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A BATTALION/BRIGADE TRAINING SIMULATION

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Abstract.

In today's Army there exists a requirement for a simulation to train Brigade and Battalion commanders and staffs to exercise procedures and decision making skills. The key elements of this simulation are that it provide a realistic, stress-filled simulated combat training environment to practice AirLand Battle doctrine. There must be a greater appreciation of threat doctrine and tactics while providing the opportunity to exercise and evaluate the units tactical standard operating procedures and decision making processes used to control and coordinate combat, combat support and combat service support assets. The US Army has determined that an automated simulation will provide this capability. The simulation model selected to meet these goals is the Computerized Battle Simulation (COMBAT-SIM). This paper will briefly address the background of command and control training and provide an in depth discussion of the COMBAT-SIM model.

Introduction.

In 1981, the US Army initiated a research program designed to investigate the practicality of using microcomputer-based simulation for training command, control and communication skills in combat operations. The project resulted in a prototype battle simulation designed to train command and control skills needed by future commanders on the modern battlefield. The simulation allowed task organizations, it represented all normal combat functions, and it included a means of simulating the activities of units not being represented by human participants.

Most importantly -- it proved that simulation could be a low-cost, high-performance alternative to the high-cost, high-risk training systems then in use to practice command, control and communication skills.

The prototype, called BABAS or Battalion Automated Battle Simulation, was designed and built around the Corvus Concept microcomputer. The system consisted of seven networked stations that included videodisc maps, interactive graphics and menu input/output. The seven interactive stations communicated via a local area network that allowed the sharing of information and the updating of simulation data at four minute intervals (the game cycle). By 1982 BABAS had achieved a concept demonstration, proving the viability of microcomputer technology as a potential training system.

In 1985, the Australian Army obtained the software for the BABAS system from the US Army and contracted to convert the model to IBM-PC/ATs. After careful evaluation it was determined that conversion was not possible and a new model had to be created -- COMBAT-SIM. The basic BABAS concepts were retained, but a totally new approach was devised for how warfare would be simulated in the computer system. The resulting effort was so successful that in 1986, the US Army chose COMBAT-SIM as the basis for their brigade and battalion simulation (BBS) to be fielded in 1988.

COMMAND AND CONTROL TRAINING WITH COMPUTERS

Before proceeding further, it might be useful to explain some of the terms we will refer to as we discuss COMBAT-SIM. In very general terms the reader will need to understand (a) the concepts behind this type of command and control training, (b) the staffing and responsibilities of the control apparatus, and (c) the optional modes of operation.

First, let us examine the concept of command and control training as it is conducted without the aid of computers.

Manual Exercise Systems.

Meaningful training depends upon a complete program of instruction. Present, Demonstrate, Practice, Evaluate - that has been the military training model throughout history. A command post exercise (CPX) is intended to offer commanders and staff officers an opportunity to practice their war time functions -- in peace-time. This type of training is termed procedural training or exercising. It entails the creation of a war-time environment under realistic conditions and scenarios but in a peace-time setting. To conduct a CPX requires extensive preparation of operations orders, scripts, events lists, message traffic, communications networks, and an extensive staff of role players to carry out the training. It is tried and true, but todays constrained resources make it difficult to execute. Exercising a major headquarters, over a few short days, can take thousands of manhours to prepare - and - the costs do not end there.

Using traditional manual command post exercise techniques, fuel, ammunition, vehicles, equipment, and soldiers all must be diverted from other tasks to support the training. In terms of dollars, it can run into the hundreds of thousands to exercise just one headquarters staff. In terms of soldiers and equipment, the numbers are even less encouraging. As a consequence, the training that is conducted must be optimal; unfortunately in most cases it is of only minimal value.

In developing a command and control training exercise, one starts with the target audience -- the command group (or groups) to be trained. These groups, known as the "players", are placed in an actual or modeled decision-making environment. This can be their actual command posts (CPs) or tactical operations centers (TOCs) in the field, some specially "mocked-up" training facility in garrison, or CPs and TOCs set up in the motor pool.

The players are then literally surrounded by a second group -- the "controllers".

Higher control represents any agency that has the authority to give orders to, or provide or withdraw resources from, the player group. Lower control represents all the subordinate units of the player group. Lateral control (when implemented) represents all elements with which the player headquarters has a cooperative or coordinating relationship. When not expressly portrayed, the higher control cell "fills in" for the lateral control and performs those functions. Using the traditional approach (meaning manual or at best computer assisted) this controller group will out number the target audiance (player group) by as little as three to one or as much as ten to one. Large logistics or major headquarters exercises require literally hundreds of controllers.

Now let us examine the concept of computer simulation-supported training, or more specifically, the concept of battle simulation in support of command and control exercises for the commanders and staff officers at the battalion and brigade levels -- COMBAT-SIM's target.

Computer Driven Exercise Systems.

