TRAINING EXERCISE PLANNING: LEVERAGING TECHNOLOGIES AND DATA

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Recognizing that future battlefield training and preparation for "other than war" missions will rely more and more on simulators and simulations, unit commanders must incorporate new ways to efficiently use their limited resources to develop effective training plans. Currently, commanders spend hours referring to training and field manuals, training records, unit standard operating procedures and directives to develop how best to train under resource-declining conditions and limited training opportunities. Innovative methodologies must be applied to the planning process to match essential task lists against proper training resources. Also, assessments of previous training events must be fully integrated into the planning process to ensure a unit learns, and returns to train at a higher state of readiness. This paper describes a technology demonstration program being developed by Simulation, Training and Instrumentation Command (STRICOM) called Combined Arms Tactical Trainer Training Exercise Development System (CATT TREDS). The system will provide unit commanders with an intelligent decision support tool to save planning time, enhance unit training options, and automatically apply after-action review feedback in a process applicable to planning maneuver, combat support, and combat service support training, as well as, military operations other than war exercises. Some state-of-the-art technologies such as expert systems, multi-criteria decision making, voice recognition, and neural networks have been investigated for their use, adaptability, and applicability for the tool. Commercial off-the-shelf (COTS) software packages with capabilities to link applications in an object-oriented, intuitively user-friendly manner have been evaluated. Leveraging capabilities inherent in these technologies, software packages, and previously developed databases shows great promise for development of a tool allowing unit commanders to optimize training exercise planning time.

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BACKGROUND

Facing a world filled with multiple global missions and increased task diversity, the military continues to invest in a virtual simulation-based training environment to offset drastic cuts in training areas, units, and personnel. Preparation for virtual training requires extensive planning and may *incorporate a variety of static and dynamic media* forms such as text, data, graphics, still images, animation, full-motion video, speech and nonspeech audio. (Ragusa, 1994). Planning tools being developed to meet the training challenges of the future should consider using some of these available technologies and leveraging available data from databases already generated.

Future Training Requirements

The training environment of the future must be organized to meet many new world realities. Military operations other than war including peace-keeping, peace enforcement, and humanitarian assistance must be addressed in addition to *conventional training scenarios. The increasing use* of joint, combined, interagency, and international forces requires a closer look at overlapping task responsibilities. Digitization of the battlefield requires compatibility of not only weapon and communications systems, but training systems as well. The major challenge facing the training community is to effectively train for these new and *increased requirements with a downsized military* population, reduced budgetary resources, and severely restricted field training areas.

Examining Training Strategies In A Distributed Interactive Simulation (DIS) Environment

With increasing constraints and environmental *limitations on traditional field training, there is a* definite move toward, and a major reliance on, a *simulation-based training strategy.* Simulating real world situations using mathematics, computers, and symbols or icons in training devices is a common occurrence today. Simulations leverage many military areas, allowing training for dangerous combat situations or testing of future equipment without endangering the environment or equipment, while protecting the safety of personnel. DIS *technology allows large numbers of simulated* systems, both manned and unmanned, at different locations to interact at the same time to accomplish a common training mission via communication networks. Tasks to be trained, equipment and personnel resources to be used, and the degree of difficulty of exercise conditions must all be considered. Effective planning is essential for *optimal use of varying conditions, personnel and* equipment resources, whether real or simulated, while still adhering to training mission standards.

Using Developed Technologies To Solve Planning Problems

Structured planning and preparation of a training *exercise can be very time consuming. An orderly* process is warranted that takes into consideration the commander's guidance, training doctrine, scheduling needs, and unit proficiency assessments. Mission analysis, course of action development, and event synchronization and execution matrix building all require time to accomplish. There is no shortage of automated tools and technologies *designed to save time, give intelligent user help,* and provide guidance for decision making for other areas. To help solve many planning problems, existing technologies and capabilities provide a wealth of resources to examine for applicability to exercise planning. Automated schedulers, expert systems, multi-criteria decision-making support aids, neural networks, relational database structures, *automated spreadsheets, and object-oriented* database development are only a few of the possibilities.

