of the CCTT software code in other systems, therefore software components need to be developed and documented to support that goal. Where possible, software modules will be re-used within CCTT, this will both save development costs and test their reusability in future programs.

The Army wants CCTT to use Commercial-off-the-shelf (COTS) and non-developmental items (NDI) to the greatest extent possible. This will reduce program risk, control equipment costs, and insure that the technical solution is general. This goal means that the systems engineering effort will involve selecting and evaluating hardware components and integrating them to meet required operational characteristics.

CCTT has to be training and cost effective (IBM 1993). Training effectiveness will be measured by testing the improvement in performance resulting from its use. Cost effectiveness will be measured by comparing the cost of achieving that same improvement during operational field exercises and amortizing the differential (savings) over the life cycle of the system in comparison to its life cycle cost. An Initial Operational Test and Evaluation (IOT&E) will be conducted to evaluate training effectiveness at the conclusion of full scale development. The results of that IOT&E will be used as input to a Cost and Training Effectiveness Analysis (CTEA) to make the cost savings versus life cycle cost comparison. A decision to proceed with production and fielding will depend on the conclusions of the CTEA. System design and development activities will follow a spiral approach that includes evaluation at component and subsystem integration levels.

3. PROGRAM DEVELOPMENT APPROACH

In order for CCTT to move beyond the success of SIMNET and insure all human performance and training requirements are accommodated during design, a concurrent engineering development approach is being used. An Integrated Development Team (IDT) is organized to do concurrent engineering (IBM 1992, IEEE 1991). The CE Teams developing CCTT are product focused. STRICOM's and industry engineers comprise these teams. They include expertise from domains that may or may not be represented by joint working groups.

Furthermore we employ participatory design principles (Shuler and Namioka 1993), incorporating prototypical users into the CE process. The user representatives who participate in concurrent engineering are known collectively as a User Optimization Team, more specifically for CCTT, the Army Optimization Team. That team is comprised of both on-site users assigned from the Army's Training and Doctrine Command (TRADOC) and a supporting cast of Subject Matters Experts (SME) working in development assignment at the TRADOC schools and centers. Users, who are actually the customers of STRICOM, are also members of the CE Teams. Additionally, they serve as needed on sub teams developing individual components or focusing on special programmatic or technical issues.