Advances in computer technology appropriate to attacking the high cost of training have been under close scrutiny by many countries over the past several years. Electronic maps and graphics are replacing the traditional map table ringed by broad shoulders and loud voices. Shouting matches, dice rolls, look-up tables and 'guestimates' are being replaced by computer screens, software systems, and data retrieval techniques. After action reviews are being supported by computer generated print-outs of the results in-place of the more subjective 'warm and fuzzy feeling'.

The more sophisticated automated training support systems take the best of this new technology and put it to the task of simulating the environments of future battlefields. These simulation techniques allow the introduction of situations not possible in peace time, and more importantly, require very little in preparation or field troop support.

In computer driven CPX systems, players never directly use the computer system terminals. Player interaction with the computer simulation is in-direct, that is, through normal phone or radio communications with their actual subordinates. The subordinates operate inside the simulation control area, and function as role players. The role players pass player instructions to another group, called interactors, who directly operate and interact with the computer system. Results of the player orders are then computed, reported to the interactor in graphic and/or text form, relayed to the role players who in-turn report to the players. The role player then awaits another set of instructions from the player group and the cycle is repeated.

This interactive cycle is done continuously, setting a time-driven stress level in the computer driven exercise not possible in manual 'board game' systems. There are no schoolroom or textbook solutions forced on the play of the exercise. It is totally free-play. Commanders are allowed to stretch their training and experience to the limits in a time sensitive "pressure cooker" environment.

The US Army BABAS system was the first of the new microcomputer-based systems to reach a demonstration level of development and prove its' worth in early use. The Australian COMBAT-SIM development, pushes even further into the technololgy by tieing training sessions together in a common scenario using high technology digital graphics, distributed processing, and real-time local area networking.

In summary, in a manual exercise system the players send instructions to the controller cell who take the player instructions; plot or place them on the map table or game board and then create, devise, calculate, or look-up a result of those instructions. The controllers relay back to the player the results of his instruction as devised by the control cell. A very large number of controllers are required to keep up with the pace of the battle and respond to players with anything close to 'real time' results. In most cases these systems are supported by a 'canned' set of messages which are used to stimulate play, conform to the pre-ordained result or are intended to re-enforce a teaching point. While successful training is possible in the manual format, preparation is intensive and very time consuming, results are less than conclusive, and training opportunities are uneven.

In the computer driven systems, the players never interact directly with the computer system. The player group is located in either a field operations center or in a mock-up of his command post. Communication with the computer simulation is through his subordinate commanders who are in the control environment acting as role players. The players send instructions to the role players who pass them on to the computer interactors. The interactors take the player instructions and enter them into the computers which in turn forecast or calculate a result of those instructions. The interactor then relays back to the role player the computed output or results and awaits another set of instructions and the cycle is repeated.

These automated learning tools (simulations) allow the introduction of situations not possible in peacetime. Adding to this new technology pay off, real time is possible with far fewer controllers, at substantially lower costs, preparation time is measured in hours not months, and training effectiveness is significantly higher. War is the only real test of command decision making - simulation merely provides an approximation.

THE AUSTRALIAN COMBAT-SIM

COMBAT-SIM () is a totally new training simulation. Although created initially for the Australian Army from the concepts proven in earlier US Army work on BABAS, only the concept remains from that earlier work. The US Army is now importing COMBAT-SIM to satisfy the Training Device Requirement for the Brigade/Battalion Simulation (BBS), illustrating that COMBAT-SIM is really something quite different and new.

The Aussie system (pronounced AUZZY), consists of seven to ten IBM-PC/AT microcomputers tied together in a local area network. Each of the stations are given all the computational power, data and communications means necessary to discharge their assigned function. They then share information (data) with the other stations in the distributed processing architecture.

What is new: Truly distributed processing, high speed graphics, and computer networking are the keys to how COMBAT-SIM achieves real-time simulation of combat from a knowledge base of individual weapons and units in the game. Something never achieved before on a microcomputer based simulation system.

What is different: The way COMBAT-SIM resolves conflict between the opposing forces.

Training simulations usually rely on some form of fire-power-score-summing for weapons effectiveness which is fed into an equation or algorithm to determine a result. This arithmatical aggregation is normally a predictive indicator of results, which are then spread out over the time interval to simulate real events.

A very common modeling approach (widely called Lanchester-type models -- after F. W. Lanchester, the 1914 English inventor of mathematical modeling in wargames) is: measure the status of the combatants at time 'zero', total their firepower scores, integrate the environmental constraints on both sides, feed the weighted values into a differential equation to compute results, aggregate results over the time required to compute all this (the update cycle), and report the results to both the loser and winner in a tabular or graphic form.

COMBAT-SIM does it differently. For each weapon, vehicle, or system there is a performance profile that is a function of range and includes actual firing results against various types of targets. Included in the profile are mathematical probabilities associated with a weapon's terminal effects based on: detection of the target, identification, ability to acquire and whether or not a hit was recorded. Placed in a table, these 'possible' results form a matrix of effectiveness over a large number of possible conditions for all weapon types. This weapons effectiveness matrix is at the heart of the COMBAT-SIM conflict algorithm.