Other Software Development Issues

Other issues involved in development of software for military use must also be considered. One such issue is the time required for complete development and implementation of the application package. Another is the fact that most software packages are designed to run on UNIX-based platforms, not on the personal computers (PCs) with which many users are familiar. The use of Windows as an operating environment is quickly becoming a necessity when developing interactive programs. In viewing the threat of Windows NT technology on the UNIX architecture, the CEO and President of Intel, Andy Grove, predicts that the only way to succeed in new program development is to be compatible with Windows (Uninews, 1994). Therefore, if the goals for a new system development are to rapidly demonstrate a tool for planning training exercises, incorporate changes in a timely manner, and field a working model quickly, it would seem that those goals could most effectively be achieved via a Windows-based PC platform of commercial off-the-shelf (COTS) programs and previously developed databases.

CONCEPT FOR CATT TREDS

When given the opportunity to train in a simulator-based exercise environment such as SIMNET (SIMulator NETworks), a unit commander must first prepare the unit for training. The operations order must be prepared, the exercise planned, and direction to the unit must be provided. The ultimate goal of the planned exercise is to optimize the training benefit for the time, manpower, and costs involved. The success of the plan can be measured by the increased proficiency of the unit after training. The current military training development planning process requires the commander to work fast under archaic semi-automated conditions. The manual manipulation of reports, files, operations documents, maps and overlays is tedious and time-consuming. Unfortunately, the amount of preparation time never seems adequate. Lack of planning time can result in insufficient and ineffective training exercise plans, battle scenarios, and use of training time. The training exercise may become a "hit or miss" opportunity to improve specific training deficiencies. Recognizing these difficulties, the Combined Arms Tactical Trainer Training Exercise Development System (CATT TREDS) presented an automated solution to the time constraints and requirements faced by a company-level commander while preparing plans for training exercises.

Why Is There A Need For A CATT TREDS?

A need existed for a tool to help streamline the training exercise planning process. The purpose of such a tool was to provide an automated, intuitively user friendly system to minimize planning time and maximize the available training time. One of the primary drawbacks to development of a tool meeting those requirements has been the lack of computer programs which can automate tasks and actions fast enough for commanders and their training staffs to react in an accelerated mode and still plan meaningful exercises. Saving time while automating the training exercise planning process in a faster more efficient way is the goal of the CATT TREDS tool.

Who Is The Intended User?

Currently, the target user audience is the training personnel in a battalion who are responsible for platoon, company and battalion-level training exercises and planning. The primary focus of the battalion staff is on integrating platoon and company training with that of the battalion and higher echelons and ensuring that training plans coincide and complement each other. It is expected that company commanders could use CATT TREDS to plan their unit's training exercises with minimal computer experience and system training time.

TECHNOLOGIES CONSIDERED FOR INTEGRATION

The following technologies are being considered for integration into the CATT TREDS tool. Consideration is based on the ease of use, possibilities for seamless integration, and applicability to the function to be accomplished.

Knowledge-Based Expert Systems

Expert systems technology appears to be an appropriate means to employ when the following conditions occur:

- The problem at hand cannot be effectively solved with conventional programming.
- The integration of an expert system with multi-media offers the potential to improve

advisory, training, education and presentations applications from large data repositories.

According to El-Najdawi and Stylianou, (1993) "Expert systems are computer programs that incorporate the knowledge of one or more human experts in a narrow problem domain and can solve problems that the expert(s) ordinarily solve." Some benefits to be expected when using expert system technologies "include:

- Ability to capture critical expertise
- Faster application development
- Ability to distribute knowledge
- Flexibility to free experts from making repetitive decisions
- Ability to combine knowledge from several experts" (El-Najdawi and Stylianou, 1993).

Exercise Options. In developing a training exercise scenario, the unit commander must specify the criteria for success. Foremost in this development process is the issue of knowledge acquisition which sets limits and bounds. Experienced commanders draw on their own knowledge and past experience to develop scenarios that they know will meet with success and incorporate accepted doctrine and strategies. Building on this capability, well-accepted rules map an expert's description of scenarios that meet selected criteria to solve the problem.

The expert system being developed for CATT TREDS applies rules and conditions that are based upon previous experiences of other commanders to provide options that meet the selected criteria. The embedded knowledge-based expert system allows the transfer of knowledge to the commander in real time. The scenario(s) suggested may be used with confidence that they effectively solve the training "problem" and will successfully meet accepted standards.

Event Feedback. Feedback is needed by the unit as soon as a training event is completed. An After action review (AAR) may employ any number of multimedia tools and reports to draw an assessment picture for the unit commander. Usually the experts or observer-controllers who collect AAR information must recall a myriad of data and details for a ten minute briefing. The use of an expert system as an aid in this information capture process could ensure that all key teaching points, major events, and learning objectives are met. The expert knowledge base, in this case, could collect vast amounts of information during the training session, sort it quickly, and provide succinct recall directly after the exercise.