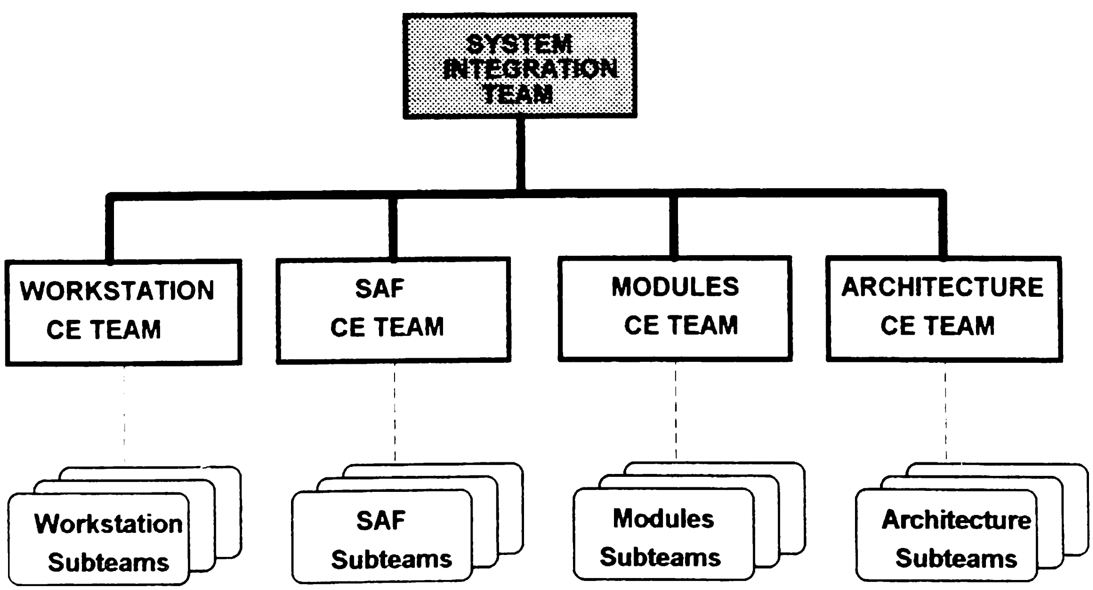

FIGURE 1 CE Team Organization for CCTT Integrated Development

The CCTT Integrated Development approach organizes all of the engineering effort and personnel into the four CE Teams shown in Figure 1. A Module Team is responsible for the design, prototyping and production of all simulator modules in CCTT. A Semi-Automated Forces (SAF) Team is responsible for designing and implementing the SAF software. A Workstation Team is responsible for software development and hardware integration of all workstations in CCTT. This includes both those used by the training audience (e.g., the workstation replicating the Fire Support Element) and those used to support system operations (e.g., the Master Control Console). The Architecture CE Team concentrates on architecture issues and products (e.g., network, databases, models, PIDS, etc.).

The System Integration Team is not identified as a CE Team per se but consists of the leads from the CE Teams and Working Groups. It integrates system level issues for the other four teams.

Sub teams are comprised of members of each CE Team. They work on a specific piece of hardware (e.g., the M1A1 tank) or software (e.g., BLUFOR tactical expertise combat instruction set). These teams meet as required and are often less formal in that they are frequently those engineers who work together, perhaps even in the same office, on a daily basis on some part of the system.

As shown in Figure 2, the CE Teams have functional expertise support across a variety of domains. Some areas of expertise reside in one or two individuals (e.g., Safety) and therefore these same individuals participate on all CE Teams. Teams are collectively responsible for addressing the requirements and concerns of each domain, they call on the assigned team member in that area to support them. Each team member is in part responsible for the team's solution.

