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COMBAT SIMULATIONS IN U.S. ARMY TRAINING AND TESTING

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ABSTRACT

The U.S. Army has invested billions of dollars in new command and control (C^2) automation systems and communications for transfer of associated information. Testing of these new systems is a very costly process that can be significantly enhanced by using simulations. Training tactical units in command post exercises can also be significantly improved if they are integrated with "go to war" systems. This paper explains how U.S. Army constructive simulations have been applied to testing of and training with C^2 systems, through automated interfaces conceived and developed by Logicon, Inc., contractor to the U.S. Army Electronic Proving Ground.

1 BACKGROUND

The U.S. Army exercises and evaluates tactical operations through a conceptual framework of seven battlefield operating systems (BOSs), shown in table 1. The Army is developing and fielding the Army Battle Command System (ABCS) to provide C^2 automation to support these BOSs. The first five BOSs in table 1 are closely related to ABCS major component systems, and the sixth (mobility and survivability) is supported by the Engineer C^2 System, architecturally a subsystem of the Maneuver Control System (MCS). The last BOS in table 1, C^2, is the process in which each of the other BOSs is executed; that is, C^2 is the synchronization of all BOSs at each battle command echelon (e.g. at a division level), referred to as the Force Level Control System.

Through a combination of manual and automated processes, these BOSs are executed at each battle command echelon. From battalion through higher echelons, each BOS becomes more complex and is supported by staffs of increasing complexity and size that acquire information, plan, and direct subordinate units to conduct combat actions. Information on the tactical situation is communicated to each command post (CP), or operational facility of larger CPs, via oral, written or graphic reports exchanged through communications systems, radars, and intelligence sensors, or direct observation by commanders and staff officers. Many of these information sources can only be present in a full operational environment, which includes properly equipped enemy player units; this is resource intensive, almost impossible to represent effectively in peacetime. Hence the Army must simulate such a combat environment to achieve realistic and efficient training, particularly for the higher echelon battle commanders and staffs.

2 SIMULATIONS IN SUPPORT OF TRAINING

To evaluate the state of training of a battle command echelon (e.g., a mechanized division battle command and staff organization), player CPs are observed either during a field

Table 1: Relationships Between BOSs and ABCS Component Systems

Battlefield Operating Systems	ABCS Component Systems
(1) Maneuver	Maneuver Control System (MCS)
(2) Fire Support	Advanced Field Artillery Tactical Data System (AFATDS)
(3) Air Defense (AD)	Forward Area AD C^2 System (FAADC^2)
(4) Intelligence	All Source Analysis System (ASAS)
(5) Combat Service Support (CSS)	CSS Control System (CSSCS)
(6) Mobility and Survivability	Engineer C^2 System
(7) Command and Control (C^2)	Force Level Control System

training exercise (FTX), in which subordinate organizations participate in associated field operations, or a command post exercise (CPX), in which only the command, staff and selected signal units are engaged in the exercise. The fewer units involved, both friendly and enemy, the fewer resources and more efficient the evaluation of the command echelon, but the greater the challenge of realistically providing information on the tactical situation to the players.

2.1 Standard Training Architecture

For evaluation of a division and its maneuver brigade command echelons, controllers are employed above and below the player echelons providing tactical information as would be directed or reported by the next higher (corps) and lower (battalion) units. These controllers must be instructed on the tactical information to be provided to insure evaluation objectives are achieved. The earliest method of providing these instructions was through manually prepared and executed Master Events Lists (MELs), a time-phased scripting of required controller actions. However MELs require high labor resources in preparation and execution. They also lack training realism because they cannot be modified during the exercise to accommodate unexpected actions by the player units and cannot easily integrate actions and reactions of a live opposing (i.e. enemy) force.

2.2 Use of Simulations

Originating as analytical tools and improving in validity and responsiveness with ever more powerful computer technology, combat simulations were employed beginning in the late 1970s to facilitate training of commanders and staffs. Known as constructive simulations, such combat resolution models receive inputs of opposing (red) and friendly (blue) player actions, wargame the exchange in cyclic updates (i.e., every so many minutes), and produce outputs of combat resolution in terms of battle results (e.g. casualties, battle damage, front line trace).

When a constructive simulation is used to drive an exercise, enormous efficiencies are gained through elimination of MEL preparation and reduction in numbers of controllers. Training realism can be enhanced through employment of controllers serving as a live opposing force (OPFOR). For added training efficiency, the combat simulation can be operated at a location distant from the player units, connected only by tactical, strategic or commercial communications.

