Combined Arms Planning Tool (CAPT)
Training Fire Planning

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ABSTRACT

Training Fire Support Teams (FiSTs) and Fire Support Coordination Centers (FSCCs) remains critical to the success of the Marine Air-Ground Task Force (MAGTF).

Currently, many virtual systems provide opportunities for individual FiST members to practice their Fire Support employment skills such as the Forward Observer's Call for Fire or the Forward Air Controller's 9 Line Brief. Additionally, numerous constructive systems provide opportunities for FSCCs to practice Fire Support execution.

However, existing systems possess numerous fire support training shortfalls. None interactively teach fire support personnel to create fire plans integrating close air support, naval surface fires, artillery, and battalion level mortars in support of the maneuver scheme. No current training system evaluates a fire plan against an SME-defined rule set to ensure the plan: is feasible based upon resources available and battlefield geometry; will achieve weapon effect thresholds on targets; synchronizes fires with maneuver; and avoids fratricide. No system permits planners to interactively observe the dynamic execution of the fire plan in support of the scheme of maneuver prior to execution.

The Combined Arms Planning Tool (CAPT) developed by the Marine Corps' Program Manager for Training Systems (PMTRASYS) addresses many of these shortfalls. Given a user defined scheme of maneuver, the tool evaluates the user proposed joint fire plan against a rule set and recommends corrective action to address errors. The tool dynamically displays the maneuver scheme as well as both direct and indirect fires on a two dimensional map using an interactive time marker. CAPT incorporates portions of the FiST's non-doctrinal Battle Board as well as a stylized version of the Scheduling Worksheet. PMTRASYS delivered Version 1.0 of the CAPT during December 2005 to the Marine Corps' Expeditionary Warfare School (EWS), at Quantico, Virginia. PMTRASYS also plans to incorporate the tool into the Marine Corps' After Action Review (AAR) capabilities.

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INTRODUCTION

This paper discusses the development and use of the Combined Arms Planning Tool (CAPT) to support fire support training. The paper also addresses instances where the tool assists Exercise Control staffs conduct After Action Reviews (AARs) and the benefits of transitioning this training device to operational systems.

The CAPT trains the Company Fire Support Team (FiST) leader as well as Fire Support Coordination Center (FSCC) personnel. Given a scheme of maneuver and a company fire support plan containing fixed wing close air support attacks, naval gunfire engagements, indirect fires from both artillery and battalion mortars, as well as maneuver unit direct fires the CAPT uses a Subject Matter Expert (SME) defined rule set to evaluate the fire support plan. The evaluation criterion seeks to ensure fire plan feasibility, adequacy and timeliness of the fires to support the maneuver scheme, and that the execution of the friendly fires avoids fratricide. Should the tool discover a rule violation, the tool recommends a generic solution.

The planning tool also assists personnel create schemes of maneuver, fire support plans, and visualize plan execution at the company level. The tool uses electronic versions of: 1:50,000 scale tactical maps; a representative Battle Board; and extracts from DA FORM 4656-R the Scheduling Worksheet. After plan evaluation, the tool can dynamically display all planned maneuver and fires on both the two dimensional electronic map and the interactive Scheduling Worksheet at speeds up to ten times real time.

As primarily a Tactical Plan Evaluating (TPE) system with an instructional assistance capability, the CAPT supports After Action Review (AAR) by offering for comparison a dynamic two dimensional map display of the Exercise Force's Plan with exercise ground truth data collected during execution. This capability permits an explicit comparison between planned actions and execution results.

The CAPT also offers operational planners the ability to better coordinate the actions of fire support agencies as well as adjacent and higher headquarters during contingency operations should the tool migrate from the training environment to operational C4I systems. Current company mission files within the CAPT are smaller than 20 kilobytes and this facilitates the sharing of orders and plans as long as common maps and software versions of the planning tool exist at all locations.

The CAPT operates on the minimum hardware requirements established for desktop computers within the Marine Corps and remains compatible with the Navy Marine Corps Intranet (NMCI).

HOW WE STARTED

Efforts to create a computer assisted training device to both assist with the instruction of and evaluate company level fire support planning began in March 2004 during the Expeditionary Warfare School's (EWS) Combined Arms Exercise (CAX) conducted at the Marine Corps Air-Ground Combat Center, Twentynine Palms, California. While observing the EWS students train at the Combined Arms Staff Trainer (CAST) using a constructive simulation, the Director of EWS and the Technical Director of the Marine Corps' Training and Education Command (TECOM) identified the need for a training capability that taught the students how to plan fire support. The leaders desired to reduce errors in planning to a minimum. They did not want the student to discover during execution what the student should have known in order to produce an acceptable fire support plan. At the time of plan execution, they did not want the student to possess any doubt about the viability of the plan. This condition would permit instructors and students to focus on avoiding execution errors rather than expend valuable time