Given that OPSTATE, range, detection and acquisition thresholds have been satisfied, each possible firer sends an appropriate round or burst of rounds to the target unit. This 'packet' of incoming rounds, passed over the local area network, identifies the type of round, the intended target(s) and the number of hits recorded. That information is received by the computer controlling the target unit, and distributed over the number of identified and available target systems. The terminal effects are then calculated. Initial results are recorded and an alert message sent to the monitor or printer for immediate reading by the interactor or role player whose unit was attacked. Detailed results of the conflict are obtained from the later evaluation of the destroyed or damaged end item by the logistics programs thus stimulating logistics play. Each and every round is tracked from gun to target -- in very near real time.

COMBAT-SIM is sufficiently detailed to ensure a valid representation of any doctrine at the tactical level. Units (e.g., sections, platoons, companies, etc.) are modeled as a collection of personnel, equipment, weapons and supplies located within a defined area. These elements act as a single entity which respond to player instructions and system computations.

The operation of most types of units can be modeled to include maneuver, direct fire confrontations, indirect fire support, close air support, rotary and fixed wing aircraft, engineers, air defense and personnel and logistics.

A unit's resources are automatically depleted in response to movement and conflict, and can be replenished by the personnel and logistics routines. Red and blue forces are modeled individually to capture the differences in tactics and doctrine. The battalion simulation represents all assets available to, or interfacing with, a blue battalion at platoon level with the red regiment (plus) modeled at company level. For blue brigade play, companies can be modeled to face battalion sized red units within a threat division with all its' normal supporting arms.

COMBAT-SIM IN THE US AND OTHER COUNTRIES

With the completion of the conversion effort and the brigade upgrades, COMBAT-SIM becomes BBS for the US Army. For the rest of the world it will remain COMBAT-SIM . The name is not as important as the concept. We have designed this system to be adaptive and responsive to any free world countries' needs in command and control training.

To adapt COMBAT-SIM to another countries requirements, the user only needs to define the terrain area to be used, the force organization and weapons data and, if desired, the hardware suite to be used. The normal hardware is the IBM-PC/AT or some compatible configuration. Perceptronics will adapt the software to accommodate other hardware, but recommends the low cost solution as the standard.

New COMBAT-SIM users are given membership in the COMBAT-SIM User's Group which affords them easy access to new developments as they occur. Through the COMBAT-SIM User's Group all user's share in future developments with minimal further cost.

The final US system -- BBS -- will train and exercise brigade **and/or** battalion commanders and staffs in the conduct of the AirLand Battle. To develop this system, Perceptronics used the Australian COMBAT-SIM battalion level software model as a starting point.

The architecture of the COMBAT-SIM model is structured around a top-down modular concept and is in a totally distributed architecture. The resulting code is easily expanded and/or modified to update or include new features. This design approach permits the addition of new features, through additions to the data base and the integration of functional modules. The basic architecture remains unchanged even as new model attributes are created and integrated. Adding functionality to the existing model, saves years of development time and many thousands of dollars.

HARDWARE

The US Army had Perceptronics convert the IBM-based COMBAT-SIM system to operate on the Digital Equipment MicroVAX II™ networked microcomputers. In that system videodisc maps, produced by Perceptronics, are overlayed with computer-generated graphics to depict the battle situation. The graphics system consists of an IEV Corp. graphics generator, a Sony videodisc player and a 25" Sony monitor.

Linked by a DECNet™ and EtherNet™ Local Area Network (LAN), the ten-station MicroVax II ™ system produces warfare in real time for up to 2,150 units, 50 air strikes, 50 artillery missions and 256 graphic draws. Updating of the network is accomplished every 15 seconds with many events reporting in under a second.

SYSTEM LAYOUT

Independent of the hardware suite selected, the system is organized around the ten station configuration. Workstation responsibilities and functions will be discussed in the next section. Facility considerations are provided in the Facilities section.

SYSTEM OPERATION

Workstation Functions and Responsibilities

There are six basic types of workstations in the ten station COMBAT-SIM simulation: higher control (HICON), maneuver (four used), artillery (ARTY), air support & air defense (AIRAD), personnel & logistics (PERSLOG), and enemy (two used). Each stations responsibilities are explained below:

HICON. This workstation is responsible for the overall control of the game. This includes implementing the initialization process, starting, stopping & changing the game time, managing control measures, controlling light & weather conditions, emplacing & clearing obstacles & mines, monitoring reports, and using the full range of options found on the maneuver menu. In the brigade version the full range of engineer options are controlled at this workstation.