Figure 1 depicts the training situation described above, complemented with a constructive simulation as well as a live OPFOR. Controllers for constructive simulations are commonly positioned within a Battle Simulation Center

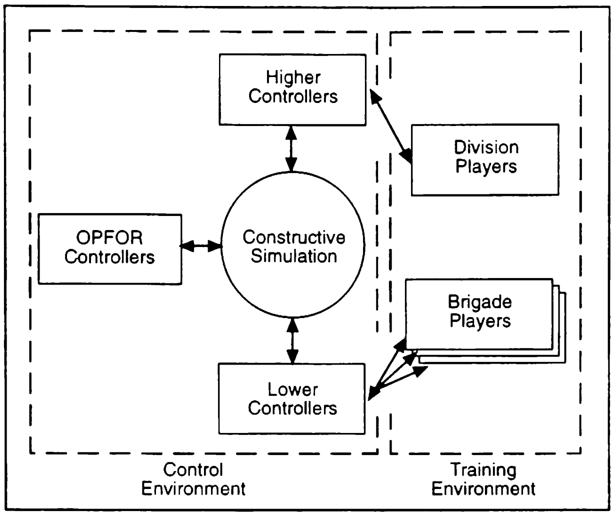

Figure 1: Simulation Supported Battle Exercise

(BSC), putting into the simulation their subordinate echelon actions and orders and reporting simulation outputs/results to the player units in their field locations.

For a division-level exercise, battalion-level controllers would normally maneuver company level units in the simulation and report results at the battalion level to player brigade Tactical Operations Centers (TOCs). OPFOR controllers are usually positioned in a separate area of the BSC, with the ability to interface directly to the simulation. To implement this concept, computer devices are required for interfacing between the simulation and controllers. Complementary simulations are frequently linked, particularly for the exercise of logistic systems.

By the mid-1980s, constructive simulations were used regularly for training by the U.S. Army, and BSCs were fielded at U.S. Army corps and division installations throughout the world. An entire family of simulations (FAMSIM) was established, and models have been continually improved in both realism and responsiveness. FAMSIM includes the Corps Battle Simulation (CBS) for employment from brigade through corps level, Brigade/Battalion Simulation (BBS) optimized for those two levels, Janus for battalion and below exercises, and supporting simulations: Combat Service Support Training Simulation System (CSSTSS) and, for intelligence support, the Tactical Simulation (TACSIM) and Battlefield Intelligence Collection Model (BICM).

3 SIMULATIONS IN SUPPORT OF TESTING

While constructive simulations were increasingly used to train battle commanders and staffs, tactical headquarters were targeted to receive increasing numbers and types of ABCS command and control automation systems that interoperate with communications, intelligence and other computer systems. Referred to collectively as C^4I systems, most were in stages of evolutionary development and fielding, requiring significant resources for operational testing, usually troop units in FTXs or CPXs.

3.1 Early C^4I System Testing

The earliest ABCS component systems (MCS and CSSCS) underwent tests based on MELs, but testers disliked the high labor intensity of preparing and executing MELs and their lack of training realism. Noting successful application of constructive simulations in the training environment, test officials directed that subsequent C^4I test exercises be driven by constructive simulation. In addition to being more efficient and realistic, this innovation provided a further technological opportunity. Since Logicon had been under contract to support testing of C^4I systems as well as development and operation of constructive simulations, our staff had experience to conceive the creation of automated exchanges between the combat simulation and the C^4I systems.

These interfaces, called Simulation Support Models (SSMs), were proposed to parse the simulation output into formatted C^4I system messages, and transmit these data into the appropriate point in the C^4I system. To a limited degree, the SSMs would take some C^4I system messages (outputs of the lowest and highest echelon blue players), parse into formatted simulation orders and automatically insert them into the combat simulation. Through these capabilities, Logicon proposed that the SSM interface would effortlessly create blue player activity of subordinate, lateral and higher units and even automated subsystems (e.g. radars) which are not actively being exercised.

3.2 SSM Development

Army officials at the Test and Experimentation Command (TEXCOM) and the former Army Tactical Command and Control System (ATCCS) Experimentation Site (AES) funded a proof of principle development because this approach offered resource savings in MEL preparation and execution as well as reduction of human errors. No longer would there be a need for numerous controllers, particularly at echelons below the player units for submission of bottom-up feeds into the players. An additional benefit was the creation of an audit trail for post hoc operational assessment. Data can be recorded for subsequent analysis of system "value added", such as comparing ground truth in the simulation with perceived truth in the player unit C^4I system.