overcoming planning errors that should have been avoided. The Director of EWS desired the training device to focus on the fire support planning shortfalls within both the resident and non-resident EWS fire support courses of instruction. Resident EWS students routinely produced fire support plans in support of maneuver schemes as part of their instruction, but the instructional staff did not possess a systematic capability to evaluate each plan. The Director wanted the ability to evaluate each proposed fire plan to ensure the plan was executable, generated the appropriate weapon effects at the proper times, and avoided fratricide. Additionally, non-resident EWS students did not receive fire support instruction to this detail so the solution needed to reach the EWS distant learning audience. These leaders believed: (1) any training device performing the functions of instructional aid and plan evaluator needed to possess evaluation criteria developed and vetted by Subject Matter Experts (SMEs); (2) the initial evaluation criteria needed to focus on the topics most likely to generate execution challenges or "friction points;" (3) the system needed to offer corrective instruction to the user for each rule a proposed plan failed; and (4) the training device should require the student to use the FiST leader's three primary planning documents; the 1:50,000 tactical map, the Battle Board, and the Scheduling Worksheet.

Limited development of the tool began in April 2005 as part of the Marine Corps' Program Manager for Training Systems (PM TRASYS) Range Modernization and Transformation (RM/T) effort with the first use of the CAPT occurring at the Expeditionary Warfare School ten months later in February 2006.

LAYOUT OF THE COMBINED ARMS PLANNING TOOL

The tool can present three displays simultaneously on the main screen: the FiST leader's 1:50,000 Map Display; the Battle Board; and the Scheduling Worksheet. Toggles on the top of the main screen permit the hiding of any one or combination of these three displays at any time.

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- The Map Display at the top of the screen contains friendly and enemy unit icons and depicts friendly maneuver paths in blue. Aviation flight path depictions from their Initial Point (IP) to the target also appear in blue. All fires (direct and indirect), threat engagement rings, and minimum safe distances appear in red. The Gun Target Lines (GTLs) appear on the map at first launch and terminate at last impact. Threat rings turn gray from the time the targeted unit receives fire and suppression affects on the targeted unit last for a user defined period after the engagement terminates. Aircraft currently start at their IP and remain visible until exiting the map in their specified egress direction from the target. During the execution of the mission, all icons move in accordance with the plan's assumptions and all fires appear only during their duration planned.

- The Battle Board located in the middle of the screen depicts the same information contained in the FIRE SUPPORT TEAM TECHNIQUES AND PROCEDURES HANDBOOK produced by the Marine Corps' Tactical Training and Exercise Control Group (TTECG) stationed at the Marine Corps Air Ground Combat Center, Twentynine Palms, California. However, the Battle Board has been modified to include Naval Surface Fire Support (NSFS) ship data. The CAPT's electronic Battle Board permits the selection of one of the three FWCAS target engagement geometries; Final Attack Cone, Direction with Offset, and Final Attack Heading.

- Friendly fires and unit movement times appear on the Scheduling Worksheet located at the bottom of the screen. A green vertical bar acts as a time marker and moves from left to right across the worksheet during plan execution. A single red dot represents a single round indirect fire engagement such as a mark or a close air support attack while solid red lines with goal posts at each end indicate the execution times and duration of both indirect and direct fire engagements.

Figure 1 illustrates the Combined Arms Planning Tool's Data Entry Layout with all three displays active, but only a small portion of the map visible
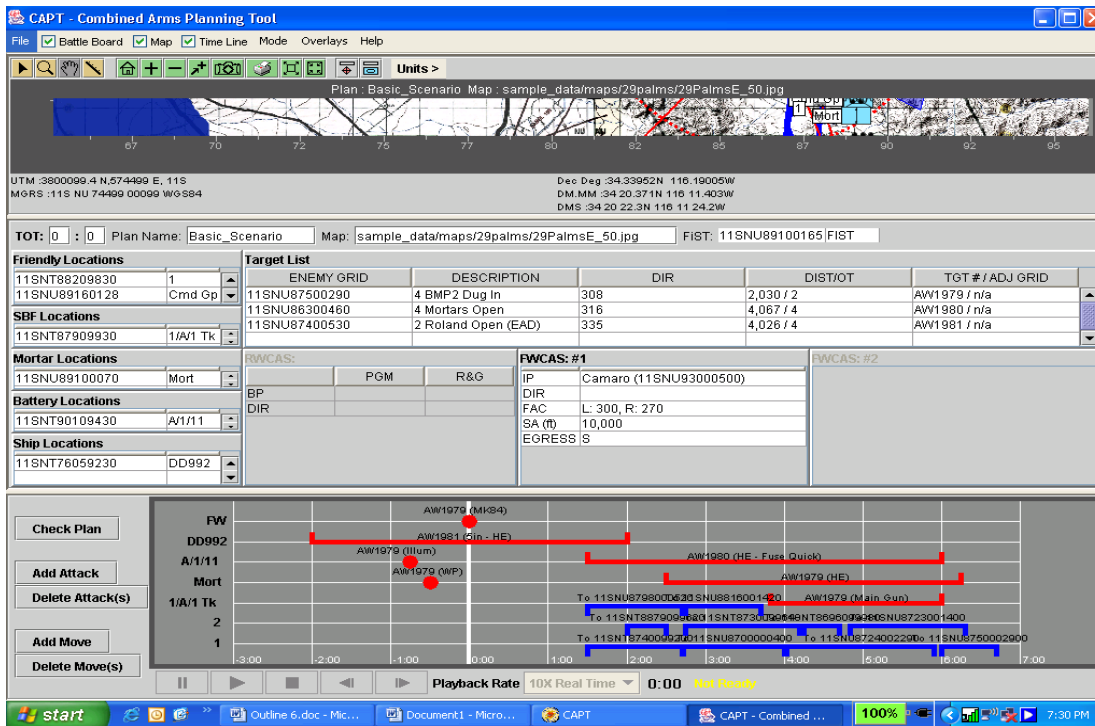
Figure 1. Data Entry Layout of the CAPT with Map at Top, Battle Board in Middle and Scheduling Worksheet at Bottom