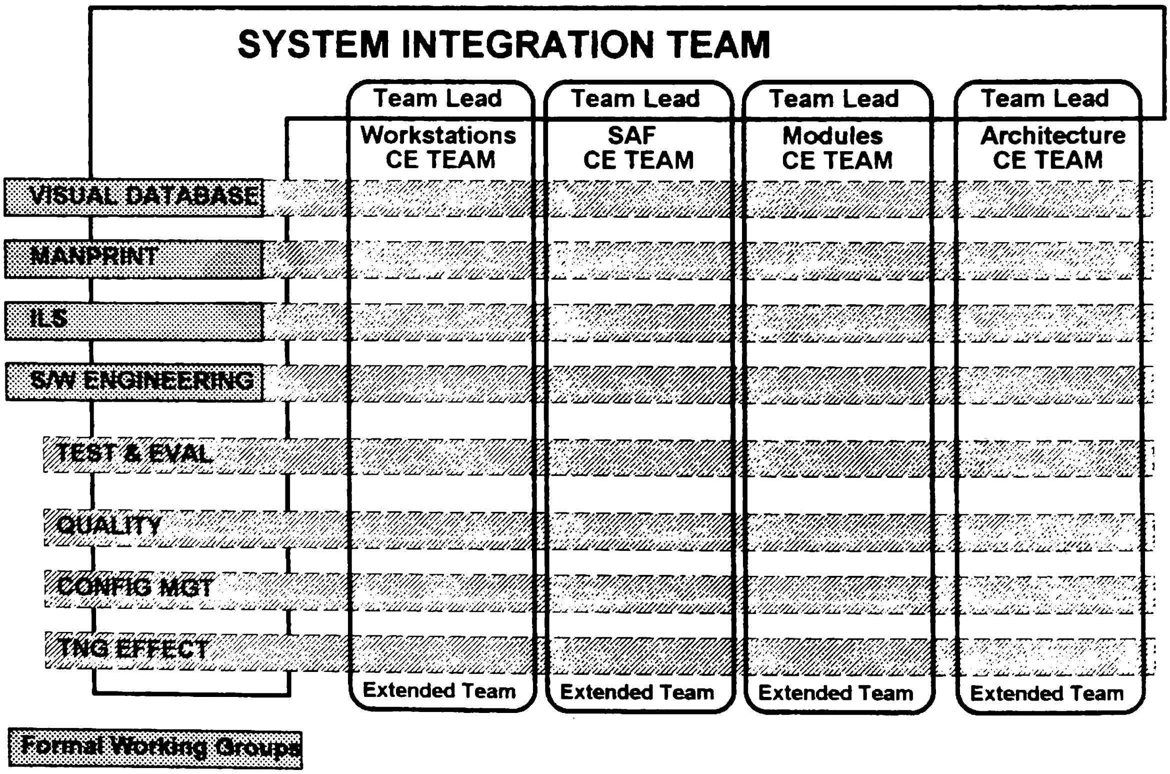

FIGURE 2. Relationship Between Functional Domains and CE Teams

4. DIS STANDARDS IN CCTT

Between 1983 and 1989, the Defense Advanced Research Projects Agency (DARPA) successfully demonstrated the core technology for networking large numbers of manned simulators, emulators, and semi-automated forces simulations to form a Distributed Interactive Simulation (DIS) of the combined arms battlefield. That effort led to a range of programs that expand the use of the technology, both for training and in support of material acquisition decision making.

DIS is being developed for team combined arms and joint training exercises as well as providing support for operational testing, combat development (doctrine, tactics, etc.) and materiel development (Figure 3). It is envisioned that a DIS system will provide a common, consistent and accredited representation of the combined arms battlefield at all echelons via linking of simulators and simulations through a common architecture for use by the training, development, test and analysis communities (Loral 1992).

The cornerstone for realization of this vision is a single architecture shared by all users. This common architecture will provide the elements, interface descriptions, and standards for linking different simulation environments. It will enable linking and interoperations of simulations, manned simulators, instrumented tactical engagement simulations and simulator/test drivers for education and training, test and evaluation, joint operations and cost analysis. All elements of the architecture relate to a common functional description of battlefield characteristics. The design of models, simulators and instrumentation allows users to select and adjust parameters for friendly and opposing forces to include tactics/doctrine, force structure, weapon systems performance, skill levels, C3I structures and world environment.

The standards and architecture (Department of Defense 1992) being developed will be improved and evaluated during the development of the Army's Close Combat Tactical Trainer (CCTT), the Navy's Battle Force Tactical Trainer (BFTT), and possibly Tactical Combat Training System (TCTS).

DIS compliance refers to adherence to established formal DIS standards (Shafer and O'Brien 1993). At present, the DIS standard is IEEE 1278-1993. This standard defines the protocols for exchanging an entity's location and motion, weapons fire and detonation information, collision data, and logistics interactions. Additional DIS standards are in development and a revision of IEEE 1278-1993 is expected in 1994.