In 1991, the first SSM was prototyped linking the U.S. Army's MCS and the Corps Battle Simulation (CBS), the official combat resolution model for tactical operations from brigade through corps levels. Although it does not portray all battlefield entities or events, CBS has provided sufficient volume and detail to successfully drive hundreds of brigade, division and corps training events since 1987. After successful use in MCS testing, further SSMs were developed for the CSSCS in 1992. By 1994, with additional funding from the Defense Modeling and Simulation Office (DMSO), SSMs were used in major interoperability tests for the five major components of ABCS supporting maneuver, fire support, air defense, intelligence and combat service support.

Because both MCS and the All Source Analysis System (ASAS) employ standard U.S. Message Text Formats (USMTF), one SSM supports both these systems, and one generic fire support SSM supports AFATDS as well as the systems it will replace. There is one additional SSM for CSS and another for air defense. In some exercises, intelligence play requires supporting intelligence simulations (TACSIM or BICM), which interface directly with CBS and hence need no SSM interface.

3.3 Database Synchronization

We have learned that the most complicated action required for simulations to support exercises is the creation and synchronization of databases for both the associated C^4I systems and the simulation. Most C^2 systems cannot operate without installation of an established database, and the manual creation of databases is labor intensive, time consuming and costly. As two and more C^4I systems were tested simultaneously, the need became increasingly apparent that databases of all C^4I systems had to be precisely synchronized not only among themselves, but also with those of the constructive simulation, as well as any of its feeder simulations (e.g. CSSTSS).

Not only do data elements need precise definition and description, essential in any computer system, but levels of data detail require the SSM to aggregate or de-aggregate detail to insure full congruence of databases. For example, some C^4I systems track general supply categories (e.g. cargo truck), others track by National Stock Number (NSN) or line item number (LIN), and still others require greater detail, such as lot numbers for ammunition. Hence effective use of constructive simulations as exercise drivers require all systems involved to have, at exercise start, precisely nested data that match actual requirements of the organizations and equipment of the player and notional units involved. During exercises, each exchange between simulation and C^4I systems requires data defined and parsed to the appropriate level of detail. The SSM performs this type of transaction thousands of times for each report cycle and each unit portrayed in CBS, thus decreasing the potential for data mapping errors and delays in processing times if this were performed by controller personnel.

To simplify this effort, Logicon has developed a database populator tool that crosswalks the Unit Task Organizations (UTO) and Order of Battle (OB) with data in the Vertical Force Accounting System (VFAS), the Commander's Tracked Items List (CTIL), approved unit planning factors, and CSSTSS data. Additional information is provided in both automated and semi-automated means from the unit or test organization. Using a combination of electronic feed and manual input of data between CBS and the C4I systems, the data is synchronized prior to the start of the exercise. This database populator tool automates what would otherwise be a burdensome, manual process of determining, synchronizing and loading databases of both the C4I and simulation systems.

Logistics data is the most voluminous, and the CSS SSM maps the CBS data to data in both the C4I system (CSSCS) and a supporting logistics simulation (CSSTSS). Because CSSTSS does not portray some logistics information required by the CSSCS (e.g., unit-level resource data), CSSTSS information provided to CSSCS is supplemented with additional information from the CBS itself through the SSM, including data for food, fuel and ammunition resources on hand. The SSM uses CBS and CSSTSS as its simulation components. CBS unit data are de-aggregated and reformatted using a variety of tools to provide the appropriate message flow for each C4I system. CSSTSS unit data mirrors CBS unit data. Through the SSM, CSSTSS provides to CSSCS Class I, II, III, V, and IX at the supply points, and data for Class VII, maintenance and personnel assets in units.

3.4 Architecture

Figure 2 shows the comprehensive picture of how simulations support testing or training with relationships among all the components described earlier. On the right side of the figure, player units in field CPs are employing C4I systems driven by constructive simulations (CBS and CSSTSS). These are both influenced through SSM and controllers using CBS workstations. All data is synchronized not only at exercise start, but continually throughout the exercise.