Neural Networks

"A neural network is a dense interconnection of computationally simple processors (i.e., neurons) that is based on the anatomy of the brain. Neural networks do not allow us to solve computational problems that have been unsolvable in the past. They simply provide a different way of solving a problem that may or may not lead to a better solution than some alternative method." (Georgiopoulos and Heilman, 1993).

Logistical Information Integration. The integration of logistical information into the training exercise scenario appeared to be a place to investigate the use neural networks. In this case a neural network could replicate a commander's thought process in building the criteria for equipment and personnel resources. Morrison (1992) suggested that "in non-lexical problem solving domains, the patterns applied by experts to classify their environmental stimuli and the mental models from which they generate responses, incorporate spatio-temporal patterns that can not be implemented under the current symbolic paradigm." In other words, the commander's thought process may be too complex and unknown for adequate modeling via conventional techniques currently in use. With software applications and hardware for neural networks enabling dynamic transfer of data between routines, the neural network submodel presents a viable option for representing temporal and spatial relationships, especially applicable to logistical determinations.

Training Paradigms Automated. Another possible use for neural network technology is in the area of collective tasks. Training in the Army permeates through initial basic individual skills to larger unit or collective abilities. From this perspective, training captures the essence of learning layers of tasks. Once lower level or individual tasks are learned, an automated neural network system could then model this level perfectly, omitting errors to work solely on the tasks at the next level. A neural network of trained individual tasks can track the unit's training as a collective team. This integration of multi-task, multi-echelon training allows the commander to focus his efforts on collective training, while maintaining the unit's individual training tasks.

Voice Recognition

"Computer users have always yelled at their machines. But now the computers are beginning to listen." (Thyfault, 1994) In looking at technologies that would enhance its user friendly capabilities, voice recognition technology was a natural for evaluation for use in CATT TREDS. Using a digital signal processor installed on an 80486/50mhz computer, IBM has made a speech server which allows good dialogue with a PC after several iterations of training to recognize user accent and pronunciation style (Andrews, 1993).

For CATT TREDS, several voice recognition packages with similar characteristics are being tested on a multimedia personal computer. Even though these systems recognize voice commands at an affordable price, the downside is that usually several hours of time are needed for "training" the system to respond to user commands. Typical response reliability has not been consistent during initial research and trial efforts. One inexpensive system tested with a 40 word vocabulary provided a 91% response accuracy when trained and used by the same individual, but only a 57% response accuracy when trained for generic voice and used by an individual.

In addition, recent testing on the Toshiba multimedia system which uses DragonWriter software revealed a longer response time using voice commands than using the mouse to execute the same command. For the experienced mouse user, this system might seem much slower and inefficient, thus defeating the purpose of incorporating voice technology. More research is required to find an affordable tool with high response accuracy that does not require individual training.

Multi-Criteria Decision Making (MCDM)

Almost all real life decision problems involve multiple objectives. There is really nothing new about multiple objective problems. Humans have been making such decisions throughout history. These problems have often been resolved through the use of intuition or by various processes of choice that developed over time. Simple problems (i.e., those involving a few objectives and a small number of alternatives) can usually be solved without the use of sophisticated methods. Only when the number of objectives and alternatives increase does the need for formal techniques become acute. In the presence of a large number of conflicting objectives and numerous alternatives, the use of techniques that aid the decision maker in structuring his preferences and criteria is necessary. This is due to the difficulty encountered in articulating tradeoff information and maintaining the required consistency. In choosing a solution, the decision maker must be willing to accept a loss in one or more of the objectives, or tradeoff one objective in order to increase the value of another objective. This tradeoff information is often very difficult to elicit especially in the presence of a large number of criteria. With the use of more formalized techniques, the decision maker is guided throughout the process, and can reduce the cognitive burden and ensure consistency.

Over the past 20 years there has been a plethora of tools and techniques developed for solving multiple criteria problems. These multi-criteria decision making methods are designed to clarify the decision problem, help generate useful alternative solutions, and help evaluate the alternatives based on the stated preferences. They generally involve the use of computer models.