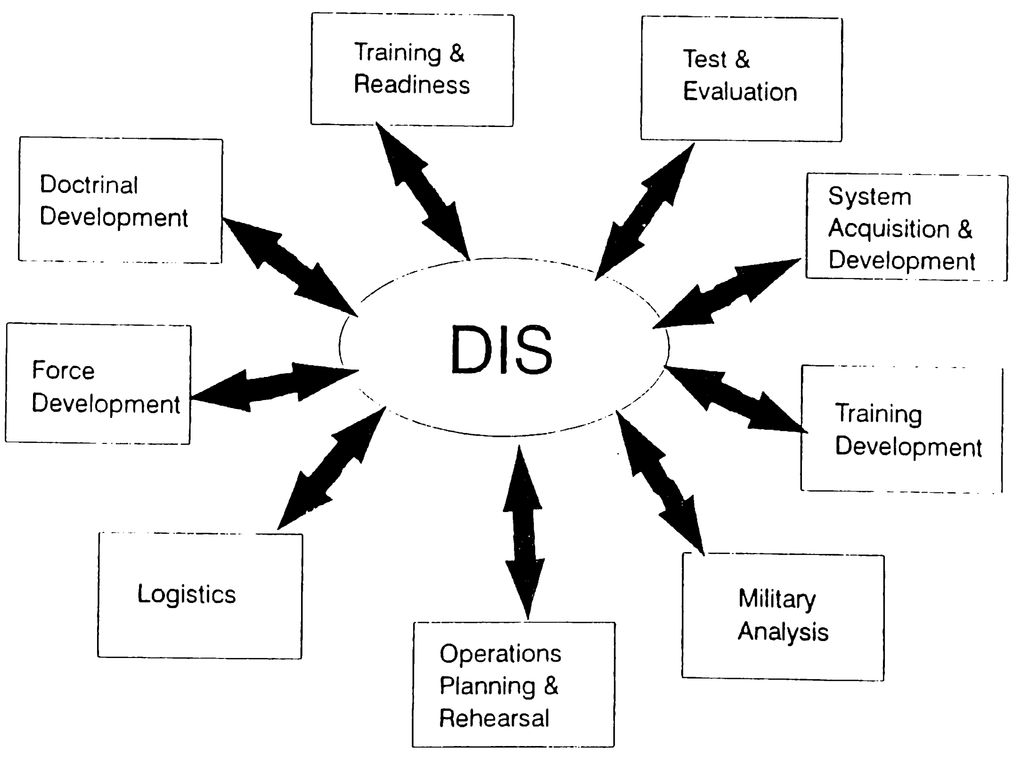

FIGURE 3

In a more general sense, DIS compliance requires that an implementation be in accordance with developing standards in the following areas:

- DIS Architecture
- Application Protocols
- Communication Protocols
- Shared databases
- Shared Models

Currently, DIS does not have a well articulated architectural framework. The DIS protocol standard was developed within the context of an "implied" architecture articulated, in part, by these key architecture concepts:

(1) No central computer controls the exercise.

(2) Autonomous simulation applications maintain the state of one or more simulation entities.

(3) A standard protocol is used for communicating "ground truth" data.

(4) Changes in the state of an entity are communicated by simulation applications.

(5) Perception of events or other entities is determined by the receiving application.

(6) Dead reckoning algorithms simplify inter simulator communications.

DIS compliance refers to the correct implementation of formal standards. DIS compatibility is a more subtle concept, referring to the ability of different DIS implementations to successfully work together to achieve a user-defined goal. While compliance with the full suite of DIS standards ensures a basic level of interoperability, it does not guarantee compatibility for every intended use. Compatibility requires that the models underlying the simulation be compatible to the degree required by the purpose at hand. Examples of underlying models include: weapon ballistic flyout models, internal damage models, models of vehicle mobility, models of atmospheric attenuation of thermal signatures, models of terrain objects such as trees, and radio propagation models.

DIS Compliance deliberately imposes minimal requirements on the models represented within a simulator. For example, DIS requires that entities, such as vehicles, must exist at a location and orientation in space (Figure 4).

DIS PROTOCOLS

CATT

SIMNET PDUs (6.6.1)

Activate Request
Activate Response
Deactivate Request
Deactivate Response
Vehicle Appearance
Radiate
Fire
Impact
Indirect Fire
Collision
Service request
Resupply Offer
Resupply Received
Resupply Cancel
Repair Request
Repair Response

SIMNET PDUs 6.6.1 +

Marker
Breached Lane
Mne Field
Exercise Status
Simulation Status
Vehicle Status
Status Query
Status Response
Status Change
Laser Range
Event Flag

DIS 1.0 PDUs (IEEE 1278)

Entity State
Fire
Detonation
Service Request
Resupply Ofer
Resupply Received
Resupply Cancel
Repair Complete
Repair Response
Collision

DIS 1.0 +

Activate Request
Activate Response
Deactivate Request
Deactivate Response
Emitter
Radar
Update Threshold Request
Update Threshold Response