It is important to note that no changes to the core CBS models or algorithms need to be made for SSM activities. The SSM interface software uses the standard CBS software package as delivered by the U.S. Army National Simulation Center (NSC). The SSM establishes CBS unit databases and task organization, model input orders if required, and utilities to extract information from CBS databases and messages. The information extracted is loaded into high resolution databases and used to generate messages transmitted as manual output to controllers or electronic data to the C4I systems.

4 THE SSM IN SUPPORT OF TRAINING

Initially CBS and SSMs were used in technical testing of C4I systems, and these tests normally involved, as C4I system operators, either technicians or soldiers borrowed from troop units. However, when full scale operational tests began with troop unit commanders and staffs, officials realized that there were additional training benefits, because the CBS with SSMs:

- Permits player units to "train as they fight", allowing them to take precisely the same C^2 actions as they would in actual combat and avoiding "swivel chair" interfaces between simulation and C4I systems.
- Creates more realistic training through automated displays on C4I systems of such data as real-time air tracks and counterfire radar returns.

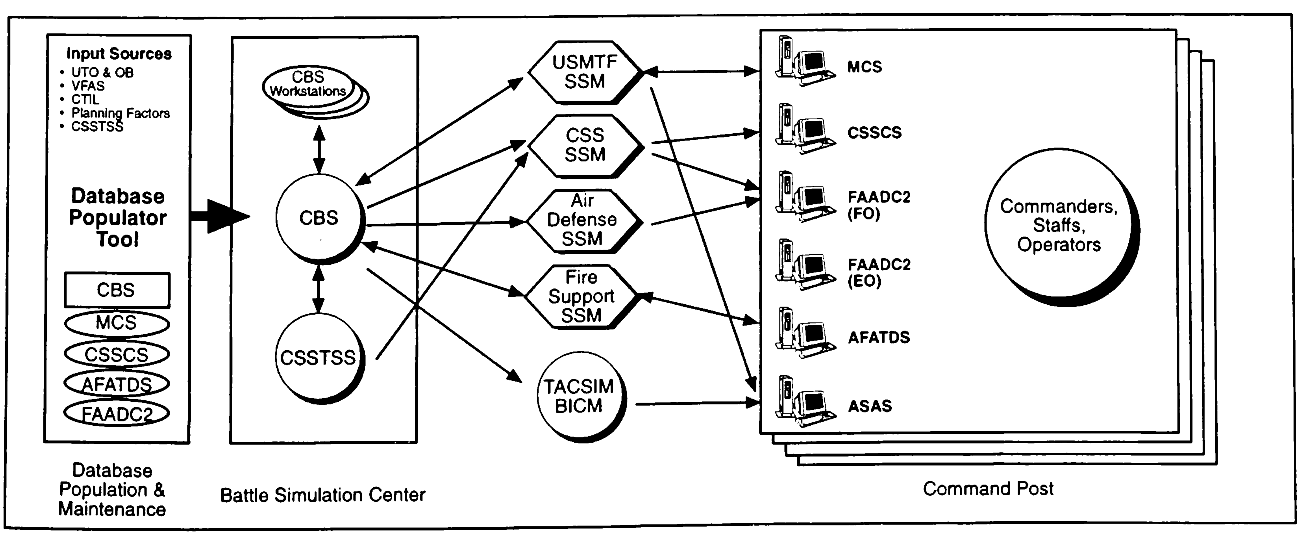

Figure 2: Simulation Supported Training and Testing

- Facilitates multi-echelon training. For example, in a division exercise, maneuver units could play down to battalion level (two echelons), but artillery and support commanders could play down to only one echelon, division artillery (DIVARTY) and division support command.
- Frees soldiers for training who would otherwise be filling increased controller requirements.
- Enhances interoperability of C^4I systems when all use synchronized databases.
- Allows troop units to participate in simulation-driven joint exercises through linkage of the SSM to the Joint Confederation of Models.
- Permits flexibility in exercise architecture by replicating simulated operational units.
- Induces greater user acceptance of C^4I systems by showing staff and commanders the benefits of the systems on live exercises.

5 FIRE SUPPORT TESTING AND TRAINING

To fully exercise the fire support BOS or to test the AFATDS automation system, all the type units in figure 3 would have to be fielded and replicated in full to assure sufficient loading and exercise of the fire support system. Consequently, test or training organizations employing AFATDS in conjunction with other ABCS component systems would have to field large formations of soldiers and equipment to generate the input necessary for evaluations of artillery units or the utility of AFATDS itself. (If field artillery units are exercised without other ABCS component systems, the Fire Support Automated Training System (FSATS) can be used for AFATDS stimulation.)