CAPT'S TECHNICAL SPECIFICATIONS

The Combined Arms Planning Tool is written in the Java programming language. This permits the system to operate on Windows, Macintosh or Linux based machines.

The tool relies heavily on standard open source libraries for parts of its functionality, such as parsing XML files or rendering SVG graphics and wherever possible uses industry standard solutions for object persistence and file formats. In particular, extensive use was made of the standard Batik, JAXB, and Xerces libraries.

The core of the map display is a light weight display widget that provides a geo-referenced display of map objects over a registered map image. This display provides zoom, drag, go to location, intra-point distance measurement, display of location in MGRS/UTM and Lat/Lon, and similar features. The display incorporates a layering capability allowing selected portions of the display to be turned on or off based upon a display object category.

The tool uses Mil-Std-2525 symbology. All icons are available within the system, but only subsets of icons

are accessible to the user. An XML formatted metadata file controls which icons are available.

The tool comes packaged with a multiplatform installer that installs the necessary files with an appropriate Java runtime environment. The installer can modify the target computer environment to enable the CAPT to begin operation by clicking the tool's desktop icon.

USING THE CAPT TO SUPPORT FIST TRAINING

After instruction on fire support concepts, the student receives a scenario and performs the duties of a FiST leader. The scenario provides the student with detailed planning guidance which includes; the company commander's intent, fire support resources available, and the company commander's maneuver scheme. After entering the maneuver scheme into the tool, the student performs the following steps to first create and then ensure the proposed fire plan supports the commander's expectations.

- Entering Fire Planning Data: Using the student's map, paper copies of the Battle Board and Scheduling Worksheet, the student creates a fire support plan and then enters the data into the CAPT's Battle Board, and Scheduling Worksheet.

• Evaluating the Plan: After entering all the planning data into the tool, the student selects the CHECK PLAN button to the left of the Scheduling Worksheet the near the bottom of the screen. The tool then checks the proposed solution against the existing rules set. If the plan does not pass a rule, the tool indicates which rule failed the plan and provides a reason for the failure. However, even with a rule failure the student could elect to observe plan execution at this time by selecting the PLAY arrow at the bottom of the screen. If a rule failure is detected, the student continues to modify and recheck the plan until the proposed plan passes the evaluation criteria.

• Observing the Plan: Once the student's proposed plan passes the evaluation, the student selects the PLAY arrow and observes the two dimensional dynamic display of all ground maneuver, direct fires, aircraft flight paths, and indirect fires. The dynamic display begins 30 seconds prior to the start of the plan and ends 30 seconds after the completion of all activity. However, should a rule error still exist at the time the student elects to view the dynamic display, the tool stops at the moment during execution that each rule violation occurs. At this point the student can choose to ignore the rule violation and continue or to review the included instructional materials addressing

the rule's purpose, evaluation methodology, and generic solutions to specific error messages. Additionally, the student can elect to PAUSE the dynamic display at anytime, change the display speed from real time to up to ten times real time, or once paused hop forward or backward incrementally in order to scrutinize key events. At any time while paused the student can resume the dynamic display at the speed desired by selecting the PLAY arrow. Finally, the student could at any time stop the dynamic display and alter the plan by modifying the data entries. However, the student's modified plan must receive a rules evaluation before another dynamic display can occur.