DIS 2.0.3 PDUs (Proposed)

Emission
Laser
Transmitter
Signal
Simulation Mgt
 Create Entity
 Remove Entity
 Start/Resume
 Stop/Freeze
 Acknowledge
 Action Request
 Action Response
 Data Query
 Set Data
 Data
 Event
 Message
Instrumentation

DIS 3.0 PDUs (Potential)

C3I
Dynamic Terrain
Weather/Atmosphere
Fidelity Controls
Transfer Control
Aggregate/Deaggregate

FIGURE 4

ENTITY MAKEUP (REPRESENTIVE)

HEADER
Version #
Exercise ID

ENTITY ID

ENTITY TYPE
Type (Tomahawk)
Domain (Ship Launched)
Country (U.S.)
Category (Land Attack)

TIME STAMP

ENTITY LOCATION
X,Y,Z

ENTITY VELOCITY
X,Y,Z

ENTITY ORIENTATION
Psi, Theta, Phi

DEAD RECKONING PARAMETERS

ENTITY APPEARANCE
ICON to display

ENTITY MARKINGS
Special Markings not part of standard ICON

CAPABILITIES
Weapons Load
Special Equipment
etc.

FIGURE 5

The standards provide a mechanism to exchange this information between simulators in real time. DIS does not, however, specify the fidelity of dynamics and kinematics simulation within the originating simulator. Vehicle dynamics may be simulated at a great range of fidelities. Ground vehicle dynamics may include detailed soil, track, suspension, transmission, and engine models, or instead be based on a simple aggregate performance model.

Similarly, aircraft dynamics may include complex aerodynamic and aeroelastic structural effects, or be based on simple linear models. Simulators that use any of these different internal models can be DIS compliant. All that is required for DIS compliance is that they communicate the resulting location and orientation information using the DIS protocols (Figure 5).

However, being able to work within the DIS environment does not ensure that a system is able to work with other CATT Systems such as the CCTT. The ability to generate the appropriate DIS protocols and adhere to the key DIS architecture concepts is just an initial level of compatibility. All of the components of the synthetic environment must be understood. These components consist of: Physical Objects, Cognitive Processes, Environments, and Interactions.

Physical objects consist of the entities represented in the electronic battlefield, such as tanks and dismounted infantrymen. If a tank developed for use in SIMNET uses performance data less precise than that used in CCTT then the user may perceive an unfair fight and lose confidence in the system.

The characteristics of the electronic battlefield perceived by the soldier-in-the-loop is what truly represents his tactical environment. A system using a database without trees limits the ability of a fighting vehicle to take cover. An opposing force with a culturally rich data base may believe that he is taking advantage of the cover but his opponent could see him in an open field and inflict unrealistic casualties.

Ultimately, we must address the problem of interoperating heterogeneous simulators on the same network. Establishing interchange standards for modeling and simulation data and realistic correlation metrics based on proven scientific and engineering methods is a basic criteria for arriving at this objective. This is the greatest challenge faced by the DoD modeling and simulation community. CCTT will certainly not answer all of these issues, but its development process and subsequent use will help us understand and clarify both the problems and potentially effective solutions.

5. COMPUTER-GENERATED FORCES IN CCTT

CCTT will reduce the training support requirements when compared to field exercises. The use of artificial intelligence technology to model opposing force enemy units is feasible because the operations take place in a synthetic, computer-generated world. This alleviates the need for a fully manned opposing force to engage training units. The Semi-Automated Forces (SAFOR) capability allows a man-in-the-loop to manage up to an enemy regimental-size force. The approach is extendible to replicate cooperating friendly forces involved in the same battle.

The most realistic combat training takes place in the field against professional opposing forces (OPFOR) at instrumented ranges. CCTT has to provide a similar capability but cannot be designed to require a professional opponent operating "enemy" simulators. This is not a cost effective approach because of the additional simulators that would be required and the personnel requirements to staff them. Instead the CCTT training audience will operate in opposition to virtual simulators controlled by semi-automated forces (SAFOR) operators from workstations. SAFOR vehicles will appear and behave within the virtual battlefield no different than manned simulators.