MANEUVER. This workstation is responsible for managing and controlling the ground units which fight the battle. Controlling unit moves, monitoring alert messages, directing conflicts, changing displays, altering unit OPSTATES & status, checking line of sight, and placing & removing OP's & sensors are the functions performed. There are four of these workstations in the simulation. The maneuver functions found at this workstation are also repeated at the other workstations since all elements must move, can be fired at, and consume resources.

ARTY. The artillery workstation is responsible for managing and controlling Artillery firing and manuever of artillery and support units assigned or attached. All normal artillery missions and relationships are played. Adding, displaying, editing & clearing indirect fire mission, controlling unit moves, and monitoring reports are functions performed at this workstation.

AIR/AD. The air support & air defense workstation is responsible for managing and controlling close air support, rotary & fixed wing missions, and coordinating air defense support. Adding, displaying, editing & clearing air mission, controlling unit moves, and monitoring reports are all functions that are performed at this workstation. In addition, the maneuver of ground units associated with the air play are controlled here.

ENEMY (2). These workstations are responsible for all of the same functions for threat forces as are controlled by the Maneuver, ARTY, AIRAD and PERSLOG workstations. There are two enemy workstations operating in the simulation.

Modes of Operation

In any of the various modes of operation emphasis is placed on creating the most realistic training environment possible. The players do not directly interact with the computer system and if possible should not see the control facility until after the training session is completed. All controllers and interactors are cautioned not to discuss computer system operation, mention the computer on radios or telephones, or provide information to the players that they would not be able to get through standard means.

Placing the player in realistic environment is only half the effort. Role players are the key to a successful exercise. The information they pass to the staff and commander must be realistic, stressed with the 'heat and blood of battle' and most of all, be believable. Without this added effort, the effectiveness of the exercise is greatly deminished.

The three modes of play envisioned for COMBAT-SIM are: 1) single echelon battalion staff exercise, 2) a multi-echelon exercise for both brigade and battalion staffs, and 3) a single echelon brigade staff exercise.

Mode 1 (battalion level) is the first mode available to units in the field, thereby building a "cadre" trained to control the battalion game and operate the simulation. Only the battalion commander and his staff are in the field. His subordinate commanders (company), are in the control environment acting out their roles and responding to direction from the battalion staff. Company commander role players focus on the actions of individual platoon and sections when moving them or fighting conflicts.

Mode 2 (the multi-echelon game) places both the brigade and battalion commanders and staffs in the field requiring the control staff to represent division level activities. The operation of the simulation proceeds in much the same fashion as Mode 1 with the exception of the size of the control organization and specific functions of the higher control staff. This mode allows the brigade command group and staff and the command groups of one or more of the subordinate battalions to be exercised at the same time. The brigade interacts directly with its battalions, to higher and to adjacent units using organic communications. The battalions fight the battle as in Mode 1, (IAW brigade orders, instructions and SOP's). The simulation provides for control in unit movements, conflicts, indirect fire missions, and personnel and logistics support as is done in the battalion exercise. As before, company role players focus on the actions of individual platoons and sections when moving them or fighting conflicts.

Mode 3 (single echelon - brigade exercise) places only the brigade command and his staff in the field. The subordinate battalion commanders and staff activities are represented in the control room. Battalion level role players focus on the actions of companies (where required, platoons and sections) when moving them or fighting conflicts.

In each mode the exercised unit(s) provide(s) the role players and interactors who are responsible for operating the simulation. They take instructions and orders from the player command group and enter them into the computer. They monitor the output and relay the results back to the exercising command group(s).

MODEL FEATURES

Game Update Cycle. COMBAT-SIM works on a 15-second update cycle with many functions occurring in real time. Under full loading COMBAT-SIM is required to maintain a one minute game cycle to meet the characteristics of the US Army's BBS TDR.

Model Parameters. Everyone loves to compare numbers of things when looking at models of this type. At a minimum the following number of units, control measures, ammunition types and other parameters will be modeled to accommodate COMBAT-SIM operations:

Ammunition types	200
Concurrent smoke missions	120
Number of units	2,150
Minefields/obstacles	100
Control measures	100
Interactive workstations/consoles	10
Data recording capability(hrs)	72
Digitized terrain area (Sqkm)	10,000
Equipment types per unit	10
Equipment types	300
Weapon types per unit	10
Weapon types	300
OPSTATES	16
Weather types	8
Terrain types	16
Terrain data resolution(meters)	100
Preparation time for new game(hrs)	4-8*
Restart/Instant Replay (mins)	10

*Assumes a starting unit data base is being modified for the new game.

Line of sight. LOS calculations are measured and computed from center of mass of each unit using the terrain data base. These calculations, coupled with terrain features and elevation, light conditions, operation states of the two units and the probability of detection at range, effect the initiation and results of all conflicts.