Figure 2 depicts a pause during the dynamic two dimensional display with the interactive timeline just passing the time of the CAS attack. The final attack cone appears as a blue triangle. The naval gunfire gun target line appears as a solid red line while it engages an ADA system at the top of the map. The Threat Ring of the enemy mortars appears in red and the suppressed Threat Ring of the enemy strongpoint has turned gray to indicate the strongpoint is suppressed at this time.
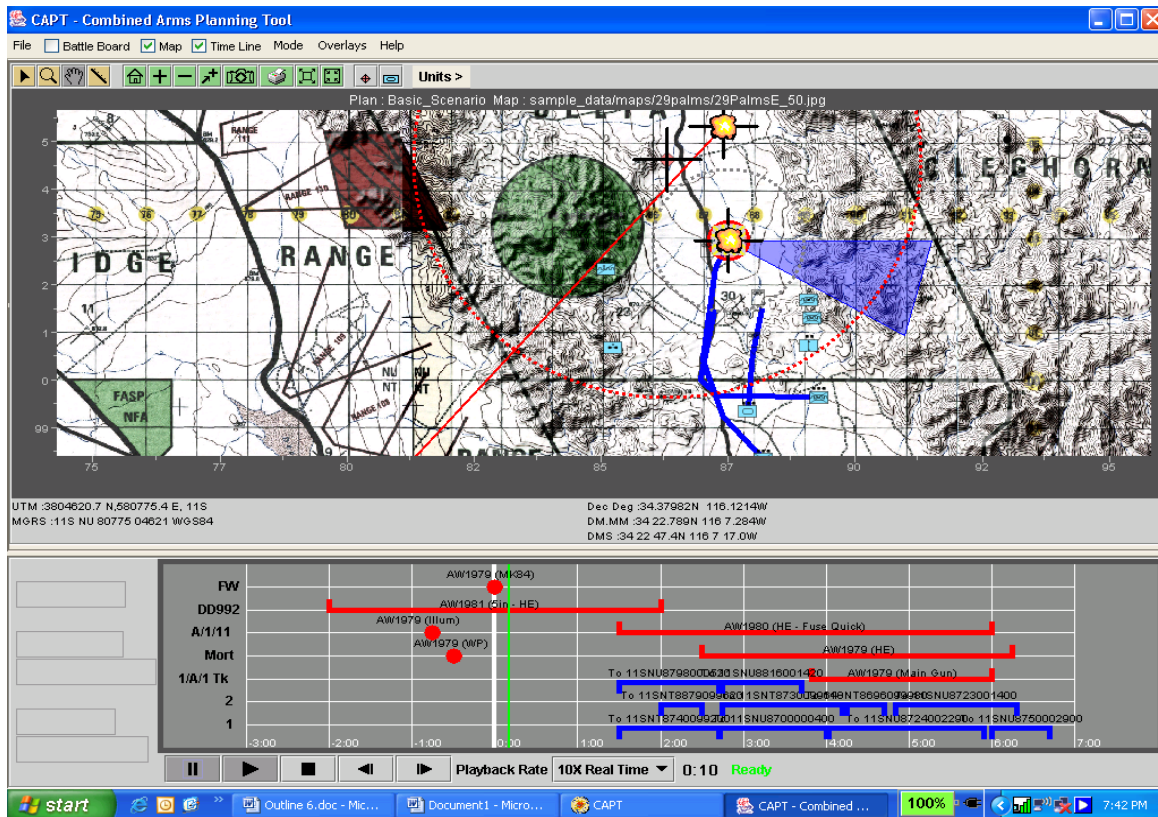

Figure 2. Pause of CAPT during Mission Execution

TACTICAL FIRE SUPPORT PLANNING AND EWS FIRE SUPPORT PLANNING TRAINING REQUIREMENTS

The Commander of a maneuver company designates the individual responsible for the planning, coordinating, and supervision of indirect and air delivered fires in support of each mission. This individual assumes the role of the Fire Support Team (FiST) leader. Within a maneuver company this individual is often the Weapons Platoon Leader, Company Executive Officer, or one of the indirect fire Forward Observers. Each maneuver battalion also possesses a Fire Support Coordinator (FSC) who monitors each company's fire support activities within the battalion and coordinates with adjacent battalion level or higher units. Individuals fulfilling the role of the Battalion's FSC must also possess the skills required of the Company FiST leader. This condition permits a device designed to support FiST training to also support FSC training.

