INTEGRATING EXERCISE CONTROL AND FEEDBACK SYSTEMS IN DIS

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Trainers for collective exercises control the exercise by manipulating mission, enemy, terrain, troop, and time (METT-T) situation variables to support a training or exercise objective. The feedback system must then examine the performance of a unit as a function of the evolving METT-T situation. Integration of exercise control and feedback functions is necessary to reduce and simplify the workload of trainers and to make sure exercise control and feedback systems are mutually supportive. Integration is especially crucial in the Distributed Interactive Simulation (DIS) environment for two reasons. First, efficient use of training resources requires substantial temporal overlap and competition between exercise control and feedback functions to provide rapid feedback. Second, the exercise control function expands to include controlling the behavior of enemy and friendly computer generated forces (CGF). This paper describes current problems integrating state of the art exercise control and feedback systems in the DIS environment and presents potential solutions requiring research and development.

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The objective of a collective exercise may be to train a unit to perform a collective task or to assess the effects of doctrinal, organizational, training, materiel, leadership, or personnel interventions on unit performance for research, development, and acquisition (RDA) or advanced concepts requirements (ACR) efforts. Measurement of unit performance is accomplished by a feedback system that assesses how well a unit reacts to the situations that confront it. The job of the exercise control system is to support the feedback system by creating the situations calling for the collective behaviors to be examined and by making sure measurement is accomplished in an efficient manner.

In the case of an Army unit, the collective tasks to be performed are described in the Mission Training Plan (MTP) documents that have been prepared for each unit type and echelon. Also for Army units, the situations calling for collective task performance are generically referred to as mission, enemy, terrain (and weather), troops, and time available (METT-T) situations.

Exercise control includes every action taken to control the METT-T situation presented to a unit at the beginning of an exercise as well as monitoring and adjusting changes in the METT-T situation during an exercise. Exercise control functions are accomplished by developing an exercise scenario, controlling the behavior of forces playing the role of enemy and supporting friendly units., aiding the simulation of weapons effects , and communicating with units. Exercise control can include such diverse actions as selecting a route for a unit movement, developing orders and graphics, testing and refining a scenario, giving orders to an opposition force (OPFOR), damaging or destroying enemy or friendly forces through the simulation of weapons effects, providing a unit with intelligence data intended to key a response on the part of the unit, issuing a fragmentary order to a unit being trained, or terminating an exercise early when it becomes apparent that the unit is not ready to attempt further tasks.

Regardless of the purpose of an exercise, an After Action Review (AAR) is a critical component of the feedback system. The AAR is an interactive process in which exercise participants discuss mission planning and execution under the guidance of a leader (Scott, 1983). The starting point for the AAR is normally a description of the unit's plans for the mission followed by a discussion of what happened during the mission (Department of the Army, 1993). The goal of the AAR process is to help units discover what they did, why they did it, and how to improve future performance. The AAR process is facilitated by aids such as data displays showing what happened during an exercise and aids illustrating alternative courses of action.

The feedback system defines the goals of exercise control, and exercise control makes feedback possible. In practice it is difficult to integrate exercise control and feedback, because these functions compete with each other for the time of trainers, exercise directors, and exercise staff. As we move into the distributed interactive simulation (DIS) environment to support collective exercises, we increase the degree of conflict between exercise control and feedback functions. This paper describes the integration problems in the DIS environment, identifies ongoing efforts that help to alleviate these problems, and suggests additional courses of action.

INCREASED INTEGRATION PROBLEMS IN THE DIS ENVIRONMENT

The networking of simulators provided a new environment for the conduct of unit exercises (Alluisi, 1991). Entities are capable of interacting by sending data on their status, position, and other pertinent information to other entities over a network in the form of protocol data units (PDUs).

Exercise control functions can be especially demanding in the DIS environment. One of the many benefits of using DIS is that exercise costs can be reduced by using computer generated forces (CGF) to play the role of enemy forces and supporting friendly forces. This feature reduces the turn around time between exercises as well as reducing the cost of each exercise. Controlling the behavior of these forces requires interacting with a work station to program the behaviors of the CGF prior to the start of the exercise, and it involves initiating or modifying behaviors of the CGF during an exercise. Due to the fact that part of the friendly forces are CGF, the trainer must take on the duty of simulating the role of leaders of sister units by passing on appropriate information through radio communications.

Another benefit of DIS is that it supports the play of a wide variety of enemy and friendly weapon systems, creating a richer environment in terms of the METT-T variables that can be manipulated. Many of these systems may be implemented by the exercise staff using a CGF workstation, such as when the staff provides a close air support mission in response to a unit's request. Using the capability to simulate weapons effects adds to the duties of the exercise staff

, because decisions have to be made regarding how these weapons effects might influence the objectives of an exercise. Many of the exercise control decisions may have to be made very rapidly during exercises as units request different types of supporting fires.