Resolution. Resolution is the degree of specificity and detail that is used when controlling and describing units in the simulation. In COMBAT-SIM results are reported by platoon and section. These results are given to the company role player who in-turn reports to the brigade/battalion players. As COMBAT-SIM is fully developed, the basic combined arms representation in the model will be variable depending on the level being exercised: for brigade exercises, at the friendly company level - with the threat at maneuver battalion; for battalion level exercises, at the friendly platoon - with the threat at company. In all cases direct combat is resolved at the individual weapon (shot on shot) in real time.

DATA SYSTEM

The Data System. COMBAT-SIM removes much of the mystery surrounding the data that drives any simulation. A very user friendly data editing capability has been added which allows the user to read the information in common language using a spread sheet. For the Australian System this is DBaseIII™ or Lotus 123™. In the US system DataTrieve™ from DEC or an on screen editor is being used. The concept is the same - allow easy access to the data by the user without the need for a professional system analyst looking over his shoulder.

In COMBAT-SIM, game resolution is selected at game initialization. Prior to each exercise a data base of friendly and enemy forces is created or modified using the data editor described above. The simulation can depict and control maneuver units as small as sections and platoons or as large as battalions. The expansion of the data structures will permit the play of any of the three modes with only the selection of game level or resolution desired. The level of resolution required is determined by the training objective. This decision is only made during the initialization process and cannot be changed once the game has begun.

Terrain and Environment. The videodisc map display currently used allows each workstation to pan and zoom independently through six levels of view ranging from a display of 3 x 4 kilometers at 1:50,000 to 90 x 120 kilometers at 1:100,000,000. The model automatically determines when line of sight (LOS) exists between units, incorporating the effect of foliage and terrain. The model controls the unit speed over various types of terrain. The role player's appreciation of terrain is enhanced by using an intervisibility fan which indicates dead ground. This same facility can provide a cross-sectional view, and a perspective or three-dimensional view from a specified observation point to a specified target location. This feature allows a role player to carefully select defensive positions in order to obtain the best fields of view and fields of fire for the unit.

Weather. Weather conditions are specified during game initialization, and may be changed at any time by the Higher Control (HICON) station. Weather conditions are described in terms of cloud cover, precipitation and light conditions. A unit's ability to observe and detect enemy units is automatically limited or enhanced by visibility. Rate of movement is effected by both visibility and precipitation. A weather report describing the current weather and the limit of visibility is available upon request at any workstation at any time.

FUNCTIONAL AREAS

Operational States COMBAT-SIM uses a powerful method of modeling the combat characteristics of each unit. A commander can allocate any one of 16 operational states (OPSTATES) according to the current posture and task of each unit. The maximum speed of the unit is automatically limited by the tactical posture reflected in the OPSTATE. The OPSTATE specifies the vulnerability to enemy observation and fires as well as the proportion of the unit's weapons which can effectively engage an enemy unit. Typical OPSTATE's include tactical deployments, administrative convoys, rapid move, assault, halt, etc. The commander can change OPSTATE's at any time to reflect the normal changes of posture that occur in battle. If the attacking unit is so damaged that its equipment or personnel levels fall below a specified threshold or if all of its ammunition or fuel is depleted, the automatic allocation of the "assault stalled" OPSTATE prevents the unit from continuing its attack until it is reinforced or resupplied. OPSTATE's can be tailored to account for the particular characteristics of the type of unit which is being simulated. This allows the implicit modeling of the tactical formations and minor tactics of particular units, e.g., maneuver units, helicopters, artillery, etc.

Movement. At initialization, each unit to be played is given a starting location. Once the simulation has begun and movement orders are entered, the position of the unit is updated every 15 seconds. The role player may order a unit to move at any speed, however, the OPSTATE, type of terrain, degree of suppression and MOPP status will limit the actual speed achieved. Speed is further limited to the speed of the slowest equipment (including dismounted foot soldiers) in the unit. Vehicles can be modeled with crews mounted or dismounted, and units with no organic vehicles can be transported by wheeled or tracked vehicles, or by rotary or fixed wing aircraft. Consequently, the model can be used to simulate motorized, mechanized, air mobile, and airborne operations. Mechanized infantry or air mobile forces can operate together with or separated from their organic APC's or helicopters as needed. The movement module also includes two functions which may be used by the role players to shift a unit by 100 meter increments in any given direction, or relocate a unit to a specified grid coordinate without being effected by the usual movement constraints. These **shift** features facilitate the play of passage of lines and relief in place and allow for the execution of a time jump where required.

Minefields/Obstacles. Minefields and obstacles can be emplaced or cleared at any time during an exercise. Both measures restrict movement, and inflict casualties where appropriate. The emplacing and clearing of obstacles and minefields by engineer units is to be modeled explicitly in the US BBS. Changes include the addition of all divisional and some corps combat engineer units (bridging, construction, and pioneer) to the data base. Engineering assets are controlled and man-
euvered by the HICON station and can be field exercised in the CPX if desired.