The Expeditionary Warfare School teaches the doctrinal integration of fires in support of schemes of maneuver to Marine Captains for both company and battalion level operations. However, the school also believes all Marine Captains should possess a detailed understanding of fire support planning regardless of either Military Occupational Specialty (MOS) or the student's next duty assignment. Therefore the EWS faculty requested the planning tool not only compliment existing fire support coordination instruction, but explicitly guarantee each student the opportunity to apply the following concepts of fire support planning:

- Understand the synergistic effects of combined arms

- Appreciate the complexity of even a simple combined arms application

- Understand basic weapon - target pairing

- Understand the interrelationship of gun-target lines and aircraft flight profiles

- Understand and apply the concept of minimum safe distances

- Understand and apply the concept of maneuvering under the effects of suppression

- Understand and apply the principles of SEAD

EXISTING FIRE SUPPORT TRAINING SYSTEMS AND THE CAPT

Virtual training devices provide forward observers, forward air controllers, and naval gunfire spotters an opportunity to refine their target engagement skills. These virtual devices stress the communication procedures between the fire support requesters and the providers of the fire support. However, these training devices do not always focus on the sequencing of fires in support of maneuver and some of these operate as stand alone systems that prohibit fires from weapon system to affect the target in another. Additionally, many do not always include friendly maneuver forces within the training scenarios; a situation that avoids the issue of fratricide. This list of shortfalls should not be taken to indicate these virtual training devices do not offer value. They certainly assist with the mastery of basic observer and controller skills, but they do not often provide a context for the engagement directly support the training of the fire support team.

Plan execution practice remains a critical component to building the unit's combat readiness and constructive simulations can provide training realism to company and battalion staffs since these simulations attempt to dynamically account for the interactions of a wide variety of non-linear relationships found on the battlefield. However, fire support activities within constructive simulations focus on the execution of the fire plans. Few existing constructive simulations offer a plan review capability prior to execution. This limitation permits staffs to unknowingly attempt the execution of a plan with built in errors and unless the errors generated during the execution of the plan receive visibility from knowing SMEs who look for those violations, the potential for negative training remains.

The CAPT compliments both existing virtual and constructive systems discussed above by permitting the evaluation of a fire plan and then allowing the user to observe the dynamic execution of all maneuver and fires prior to execution. Production of an acceptable fire plan prior to mission execution can provide context to the vital target engagement skills trained in simulators and also provide an acceptability check for operation orders later executed in constructive simulations.

THE CONCEPT OF FIRE SUPPORT PLAN EVALUATION WITHIN THE CAPT

Prior to beginning detailed fire planning numerous assumptions have been made in order to develop the scheme of maneuver and assume the enemy's most likely course of action. Based upon these critical decisions detailed fire planning like that addressed in THE FIRE SUPPORT TEAM (FiST) TECHNIQUES AND PROCEDURES HANDBOOK published by the Marine Corps' Tactical Training and Exercise Control Group (TTECG) can begin. This planning follows a very specific sequence and remains highly objective. Since all the interactions between variables associated with fire support activities possess very discrete cause and effect relationships, this permits the creation of a rigid rules set that can evaluate a proposed company fire support plan in support of a specific maneuver scheme.

Each of the CAPT's rules focus upon at least one and often two or more of these four general concepts:

- **Feasibility**: Available resources exist in enough quantities and the battlefield geometry permits the execution of the plan.

- **Effectiveness**: Each engagement achieves the desired result.

- **Timeliness**: Results occur at the appropriate time to support the maneuver scheme.

- **Safety**: The chance of fratricide significantly reduced or eliminated.

The CAPT Rules at Version 1

Using the concepts above to assist with the evaluation of the SME selected friction points, the initial release of the CAPT evaluated fire plans with following seven rules:

Rule 1 evaluated interactions between Close Air Support (CAS) fixed-wing aircraft flight paths and Gun Target Lines (GTLs). The rule ensures indirect fire ordnance trajectories do not hazard the aircraft.

Rule 2 evaluated friendly units and friendly indirect fire impact locations to ensure friendly units did not exist inside friendly minimum safe distances (MSDs) at the time of engagement.

Rule 3 ensured the fire plan engaged all identified targets even if the target could not influence the maneuver scheme.

Rule 4 reviewed the marking technique proposed for the fixed-wing close air support attack and ensured redundant and dissimilar firing platforms had been scheduled and different mark types planned.

Rule 5 reviewed the plan to suppress enemy air defenses in accordance with standard interrupted, standard continuous, and non-standard engagement techniques.

Rule 6 ensured whenever friendly forces maneuvered inside an enemy system's effective engagement range or Threat Ring that the enemy unit was affected by indirect, close air, or direct fires.

Rule 7 ensured friendly units did not operate within the safety region of an active friendly mortar.

As use of the tool continues we expect to implement additional fire support planning rules to account for rotary-wing engagements in addition to any other fire planning topics that SMEs designate for inclusion.

Building Comprehensive Rules

Two complimentary efforts helped account for all the interaction between variables associated with each rule; the initial description of the SME defined "friction points" and the creation of a Master Interaction Table.

A friction point identifies a sequence of actions that historically presented execution challenges to FiST leaders. The Marine Corps' SMEs assigned to the Tactical Training and Exercise Control Group stationed at the Marine Air-Ground Combat Center in California and the instructor staff supporting the Expeditionary Warfare School at Quantico, Virginia provided the detailed descriptions of the friction points. Producing rules to evaluate the interactions described within the friction points required a detailed understanding of the physics associated with the events.