Another benefit of DIS is that it provides an electronic data stream that can support the AAR process. This data stream can be used to replay portions of the exercise, and it can be used to prepare a variety of graphs, tables, and other types of data displays. To take advantage of the data stream the trainer must analyze the performance of a unit, decide which data displays should be used to support an AAR and create these aids. An integration problem arises from the need to perform these feedback tasks at the same time the exercise staff is busy performing exercise control functions. For example, at the Fort Knox Mounted Warfare Simulation Training Center, the goal is to start conducting AARs within ten minutes of the end of an exercise. Such prompt feedback is needed to take advantage of the quick turn around time between exercises and to make effective use of the time of exercise participants.

TRENDS SUPPORTING INTEGRATION

The software systems supporting exercise control and feedback functions are in transition. In addition, both types of systems are being influenced by the Army's effort to improve unit training under the Warfighter XXI program.

Improved CGF

A key variable in determining how much effort is required to control a CGF is the extent to which the behavior of a CGF is directly sensitive to the METT-T situation. For example, a comparison between Modular Semi-automated Force (ModSAF) Version 1.2 and Semi-Automated Force (SAFOR) Version 4.1.3 included a test where tanks representing each
Another trend in CGF evolution is the addition of displays that help the exercise staff to monitor the activity of the CGF . For example, ModSAF Version 1.5.1 made it possible to call up a display showing the field of regard for a specific vehicle by selecting that vehicle when viewing the ModSAF Plan View display. This information might be used by the staff to move a CGF vehicle to a location that increases or decreases the possibility that two forces will make contact at a particular point in the scenario. This enhanced monitoring capability is most likely to be used when testing and refining exercise scenarios. It is unlikely to be used to adjust the METT-T situation during an exercise, because of the time required to implement changes in CGF positioning and behavior; however, a more

type of CGF crossed the same terrain using the same route (Meliza and Vaden, 1995). The SAFOR tank drove at the same speed for ninety-eight percent of the test period showing little or no sensitivity to slope and other terrain variables influencing speed, while the ModSAF tank drove at a wide variety of speeds. To provide realistic movement speeds for CGF vehicles would require greater effort for a trainer using SAFOR in comparison with one using fModSAF.

An important long term goal of CGF development is to provide more intelligent CGF (Brooks, Dymond, & Sandmeyer, 1996). Without an intelligent CGF the exercise staff is forced to continually intervene and adjust the behavior of the CGF. Quite simply, a more intelligent CGF is one which is better able to analyze the METT-T situation and act upon the results of this analysis. An example of intelligence from Version 1.5.1 of ModSAF is the ability of a ModSAF platoon to automatically increase its speed when indirect fire impacts within fifty meters of any vehicle in the platoon, then to slow down when a certain number of minutes passes without receiving indirect fire (Loral, 1995). This sensitivity to indirect fire removes the need for exercise staff to increase and then decrease the speed of movement.

The CGF being developed as part of the Close Combat Tactical Trainer (CCTT) places emphasis on the development of an intelligent CGF (Brooks et al,, 1996). Implementing a more intelligent CGF required developing an extensive database describing the behaviors required to perform specific collective tasks in greater detail than that found in current MTP documents. The information from this database, referred to as the Combined Arms Tactical Trainer (CATT) Task Database, is being used to prepare combat instruction sets that guide the behavior of the CCTT CGF.

Improved CGF Data Displays

intelligent CGF would make it more practical to introduce changes during exercises.

The data displays might also be used to support the feedback function. For example, information about the field of regard might be used during feedback sessions to show how well a unit was positioned to observe likely routes of advance for the enemy.

Automating the AAR Aid Preparation Process

The trend towards automating the preparation of AAR aids is represented by the Automated Training Analysis and Feedback System (ATAFS), a system designed to support AARs within ten minutes after an exercise ends (Brown et al., 1955). ATAFS meets this objective by giving exercise staff the capability to move back in exercise history and manually create data displays while an exercise is in progress and by using a knowledge database to guide the automated preparation of AAR aids.

The two most important decisions feeding automated AAR aid creation are the selection of the type of aid and the identification of the beginning and end of the period to be covered. For example, the exercise staff may want to use a Battle Flow display tracing movement of a unit to show excess movement and wandering as a unit withdraws to an alternate battle position. The trace might begin when the first vehicle leaves the initial position and end when the last vehicle arrives at the new location. The interactions with ATAFS required to create aids manually and automatically can be illustrated using Figure 1.