Conflict. At present, conflict can only be initiated by a role player, based upon a tactical decision to employ direct fire, indirect fire, aerial bombardment, or a combination of the three, and on resources available. Automatic engagement is being done as an enhancement under the US BBS development.

Direct Fire. Each direct fire conflict is assessed continuously throughout the engagement on a 15 second cycle, rather than as a once only event as done in some models using firepower scores. Once initiated, direct fire engagements are resolved on a "shot by shot" basis. The model examines the firing unit to determine whether it has the ability to engage the target. The ability to engage is based on LOS, detection, equipment/ammunition availability and weapon ranges. If the firing unit can engage the target unit, then each weapon of the firing unit is considered in turn to determine the priority of fire against each piece of target equipment which is exposed to fire. This allows calculation of the numbers of bursts fired against each piece of target equipment. Once the distribution of bursts has been determined, the information is sent through the network to the workstation which manages the target unit. The passed information specifies the firing unit, target unit, range, weapon firing, target equipment and burst sent. The rate and accuracy of fire may be degraded by a suppression factor if the firing unit is also engaged. Direct fire effects are then calculated for each engagement by determining the probability of hit (a function of weapon accuracy and range), where a hit has occurred, and the probability of kill. A kill does not necessarily mean catastrophic damage. This permits a range of possible types of damage or wounds resulting from the hit. When a direct fire engagement is initiated, target units return fire automatically during the next 15 second cycle. Only those weapons which are in range will fire. This action simulates the normal contact drills that take place without orders prior to the commander determining an appropriate course of action. In practical terms, it also allows the workstation interactor to complete the current activity at the keyboard prior to implementing the commander's reaction to the engagement.

The major factors considered include line of sight (LOS), detection, engagement, and attrition. LOS is recalculated between any moving unit and all opposing force units out to the limit of visibility whenever any unit moves more than 100 meters. Target detection is based upon the range, target type (i.e., mounted, dismounted, or dug in), and the speed of movement of the target unit. Theses factors combine to give a probability of detection (assuming LOS exists).

The resulting damage is assessed at the workstation owning the target unit and is presented as an alert message. Alert messages are shown on the monitor or the printer. Review of alert messages allow the role player to "read" the battle as it develops. The same results are also passed on to the PERSLOG workstation, for further casualty classification, and subsequent evacuation and/or recovery simulation.

Indirect Fires. In contrast to direct fire, indirect fire is directed at grid coordinates rather than a specific target unit. Indirect fire engagements in are resolved by determining if the target grid coordinates are within range of the guns. If within range, and if the target grid coordinates have not previously been engaged by the firing unit (not a registered target), a circular error probability (CEP) is applied to the initial concentration in order to force realistic adjustment procedures. Fire missions against previously registered targets will fall on target. The area covered by the concentration is compared to the area occupied by the target unit to determine the percentage of the target unit actually covered by fire and the percentage of rounds landing in that area. These calculations provide a distribution of bursts, which are sent to the managing workstation in a manner similar to that described for direct fire. Indirect fire effects are also calculated to give probability of hit and kill. Indirect fires are effected by the availability of ammunition and personnel. Preplanned fires are modeled by using the time on target entry. The time can be set for any future game time required. Nuclear and chemical munitions, and their immediate and subsequent effects, will be simulated in the brigade enhancement.

TAC Air. Close air support (CAS) aircraft are treated as additional fire power assets not as identifiable entities. They are a finite resource available on demand for a specific mission. CAS sorties are portrayed on a flight basis and are vulnerable to all battlefield ADA weapons capable of engagement. Aircraft performance is sensitive to range, weather, ADA threat, attack profile and munition load. CAS sorties are executed only after the application of a global air defense ajudication. Then the damage caused by the aircraft which survive the target is assessed. This assessment is made using the indirect fire logic (including the application of a CEP to the point of impact). Aircraft on-board ECM system effects against threat ADA radars are portrayed as is battle damage assessment.

Army Aviation. Rotary and fixed wing aircraft are modeled as maneuver units, except that they move at a height above the ground level, and use tactical formations and associated OPSTATE factors which more closely represent Army aviation operations. The direct fire engagements process is used to assess all air-to-air, air-to-ground and ground-to-air engagements involving these units.

Air Defense. Currently, air defense operations against close air support are modeled globally in the simulation. Air defense operations are coordinated between the role players at the AIRAD and ENEMY workstations. The role player initiating the CAS mission requests the AD level along the flight path of the mission and in the target area. The opposing role player can allocate one of the following four AD levels: 0 - no AD; 1 - very low level concentration of AD systems; 2 - mid level AD systems; and 3 - heavy levels of AD systems and AD aircraft. Based on the information received the role player initiating CAS mission enters that level into the air support mission request. At the start of the mission the model degrades the close air support mission according to the level of AD protection. It is up to the role player to decide when in the mission the losses would have occurred. In the brigade enhancement Air Defense weapons will be assigned to the maneuver units. They will be fired like the direct fire weapons (air and ground targets) and they will be vulnerable to the normal battlefield attrition conditions.