The SMEs' description of a friction point did not always provide enough detail for the designer and coder to account for all possible interactions. To overcome this development challenge, the CAPT design team produced the CAPT's Master Interaction Table. This table consists of an "X by X" matrix accounting for the entities, actions, data elements, and control measures contained or represented within the CAPT documents or map. The concept behind this approach is the belief that a single SME or even a group of SMEs will not systematically address all possible interactions associated with a friction point.

Additionally, the design team needed to know if variables and activities critical to one friction point could influence another and if they did what affects needed consideration. This table provided a detailed list of topics that assisted the design team account for situations that a SME may not routinely encounter or had not yet experienced. Reviewing the intersections of each of the table's current 112 columns with each of its 112 rows reduced the chance the tool would inadvertently generate a condition a SME would deem invalid or negative learning. Of the 12,544 possible interactions within the table, the design team identified 1,002 questions requiring SME review. This table not only ensures all possible interactions receive visibility within the design effort, but also assists the design team address questions posed by SMEs who only recently joined the tool's development effort. Review of this table continues and entries are expected to grow as the number of rules increase or existing rules become more encompassing.

FIRST USE OF THE CAPT AT EWS

The CAPT's first use to support fire support instruction at the Expeditionary Warfare School during February 2006 proved successful. Instructors appreciated the following features and capabilities:

• Students received feedback almost immediately. If the student created a fire plan with a rule violation, the student did not have to execute the plan in a constructive simulation or wait for an instructor to identify the error. Also the student received notification of the error a second time during the tool's dynamic two dimensional display of the plan when the tool halted all fires and maneuver on the map at the time of the rule violation.

• Even if the tool indicated a planning error existed, the student could elect to accept the error and continue to run the dynamic two dimensional display to the end of the fire plan.

• One instructor indicated all students had the opportunity to receive something close to a formal evaluation of their fire plan.

• Almost twice as many students performed the role of a FiST leader during the fire support instruction period compared to previous years.

• Due to the perceived educational benefits offered by the tool, the EWS staff is considering placing the CAPT in the hands of the students earlier in the instruction schedule.

Unlike the highly subjective decisions associated with maneuver, the evaluation of fire support in both planning and during execution appears scientific and could be largely addressed within a single comprehensive evaluation criterion. In the opinion of the Expeditionary Warfare School staff, the Combined Arms Planning Tool's Version 1 configuration possessed enough capability to adequately teach the basics of fire support planning and execution at the Fire Support Team level though members of the staff were quick to point out the additional rules are required to fully support FiST training outside the EWS classroom. The EWS staff believes a finite set of rules can exist to address FiST fire support planning.

HOW RULES BASED FIRE SUPPORT PLAN EVALUATION SUPPORTS AFTER ACTION REVIEW (AAR)

The Marine Corps plans to use the CAPT to support AARs of live training events. The ability to compare a two dimensional dynamic and interactive copy of the training audience's plan with data collected during exercise execution significantly facilitates AAR discussions. Adding a view of the training audience's command and control systems allows a three way comparison between the training audience's plan, the actions of the training audience during execution, and the training audience's perspective of their actions. Looking for "deltas" between the three views highlights topics for discussion. Figure 3 presents this concept.
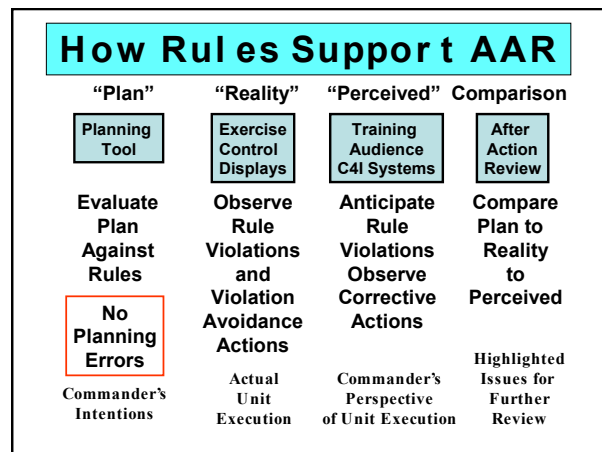

Figure 3. Planning Rules Support to AAR

Using rules to first evaluate plans and then tracking rule violations during execution can benefit the training audience. Current virtual and constructive systems possess the ability to easily track fire support rule violations during exercise execution. However,

the explicit tracking of fire support rule violations remains largely untapped in these training events since planning rules do not normally compliment the use of these training systems. Hence, training audiences do not execute their orders during training against resident standards. Current live, virtual, and constructive environments offer impressive opportunities to practice mission execution, but do not routinely offer rules based comprehensive evaluations within their After Action Review (AAR) components.