SAFOR will also be used to extend the friendly forces by filling in units with SAFOR controlled vehicles in place of crews operating simulators. This is the approach that will have to be used to execute the CFX mode described above. The rest of the vehicles in the leaders platoon (and all other platoons) would be emulated in the simulation using SAFOR.

6. FUTRE ROLE OF CCTT

The world in which the next generation of military leaders will operate will be significantly different from that of the their predecessors. Gone is the monolithic Soviet threat. Gone are the days of nearly unlimited maneuver opportunities and massive forward deployed forces. As a result, the challenges to maintaining military readiness for the next fifty years are significantly different from those of the last fifty years. The approaches which produced combat-ready units of the Cold War will no longer work. Although not all constraints are new, we are already seeing the effects of heightened constraints on unit readiness.

Environmental constraints pose significant challenges to mechanized forces. The presence of endangered species of plants and animals have curtailed or halted certain training activities. The effects of erosion on downstream water-courses has reduced the ability of units to conduct realistic mobility and counter-mobility operations.

We have seen drastic cuts in Department of Defense spending reduce force structure and the amount of funding to use for training tactical units. This means less time in the field practicing warfighting skills.

Our force modernization efforts have produced a generation of weapon systems and tactics which require more training to realize their full potential than we needed against previous threats. During the Cold War, we trained on the ground in Europe that we would defend in war. However, the change of focus from "forward deployed" to "force projection" means that units must train at home station to deploy anywhere in the world and fight on terrain that they may have never seen before. The political realities in the united Germany--herself subject to the environmental and fiscal constraints described above--have reduced our ability to train in local training areas, limiting the conduct of tactical exercises with equipment.

It is prudent to assume that these trends will continue--if anything, they will increase. Looking into this future, we see the need for training systems such as CCTT, using the technologies described above, to help maintain unit readiness. A battalion company commander preparing to take his line companies out for a field exercise would use CCTT to pretrain the selected missions that his companies will execute in the field. Upon returning from the field, he can use CCTT to post-train in several ways. He can retrain the unit on tasks he assessed as needing more training. He can train tasks the unit performed to standard, but under more difficult conditions than he could in the field (e.g., reduced visibility against a much larger enemy force). And he can conduct training that he can not accomplish under existing constraints (e.g., danger close artillery fires, use of FASCAMM). In all cases, the commander is in charge of training his subordinate units.

CCTT will be fielded with two different types of terrain represented in its Terrain Data Bases (TDB)--temperate forested/agricultural and desert. A commander deploying to a trouble-spot will have the tools to transform digital terrain data of that area into a TDB for use in CCTT. Although such terrain-specific mission rehearsal is not an original intent of CCTT, the SIMNET-T facility at Fort Stewart was used by the 24th Mechanized Infantry Division to pretrain its tank and infantry platoons before deployment to Desert Storm. It is reasonable and prudent to anticipate similar uses of CCTT in a future contingency.

7. CONCLUSION

CCTT is the leading edge of a revolution in training called the Combined Arms Tactical Trainer (CATT) program. Other branch specific programs are following for Field Artillery, Aviation, Engineer and Air Defense Artillery. When they are fielded, all members of the combined arms team will be able to train in a simulated combined arms battlefield as the armor and mechanized infantry will in CCTT. Each component can be linked to allow true combined arms training with the actual leaders and crews of all weapon systems performing their tasks on the interactive battlefield. CCTT and the other CATT systems will be our generation's legacy to the next generation of Army leaders and soldiers.

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Paul Peterson is an Army Lieutenant Colonel currently serving as the Training Development Officer in the office of the TRADOC System Manager for Combined Arms Tactical Trainers. He is the System Manager for the Close Combat Tactical Trainer (CCTT). He is a graduate of the Armor Officer Basic and Advanced Course and Army Command and General Staff College. He holds a Masters of Science in Operations Research from Stanford University.