5.1 Fire Support SSM Utility

The fire support SSM stimulates AFATDS, in near real time, by transmitting CBS-generated resource and update messages, causing AFATDS to compose and transmit messages needed for data collection and analysis. The SSM accepts orders to fire artillery and inputs those orders into CBS for execution for all CBS-fired ammunition types.

In figure 4, all the elements from figure 3 which are depicted in clouds are represented by the fire support SSM, which receives CBS outputs of resources and other update messages and formats them into resources and messages, causing trainer/tester AFATDS systems to compose and transmit messages to player AFATDS systems. The fire support SSM can replicate those echelons and automated systems that would provide information to AFATDS

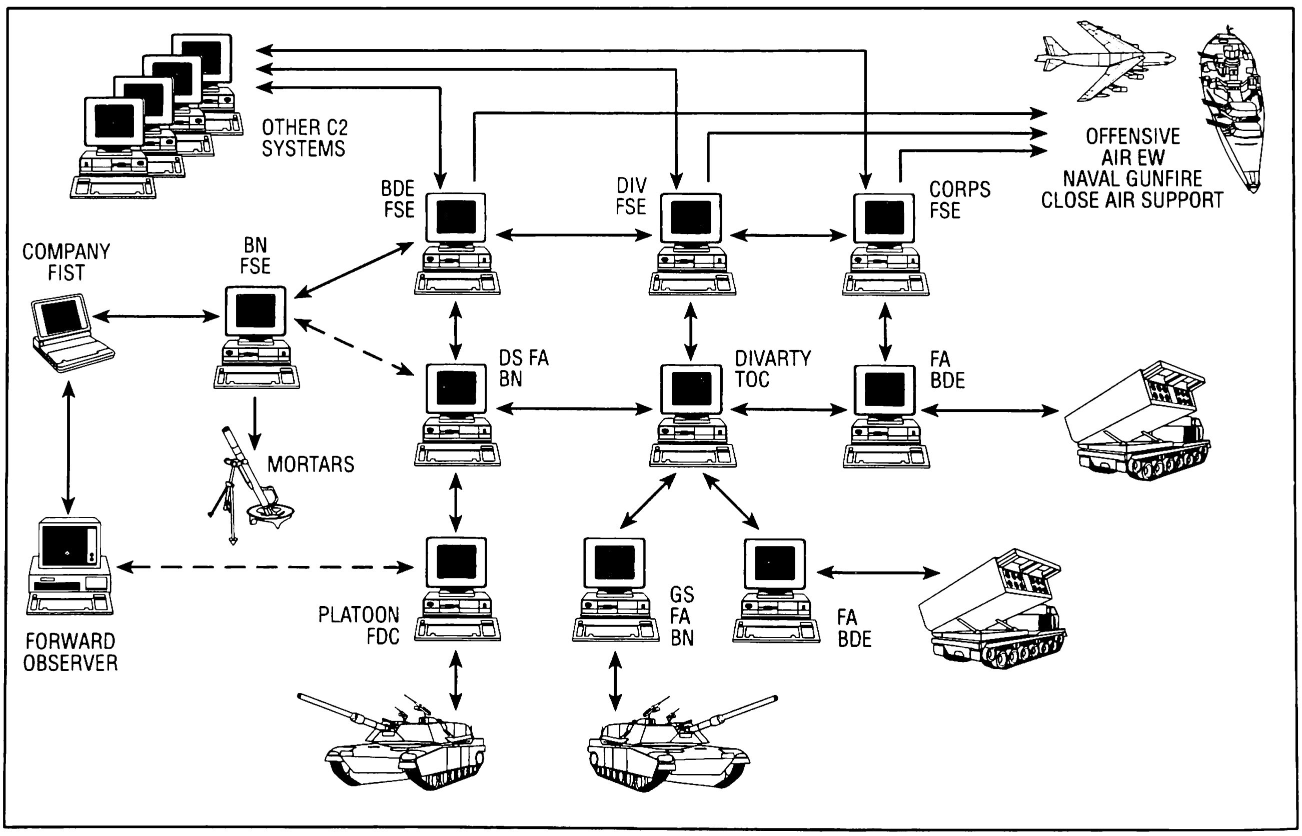