Today AAR still remains largely the responsibility of the senior member of the training audience present or a group of designated SMEs. Training device limitations place great stress on both leaders and SMEs to adequately address a variety of topics across a range of Military Occupational Skills (MOSs). Many systems offer instantaneous feedback to operator performance violations such as impact with the ground in flight simulators should an aircraft fly too low or the destruction of a friendly vehicle should a gunner choose an incorrect target which are very valuable lessons, but only begin to scratch the surface when AAR staffs attempt to address the why did the event occur. Tracking timing and battlefield geometry violations associated with fire support based upon planning rules improves AAR capabilities noticeably by offering the ability to first forecast a potential problem during exercise execution and then should the situation occur, the ability to review move and fire commands within the software to assist AAR staffs determine the why the situation was created within the training audience. Figure 4. presents this concept.
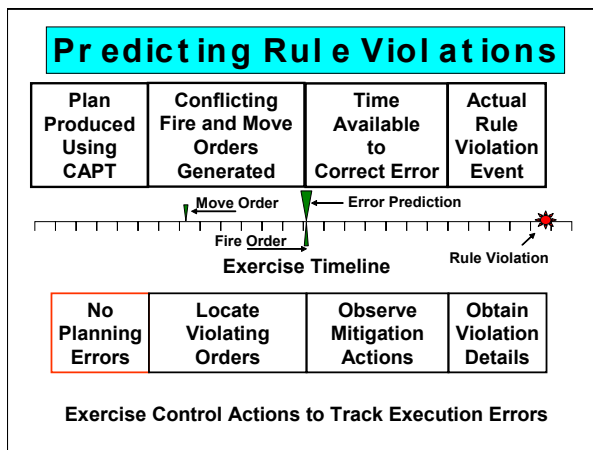

Figure 4. Predicting Rules Violations During Exercise Execution.

Additionally, since the presence of thoroughly knowledgeable SMEs is not always guaranteed, evaluating both planning and execution against the same rules overcomes this limitation. Rarely can one individual or even a group of trained individuals critically evaluate a large sequence of individual and collective tasks and if a group of SMEs do exist within an organization the chance of that group evenly supporting all elements receiving the training remains challenging. Often the leader of the training does his best, but only within the context of his knowledge base. Providing user friendly copies of the evaluation rules for dissemination will increase the number and depth of SMEs.

WHAT RULES BASED EVALUATIONS OF FIRE SUPPORT PLANS OFFER OPERATIONAL PLANNERS

The CAPT offers many advantages to operational fire planning agencies. The CAPT can act as the single fire support planning system for coordinating close fires throughout the Department of Defense. The CAPT can assist operational planners by providing dynamic and interactive two dimensional displays of all planned maneuver and fires. The addition of optimization software presents the opportunity for software to produce a system generated fire support plan after entering a scheme of maneuver. Planners can use rule violations as justifications for allocating additional resources. The size of the company mission files offers easy dissemination among headquarters to facilitate coordination.

Single Fire Support Planning System for the Department of Defense (DoD).
The current configuration of CAPT can become the starting point for the development a single fire planning system to coordinate all fire support planning at the company or battalion levels throughout the Department of Defense. The CAPT could stream line close air support (CAS), naval gunfire, and indirect fire support planning and request procedures which would not only increase combat efficiency and effectiveness, but by using the existing rules also reduce the likelihood of fratricide.

Dynamic and Interactive Two Dimensional Display of Maneuver and Fires.
One of the most challenging decisions associated with operational planning at the company level is the selection of detailed maneuver paths and the timing sequencing along those paths of the company's elements in support of the battalion's mission. The identification of and the company's choreography along these paths becomes the company's maneuver scheme. A large number of variables influence the company commander's path selection and movement

sequence. The generation of an effective company maneuver scheme requires numerous comparisons between variables with non-linear relationships and will perhaps always remain part of the company commander's combat art. Even with these very large numbers of highly subjective considerations, the CAPT substantially assists commanders by offering a user friendly dynamic and interactive two dimensional map to observe explicitly the timing and sequencing of their maneuvers and fires.

Generation of Fire Support Plans Using Optimization Software.