Personnel and Logistics.

Equipment. The model is designed to process all battle damage resulting from direct fire, indirect fire and aerial delivered ordinance. Hit/kill data is stored for each unit until the attrition module is invoked. The attrition module only functions once every minute to simulate the "overkill" situation (where a piece of equipment is hit and damaged by one burst but may still appear as a potential threat to another firing unit and would be engaged again -- 'over kill'). Once the attrition module is invoked, each piece of equipment that has a "kill" recorded against it is assigned a random number to determine the type of equipment damage/failure. Depending on the number of kills recorded against a piece of equipment, up to six equipment failure types may be allocated to one piece of equipment. The most severe fault will determine that piece of equipment's operational status.

Personnel. The number of personnel casualties are calculated in much the same manner as equipment and a casualty type is assigned to each. Both equipment and personnel casualties are subtracted from the unit strength, and "time to repair" and "priority of treatment" assessments are made.

Non-battle casualties. Non-battle casualties are automatically determined and applied hourly. They are based upon activity rates and mean time between failure calculations. When a piece of equipment is removed from unit strength, its fuel and ammunition holdings are automatically subtracted from unit totals.

Resupply. Resupply procedures are designed to exercise the player logistics staff. Resupply decisions made by the players are implemented at the PERSLOG workstation for blue forces, and at the ENEMY workstations for the red forces. The movement of resupply, reinforcement, recovery and evacuation elements are modeled the same as for maneuver units and they are vulnerable to enemy action, minefields and obstacles. In the current system, the PERSLOG station role player is responsible for reporting in detail all losses to the Maneuver workstations. In the US BBS system, this function will be automated with detailed reporting being made after loss adjudication is complete.

Additional Resources. For the brigade level exercises more data will be entered into the simulation at the time of initialization identifying the additional CSS units. The organization of the forward support elements varies, however these units will be modeled:

a) forward support maintenance company,

b) forward supply section from the S & T battalion,

c) a medical company,

d) maintenance support contact teams from the division's heavy maintenance company,

e) an ammunition transfer point,

f) a missile support company,

g) a forward support platoon from the transportation aircraft maintenance company,

h) elements of the supply and transport battalion motor transport company.

These units will be controlled by the role player at the PERSLOG workstation and they are subject to the same maneuver and vulnerability constraints as the maneuver units. All classes of supply, except VI & X, will be modeled within the simulation. Class III (fuel), V (ammo) and VII (major end items) will be modeled and tracked in detail. Class III and IV will be treated as bulk.

Damaged equipment and major end item repair and return to combat functions are modeled at the brigade support area based on player directed plans for the recovery and evacuation of these assets. Without careful planning and detail execution of these plans, repair work will not be carried out.

Air resupply by helicopter, ammunition supply rates (ASR), required supply rates (RSR), controlled supply rates (CSR) and supply points & unit distribution will be modeled explicitly within the simulation. Field services, i.e., finance, mail, religious, legal, laundry, bath & clothing exchange and graves registration will NOT be explicitly represented in the simulation but are played in the planning.

Engineers. In the battalion level game, engineer missions of emplacing and clearing obstacles and mines are played at the HICON workstation. Players and Maneuver workstation role players coordinate with role players at the HICON workstation to implement the obstacles, mines and fortifications portion of the OPORD. For the brigade level exercises engineers will receive detailed play. An engineer company will be provided in direct support to the brigade (squad sized units can be modeled if tasks are organized in this fashion). Engineer missions will be limited by the availability of class II and IV supplies, the number & types of engineer missions required, and established engineer mission priorities. Engineer missions will include emplacing and clearing minefields, anti-tank ditches, wire entanglements, abatis, and road craters, and disabling bridges, and breaching obstacles and minefields.

To perform engineer missions the engineer units will have to be maneuvered to the site of the engineering task. Engineer units en route to perform missions are assigned the "displacing" OPSTATE and are vulnerable to the normal battlefield attrition conditions. Engineers can fight as infantry, subject to the same maneuver and vulnerability constraints as any other unit. Engineering units encountering obstacles during a move are delayed just as other units are until assigned the mission to clear the obstacle. An engineer unit will not be delayed by an obstacle or minefield that it is assigned to breach. The workstation controlling engineer missions will be able to add, display, edit and clear engineer missions. Engineer units can be controlled by either the HICON or AIRAD workstations depending on the anticipated work load. Once assigned to one station, only that station can control them until reassigned by HICON to a new mission.

Command and Control. Internal command and control is played within the exercised command group as it plans and executes the battle in accordance with its current Operation Order's and Standard Operational Procedure's. External command and control is played as the exercised command group interacts with subordinate, adjacent and higher units. Role players portray the appropriate personnel in those units. Reports and combat information will be passed to tactical units and the TOC as appropriate per unit tactical standard operating procedures (TSOP).