Figure 3: AFATDS in Tactical Employment

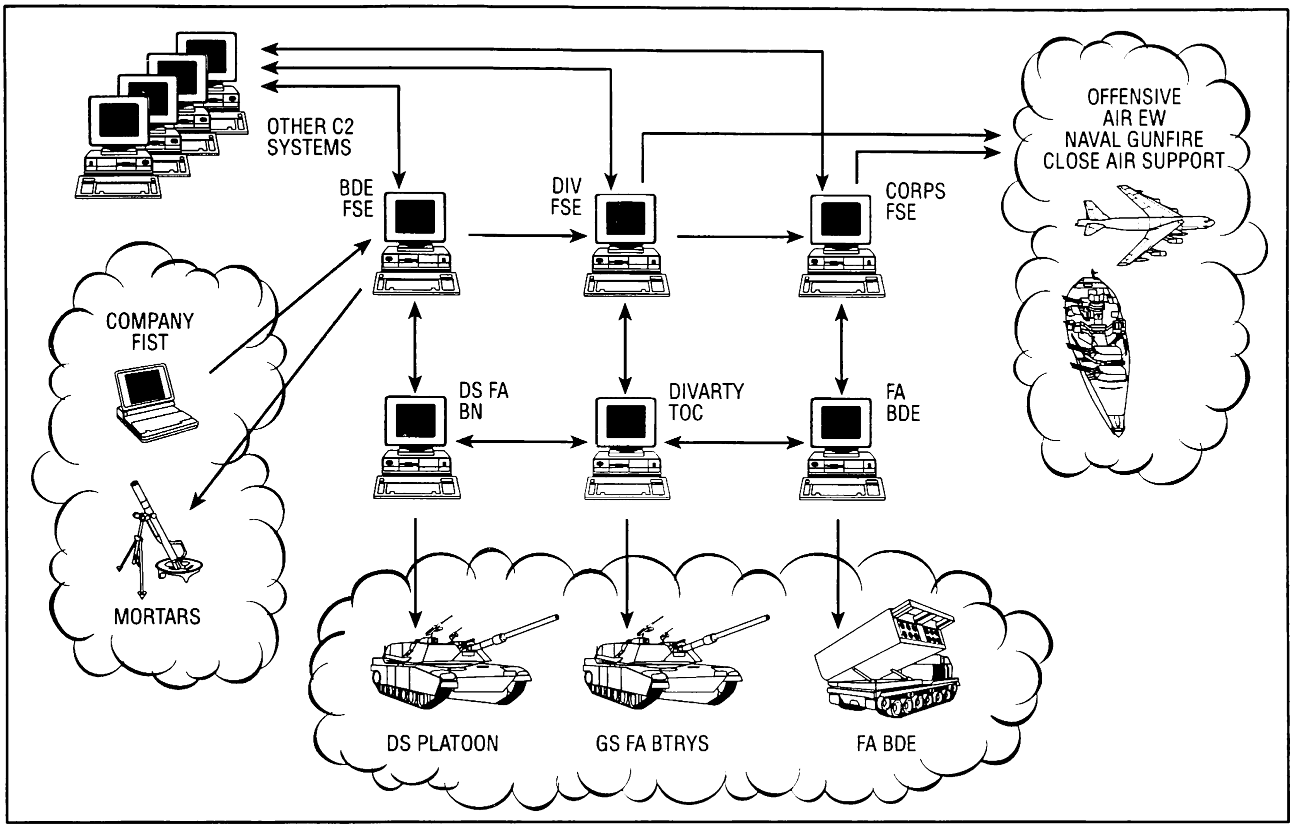

Figure 4: Fire Support SSM Employment

during tactical operations. These include computer systems within batteries and platoons, artillery and mortar forward observers using digital message devices, and the AN/TPQ 36 and TPQ 37 counterfire radar systems.

5.2 Fire Support SSM Functions

As one detailed example, when tracked CBS maneuver units (simulated, not player units) become engaged in combat, the SSM automatically generates a fire request as would be done by a forward observer accompanying the engaged unit, and transmits that fire request to the lowest responsible Fire Support Element (FSE) being played in the exercise. (Units become engaged through embedded CBS decision rules considering such factors as proximity to the enemy, intervisibility, enemy firing and weapons ranging.)