As mentioned above once a maneuver scheme has been proposed, the enemy's actions assumed, and friendly status information made available, then generation of a detailed fire plan in support of the proposed maneuver scheme can occur. Fire support planning poses challenges in the operational environment, but the solution to these challenges can follow a pattern and use rules based criteria to address feasibility, weapon effects on targets, timing of engagements, and fratricide prevention. Specifically, variables associated with these issues routinely possess either a binary state such as for the variable range, (can the weapon reach the target?), or a very explicit physics based representation. Variables with these traits permit the selection of optimum solutions. If we include these planning rules as part of the constraints within an optimization application we would possess the opportunity to generate a fire support plan in harmony with a specific maneuver scheme by prioritizing the solution sequence. This capability provides the commander and his staff at the company or the battalion levels the opportunity to obtain a system generated fire plan rather than building one. After inputting the optimization software's proposed solution into the planning tool, the commander can interactively observe the execution of this proposed solution faster than real time. Should the plan require modification the tool supports both maneuver path sequence or fire support plan edits and then immediately rechecks the plan against the rules to support the another display of the plan's execution. This sequence would continue until the commander finally approved the plan. If at that time the tool possessed connectivity with command and control systems, the tool could then digitally disseminate the proposed operation order with its firing data to all fire support agencies, their coordinating headquarters, as well as the higher and any adjacent headquarters.

Figure 5 presents the mission planning information flow with the activity sequence numbered.
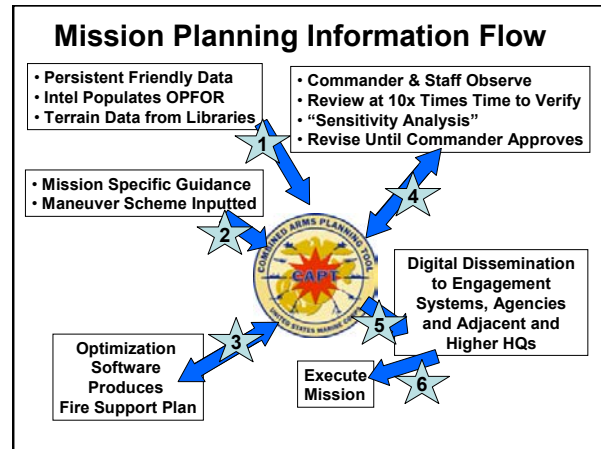

Figure 5. Mission Planning Information Flow

A CAPT possessing these capabilities may significantly reduce preparation timelines at the battalion level, reduce the likelihood of fratricide, and enhance coordination among all organizations supporting the mission. What may have taken well trained and rested staffs hours to develop, coordinate, review, approve, and communicate would take much less and reduce the likelihood of fratricide. A planning system with these capabilities becomes noticeably more valuable as the stresses of combat cumulate.

Using Rule Violations to Justify Additional Resources.

Even in the current configuration without using optimization software the CAPT can assist subordinate commanders justify additional resource requests to their higher headquarters by offering highly explicit reasons. A subordinate unit could submit their plan up the chain of command with the tool's rule violations highlighting the need for additional resources. The rule violations would illustrate specifically where the resources available do not support the maneuver scheme. Conversely, higher headquarters can become more proactive in the generation of detailed planning to their subordinate units by offering maneuver schemes with adequately resourced fire support plans.

Enhancing Coordination Among Headquarters and Fire Support Agencies.

Currently, complete company plans saved as an Extensible Markup Language (XML) file within the CAPT consume less the 20k bytes of storage space. This storage size encourages the sharing of planning data as long as all headquarters possessed the same version of the CAPT with the same map displays.

OTHER USERS OF THE CAPT

Currently, the Combined Arms Planning Tool supports two other programs, the Virtual Technologies and Environments (VIRTE) sponsored by the Office of Naval Research Science and Technology Department Code 34 and US Joint Forces Command's, Joint Management Office, Joint After Action Review (JAAR) Working Group studying the use of mobile agents to enhance after action reviews during exercises conducted within the Joint National Training Capability (JNTC).

The CAPT supports the portion of the VIRTE program focusing on the integration of indirect fire and close air support virtual training systems that when combined permit a fire support team to practice their coordinated target engagement skills such as the suppression of enemy air defenses, marking of targets, close air support, and the suppression of enemy threats with fires to support maneuver. The CAPT provides the VIRTE supported FiST Leader combined arms fire planning functionality, a dynamic map, an electronic Battle Board, and an interactive Scheduling Worksheet. Additionally, the VIRTE program will modify the CAPT's source code to permit the CAPT to generate HLA formatted messages. The CAPT produced HLA messages will then electronically disseminate fire planning data to the other VIRTE configured virtual simulators and some real world tactical systems used with VIRTE such as the Advanced Field Artillery Tactical Data System (AFATDS).

The CAPT supports the Joint After Action Review Working Group by presenting to the Exercise Control Group / White Cell the training audience's plan as well as the rules evaluation methodology. During the training audience's execution of the plan mobile agents resident on constructive training systems look for planning rule violations using the evaluation criteria resident within the CAPT. This capability

enhances after action review by offering the After Action Review Cell specific examples of fires that could create fratricide. The engineering feasibility study selected Rule 2 addressing Minimum Safe Distances. By including the CAPT as part of the JAAR system, EXCON personnel can then compare the plan to the execution data maintained by the training systems and this information to the real world C4I system depictions of events.

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