MCDM Application To CATT TREDS

In the application of MCDM to CATT TREDS, we envision using a ranking system to identify the best scenario for training. Given the tasks to be trained, the applicable METT-T factors (i.e., mission, enemy composition, time available, terrain, and troops), and the desired situational training exercise (STX) chosen, an expert system will identify several scenarios from a scenario library that fit the selected objectives of the training exercise. To arrive at a preferred scenario, the commander identifies mandatory tasks and rank orders the tasks to be trained. A matrix is then generated that identifies how well each Course of Action (COA) in the scenario library meets the training requirement of each task. The commander may then select a scenario that, in his judgment, best allows the unit to conduct the desired training.

Intelligent Multimedia Applications (Intellimedia)

Intelligent Assistance. Using 110 colorful lights, 36 water pumps, a stereo system and 1,000 feet of hose, Sea World built a magnificent water fountain show that held young and old alike spellbound for over twenty minutes. Each object used was a common, household item that creates little interest by itself when used to water a lawn, provide music or light a Christmas tree. Likewise, applications of media integration and synchronization aided by technology have been used to create captivating and entertaining courseware, tutorials and textbooks. While expert systems enable users to draw information from a large database, multimedia features provide graphical and realistic representation of information for making training decisions (Ragusa, 1994). As noted by Marchionini and Crane (1994), this process of integrating multimedia with a learning process such as setting up a training plan is not easy. Further research is still required to define workable goals and approaches.

After Action Review Applicability. One viable area for inclusion of Intellimedia appears to be for after action reviews. Current after action review technologies assist human observers by recalling the training events through video, audio, and computer methods. In the realm of multiple media inputs for a structured presentation, an intelligent system will ease the indexing, browsing, retrieval and presentation of multimedia data (Maybury, 1994). Incorporation of an intelligent multimedia system would capitalize on capturing essential training points through accurate information storage and retrieval. A possible drawback is the difficulty which may be experienced when setting up all the equipment and projecting devices necessary to conduct a multimedia-based learning event.

Rapid Prototyping With Commercial Off-The-Shelf (COTS) Packages

The design team selected three COTS software packages for building the CATT TREDS initial prototype. These are Harvard Graphics for Windows (HGW, v 2.0), FoxPro for Windows (v. 2.5), and Microsoft EXCEL (v. 4.0). The programs feature object-oriented options for launching applications, storage and retrieval of data, incorporation of multi-media files, dynamic data exchange and object linking.

Harvard Graphics. The present technology demonstration model of CATT TREDS runs in the HGW screenshow mode. The primary reason for using the HGW software was its ease of use, shorter learning curve required and the familiarity with HGW by many military personnel. The main menu of the tool is seen in Figure 1. All underlying applications are launched from this main menu.