The FSE player, using AFATDS, receives the fire request precisely as though a live player had transmitted it, and makes disposition of the fire request. If the FSE approves it, he forwards an appropriate fire order via AFATDS to the direct support (DS) artillery battalion. Using their AFATDS, battalion players select a fire unit, compute a firing solution, and transmit the order to a subordinate battery; any of these steps after the FSE can be replicated by the SSM. When the SSM receives the order, it translates the fire order into a CBS input message, then injects the message into CBS for execution. Fire is promptly emplaced on the prescribed coordinates, and CBS attrits any enemy located at that position in the CBS. The SSM registers returns from the in-flight artillery rounds on enemy counterfire radars if they are active in the simulation and directed to the air corridor through which artillery rounds pass.

After the combat resolution cycle in which the mission is fired, the SSM decrements the firing unit's ammunition stock and captures the CBS message containing battle damage assessment and munitions expenditures. If this had been an "observed" fire mission, the SSM automatically extracts the battle damage assessment, formats it into a standard message and sends it to the FSE player, who will then act to end the fire mission by so notifying the artillery battalion. When they receive an end-of-mission order from the FSE, the artillery battalion staff terminates the mission with the firing battery, which in turn sends the doctrinal mission fired report to the battalion.

5.3 Fire Support SSM Stimulation

The fire support SSM provides the following stimuli to AFATDS:

- Tactical communications connections

- Doctrinal network architecture
- Requests for fire from observers and radars
- Movement updates for all artillery unit types
- Ammunition status for cannons, missiles
- Reports on incoming enemy fires
- Mission-fired reports
- General, unformatted unit status information
- Orders to fire for simulated fire units
- Battle damage assessment from observed fire

6 SSM EMPLOYMENT

The SSMs have been used on all ABCS system confidence demonstrations and interoperability tests for the past two years. In addition, they have been used by the Command and General Staff College (CGSC) during Prairie Warrior 94, 95 and 96, by the U.S. Army Forces Command during Roving Sands 95, and by 1st Cavalry Division during training exercises. This is a significant amount of usage because AFATDS and CSSCS have thus far only been fielded to the initial units that participated in system testing.

In addition, the AD SSM has been used by several corps air defense artillery (ADA) brigades and every divisional ADA battalion which has thus far been fielded the $FAADC^2$ system. Troop units appreciate the realism of live tracks displayed to system operators just as the tracks would be received from active radars and aircraft, but stimulated from relevant air activity in CBS.

The U.S. Army Battle Command Training Program (BCTP) has initiated efforts to integrate SSMs into its warfighter exercises, which are training evaluations of U.S. Army division and corps battle command organizations.

7 ONGOING INITIATIVES

At the Fort Lewis Field Office of the Electronic Proving Ground (EPG), work continues to refine these SSMs and insure compatibility with updated software versions for both the simulation model and the C^4I systems, since all these systems are in evolutionary development. Additionally, a feasibility study is underway, funded by EPG, for determining costs and benefits of similar interfaces to the Janus simulation, used at the lower Army command echelons.

Though interfaces between C^4I systems and constructive simulations have been enormously successful in the testing environment, exploitation lies ahead in the world of training. As units become equipped with increasing numbers and types of C^4I systems, U.S. Army field commanders will appreciate the training benefits cited above. They will likely encourage fulfillment of training materiel requirements for extensions of these interfaces among all available exercise drivers and C^4I components of the ABCS. Field commanders will no doubt also demand extension of SSM downward into virtual simulations such as tank crew trainers, and upward into Joint C^2 systems and constructive simulations. Further, a Logicon independent development project has served as proof of principle that these SSM interfaces can be extended into the U.S. Army Standard After Action Review System (STAARS), thereby enhancing training evaluations of C^4I -equipped units participating in the BCTP.

The SSMs provide troop units with an inexpensive stimulus for sustainment training for commanders, staffs and system operators. We foresee that the U.S. Army will soon direct that existing SSMs be documented for fielding to BSCs for easy access by supported troop units.

In Spring 1996, the U.S. Army awarded to Loral corporation a contract for development of WARSIM 2000, the eventual replacement of CBS and other FAMSIM models. Included in the WARSIM concept are interfaces to C^4I systems, like the SSM described herein, and automated interfaces to After Action Review Systems; some WARSIM work will be executed by Logicon as a subcontractor to Loral.

On a broader scale, the DMSO has an initiative underway to develop modular reconfigurable C^4I system interfaces among simulations and C^4I systems of the several U.S. armed services, and Logicon is also expected to be involved in this effort.

AUTHOR BIOGRAPHIES

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