Reports. There are various informational outputs from COMBAT-SIM which help role players manage the simulation and/or support the command group's decision making process. The most prolific information outputs are the alert messages which generally answer the "who, what, when and where" questions during the conduct of the simulation. Alerts highlight important events within the simulated battle (such as detections, initiations of engagements, or low levels of combat supplies) and are grouped into routine, warning and critical alerts. What is considered critical will depend on pre-determined threshold variables which are set at initialization. Alert messages are provided automatically at the printer or on the interactor's monitor at each workstation. These alert messages serve as the necessary spot reports to the brigade or battalion command group. With the brigade enhancement more alert messages will be added to support the increased activity of CSS and engineer units. The level of resolution selected will determine the level of spot reports received.

Unit status reports are another major information output of the simulation. These status reports collate all relevant information on the unit including current posture, identification, location, MOPP, OPSTATE, speed of movement, suppression level, equipment, ammunition and POL on-hand. The status report is updated every 15 seconds and is available on demand at the workstations via the monitor or printer.

STAFFING THE SYSTEM

Critical to any successful training exercise is the staff needed to run it. As discussed earlier, the manual systems require large numbers of controllers to staff and run the exercise. Computerization of the training systems reduce those numbers significantly, but staffing is still a major concern.

The goal of any staffing plan is to do the job right with the minimum of 'overhead'. Key to achieving this goal is a clearly defined training objective obtained before the exercise is planned. Too often commanders don't spend enough time with their planning team defining specific objectives for his CPX. Leaving this to the controller staff will result in a general exercising of all aspects of staff planning. If the goal was a general assessment of the staff this is appropriate. However, if the objective was to work on previously discovered shortfalls the commander will miss the opportunity of really homing in on problem areas.

The old cliche, "people learn from experience" is in fact an incomplete concept. People learn by thinking about their experiences. The aim of a good training simulation is to provide participants with a realistic experience to think about. To do this, we must consider two things: the decision-making environment and the information flow. The environment will be discussed in the Facilities Section.

FACILITIES

Player Facilities. There are three different approaches to conducting command and staff exercises:1) classroom instructional exercises; 2) CPXs with the commanders and staffs in their command posts in the field or in the motor pool; or 3) CPXs with the commanders and staffs in mock-ups of their command posts in some garrison location such as a simulation facility. What ever the approach, a decision making environment must be created.

The decision making environment should be realistic; providing all the assets and liabilities of the facility that the commander and his staff will be working with under war-time conditions. If his command post is the back of a truck with a leaky canvas, kerosene lanterns and a generator chugging outside, then that's what he should get. Providing the players a high technology permanent site that looks like the National Command Center should be avoided. Elaborate does not mean better, only more expensive. The opposite is equally true.

Control Facilities. For the play of either a battalion or brigade exercise the control room should be sufficiently large to accommodate ten workstations, planning areas, a briefing / visitor area (must provide for briefing and de-briefing of player groups), administrative space for the permanent staff, and messing and latrine facilities.

COMBAT-SIM facilities must include environmental controls for the computer systems, adequate power with protection, work space and furnishings for the permanent and exercise staffs, and a work area for the system manager/engineer.

Most modern computer facilities provide for power filtration, humidity control, power surge protection, temperture control, electronic emmissions dampening, and high security. These same considerations are also appropriate for a simulation facility but can be modified depending on the level of classification applied to the exercises and the type of computer equipment used. 'Portable' systems like the Australian COMBAT-SIM are less suseptable to heat difficulties and small surge protectors are sufficient to prevent damage to the equipment. Larger microcomputers like those used in the US BBS system are much more sensitive and require a far more stable environment.

Time and dollars spent in preparing a facility properly will pay big dividends later through low maintenance costs, low down-time rates, and increased exercise success.

Conclusions.

Using traditional field exercise techniques, the costs associated with the training of commanders and their staffs can be very high. Fuel, ammunition, vehicles, equipment and soldiers all must be diverted from other tasks to support the training. In terms of dollars, it can run into hundreds of thousands; in terms of soldiers and equipment the numbers are even less encouraging. Tighter fiscal constraints portend even more focus on the training need for low-cost training solutions. COMBAT-SIM provides the solution.

COMBAT-SIM is a truly new and remarkable achievement in the area of distributed command and control training simulations. For the first time, technology has been developed that focuses on real time training of command and control skills. The simulation and design technique allow the introduction of situations not possible in peace time; and more importantly, require very little in preparation or field trooper support. Real dollar costs are substantially lower while the training effectiveness is significantly higher. COMBAT-SIM proves that not only can this training be achieved, but major new approaches to the teaching of doctrine are possible.

COMBAT-SIM affords the unique opportunity to provide a low cost, high technology training simulation, at the Battalion and Brigade tactical organizational levels, for training commanders and their staffs and is a very important factor in the molding and shaping of future military leaders.