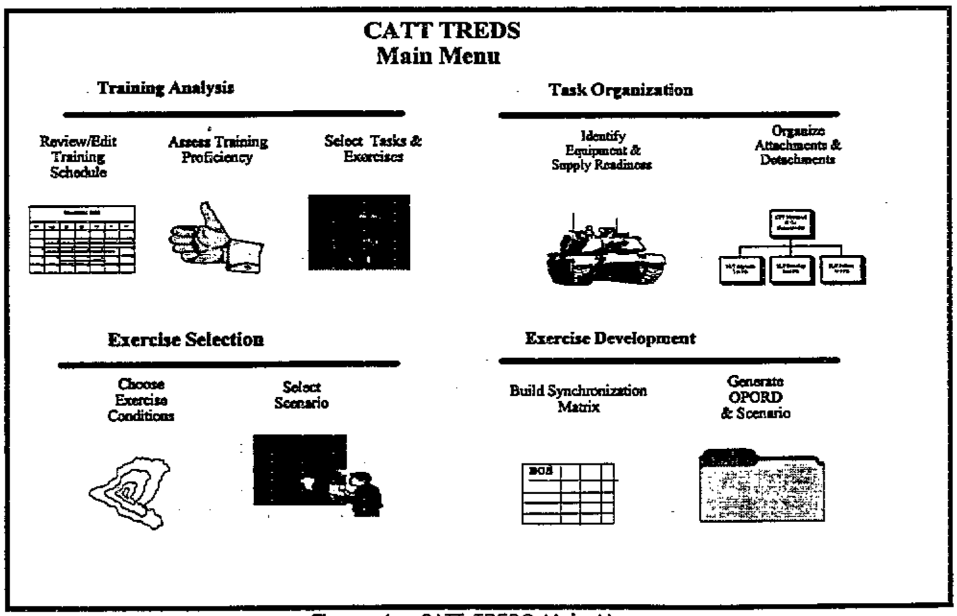

Figure 1. CATT TREDS Main Menu

Phase/Unit	TAA-Mike	Occupy Def. Sector	PL Gray	PL Yellow	Fwd of PL Silver	Consolidate
Est. Time	'0800Z	'0900Z	1200Z	1500Z	1700Z	1900Z
TM B/3-77 Mech	Move to TAA	Occupy Def Sector	Defend	1st PLT Moves back	CounterAttack, Support by Fire	
1st Plt B/3-77	-	",West fwd PL Silver	Defend in Zone	Occupy BP-33		
2d Plt B/3-77	-	", East fwd PL Silver	Defend in Sector, fwd of PL Silver		Control OBJ Melee	
1st Plt C/1-2 AR	-	", SE, South of PL Blue	Occupy BP 32		Attack along Axis Strike, into OBJ Melee	
Fire Support		Develop FS Plan	Submit FS Plan, Select FPF's	Main Effort 1st PLT	Support CounterAttack	
Mobility & Surv.	Clear Routes	Protect MSR, Emplace Obstacles	Emplace Obstacles			
Battle Command	Move to AA	Issue FRAGO's		Move 1st PLT	Order CounterAttack	Consolidate, Prepare for 2d Echelon
Logistics	Class 3, 5 & Maint. spt	Resupply in posn		Resupply 1st PLT		Consolidate
Intelligence	Recon Fwd Activity	Execute Recon Plan	Enemy at PL Gray	Enemy at PL Yellow	Enemy in OBJ Melee	

Figure 2. Synchronization Matrix

FoxPro. FoxPro application files are in runtime versions ready for retrieval and use by clicking on objects in the HGW screenshow slides. Presently two previously developed databases are used by CATT TREDS. They are CATT TASK and Equipment Characteristics Database, both developed for the Government by Resource Consultants, Inc. (RCI). Task, STX, trainability factors and proficiency rating data are incorporated from the former while equipment physical characteristics and capabilities are collected from the latter. The HGW and FoxPro merger demonstrates the easy and relatively seamless navigation that can be effected between FoxPro applications and other programs. FoxPro has the capability to import several database management systems programs for good versatility and adaptability in meeting user specifications.

Microsoft EXCEL. The synchronization matrix is the focal point for exercise implementation as it is the most widely used tactical planning tool. A standard EXCEL spreadsheet was chosen as the best tool in which to store the synchronization matrix data. Information from the spreadsheet is then Dynamic Data Exchanged (DDE) into the HGW shell. Subordinate units and predominant battlefield operating systems (BOS) are listed on the vertical axis, with events and estimated time lines along the horizontal axis. See Figure 2 above for an example format. Layout in the spreadsheet allowed the design team to capitalize on the database qualities of the matrix. The operations order (OPORD) will be stored as a series of database elements embedded in a text file unique to each scenario within the library. As the user makes changes in the synch matrix, the OPORD will be dynamically updated. The edit and update process has been designed to work in both directions. Changes made in specific fields in the OPORD are tied directly to fields in the matrix, as well as from the matrix to the OPORD.

ADVANTAGES AND DISADVANTAGES OF THE TECHNOLOGIES

Table 1 displays the initial evaluation findings of the design team for the above discussed technologies relative to use in an automated planning tool such as CATT TREDS. Criterion for the evaluation included cost of the technology, time required to develop the desired capability with the technology, anticipated acceptance by the target audience, known familiarity of the target audience with the technology, and ease of use in prototype development.

Table 1. Initial Technology Evaluation

Criterion / Technology	Costs	Time Required	Acceptance	Familiarity	Ease of Use
Expert Systems	Average/Low	Average	Average	Average	Average
Intellimedia	High	High	High	Low	Average/Low
Voice Recognition	Average	High	Average?	Average	Average/High
Decision Support Tools	Average	Average	High	Average	Average
Neural Networks	High	High	Average	Low	Low/Average
Rapid Prototyping	Low/Average	High	High	Average	Average

SYSTEM DESCRIPTION

CATT TREDS is a technology and concept demonstration development program sponsored by the Project Manager-Combined Arms Tactical Trainer (PM-CATT). The primary objective of the CATT TREDS initiative is to identify requirements, procedures and technologies to assist unit trainers in the development of training exercise plans for such CATT training systems as Close Combat Tactical Trainer (CCTT). The applicability of the tool for use with other simulation systems, for planning field exercises using actual equipment, and for other Service and joint force exercise planning has been shown to be a real possibility. CATT TREDS will aid unit trainers in many training situations to optimize their training opportunities given available resources.

Design Criteria

CATT TREDS utilizes the following design criteria:

- *Windows for PC Operating Environment.* The Windows environment allows dynamic data exchange and object linking between multiple software files.

- Commercial Off-The-Shelf Hardware and Applications Software. COTS hardware maintains pace with rapid technological change. COTS software reduces Government requirements to develop and maintain in-house computer programs.

- Object Oriented Design (OOD). OOD allows users to access a wealth of information in a single keystroke or click. Multiple applications can be embedded within a main overview application.

- Dynamic Data Exchange. DDE permits users and programmers to retrieve data transparently once links are established between a server and client application.

- User Centered Design. The human-computer interface makes the software easier to use during development, fielding, and maintenance of a system. and is one of its most noticeable features. The interface influences the ease of navigation between menus and submenus, command syntax, and editing capabilities (Babbitt, 1991). Using proven human-computer-interface techniques, an intuitively user friendly interface that is both flexible and easy to use can be provided to aid both the developer and the end user.

Capabilities

There are several categories of tasks that are essential to the training exercise planning process. They include training task analysis, task (resources) organization, exercise selection and exercise development. In addition, at the bottom of each screen are menu items to assist user navigation in CATT TREDS. The following capabilities are included by category in the CATT TREDS tool:

Training Analysis. The modules included here allow the unit commander to set up, review and edit the training schedule by day, month, and quarter, with rollup to battalion level or rolldown to platoon level. Training proficiency, in the form of Trained (T), Partially Trained (P) or Untrained (U) can be assessed and modified by training task and subtask. The Mission Essential Task List (METL) can be developed or modified. Trainability of the chosen training mode (i.e., specific simulator) relative to the particular task can be assessed, and *training tasks can be chosen for the exercise with* options provided to select or deselect as desired.

Task Organization. These modules allow the identification and assignment of organic unit resources. This includes the selection of equipment and details of equipment and supply readiness, and the organization of personnel attachments and detachments. Equipment capabilities for both friendly and enemy forces can be reviewed from an on-line library. The terrain database for the exercise can be selected. Factors identified here are used in the computer initialization of the simulation.

Exercise Selection. Capabilities included in these modules allow the unit commander to select the degree of difficulty for the exercise in the METT-T areas of enemy, troops, terrain, and time. *Environmental conditions may also be selected.* Degree of difficulty is measured as low, medium, and high resulting in over 63,000 possible combinations. Suitable scenarios complete with course of action overlays for battalion, company or platoon level may be selected from the available library as is without tailoring. A scenario from the library may also be modified, or if so desired, developed from scratch. All scenarios have the following items in common:

- Initialization data
- Established unit tactical graphics
- Enemy force organization for combat
- Graphical map of training area
- Friendly force organization for combat
- Any time compressed elements of the plan

Exercise Development. Using information developed in the various modules and employing the *expert system and decision making technologies,* a synchronization matrix such as that found in Figure 2 can be developed, modified as required. and generated. In addition, the OPORD and scenario course of action overlays can be generated. These products can be printed in hardcopy using an attached printer or by saving the appropriate files to diskette and using available print capabilities. By taking these CATT TREDS-generated tools to the training site, it is hoped that the unit commander may need only bring his own coffee cup in addition to be prepared for his planned exercise.

CONCLUSIONS FOR FUTURE TRAINING EXERCISE PLANNING

There are many techniques, tools and databases developed by industry and the military which can be applied to the training exercise planning process that allow unit planners to optimize exercise planning time. Incorporating them into a technology demonstration model like CATT TREDS has provided an opportunity to leverage these previously developed research applications into a user friendly training exercise planning tool. Probably the most exciting benefit to come from this development has been the possible uses that can be seen for other agencies. The concepts incorporated into CATT TREDS for Army use can be tailored for other Services, for joint exercises as well as those with multi-national forces, for exercises that entail not only virtual simulations, but constructive and live *field exercises, and to the civilian community for* disaster preparedness exercises, We have looked at only a few of the technologies that show promise for future use. Other multimedia techniques may meet more of the requirements required by training exercise planners in the future.

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