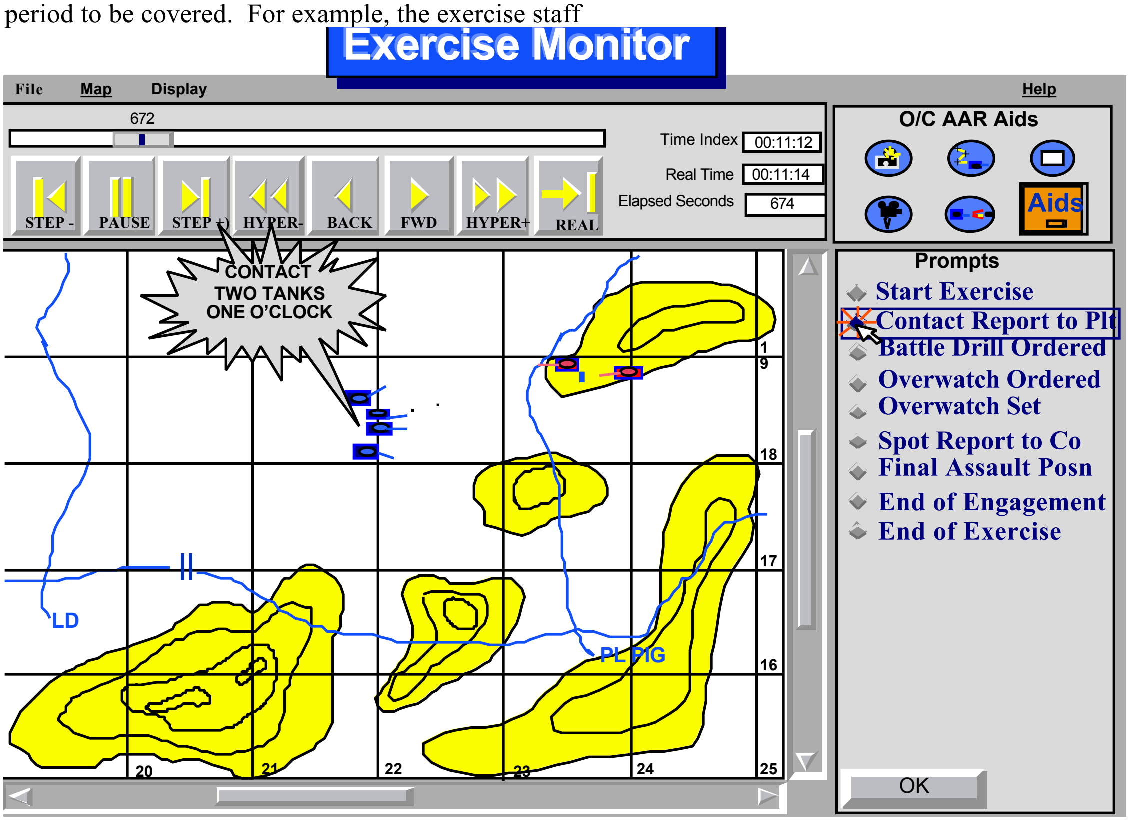

Figure 1. ATAFS screen used in creating AAR aids.

During the exercise, the staff can move back in exercise history using the VCR-like controls at the top of the screen. The staff can define the beginning time for an aid, by selecting one of the icons representing AAR aid types at the top right hand portion of the screen. The staff can then define the ending time by selecting the icon a second time. In the case of an animated plan view display, the aid created in this manner would be a replay with synchronized radio traffic covering the period of time selected by the user. The operator can return to real time by again using the VCR controls. While the user is creating aids manually during an exercise, the ATAFS continues to collect exercise data but the user cannot use the system to see what is happening in real time.

For AAR aids that are generated automatically the triggers are tactical events measured by the ATAFS (e.g., deciding that a unit has crossed a particular phase line) and events observed by the user (deciding that a platoon has reported contact to the company commander). The contribution of the staff to automatic AAR aid generation is limited to reporting when specified tactical events occur by selecting from a menu of prompts at the far right side of the screen. These events are of a type that can easily be identified by a subject matter expert, but which a computer could be programmed to identify only with a great deal of effort.

The AAR aids generated automatically by the ATAFS include a description of the tactical events defining the beginning and end of the period covered by the aid (e.g., from unit crossing the Line of Departure until contact is established with the enemy). These aids also include questions that can be used to guide discussions concerned with deciding what happened, why it happened, and how to improve future performance.

Digitization of Command, Control, Communication, Computers, and Intelligence (C4I) Capabilities

Given the improvements in unit performance associated with digitization of C3I (Du Bois & Smith, 1991; Leibrecht et al., 1992), the Army plans to move towards replacing voice traffic on the radio with digitized messages. We expect future systems like the ATAFS to support automated analysis of message traffic, removing the need for the exercise staff to respond to screen prompts addressing communications events. This digitization will also remove the need for the trainer to use radio traffic to simulate conversations with friendly CGF, if the CGF are given the ability to provide digitized messages.

Even with the digitization of C4I there will still be a need to capture certain types of trainer observations. For example, the most direct means for deciding when a unit has broken contact with the enemy is to have a subject matter expert make this decision.

Training Support Packages (TSPs)

The increasing workloads associated with exercise control and feedback are being addressed, in part, by the Army's move towards structured training. As part of the Warfighter XXI effort, the Army plans to employ Training Support Packages (TSPs) to support training on collective tasks.

The TSP concept has been demonstrated within the Virtual Training Program (VTP) at Fort Knox where exercise tables have been developed for armor platoon, company team, and battalion task force level exercises in the simulation networking (SIMNET) environment (Hoffman, Graves, Koger, Flynn, & Sever, 1995). These tables have been made largely turn-key in nature by incorporating structured scenarios, planning documents (orders and graphics), and CGF scenarios programmed for ModSAF Version 1.0. The availability of libraries of TSPs greatly reduces the time required to plan and prepare for DIS exercises.

VTP Table versions were created to provide variations in difficulty levels so that the specific exercises assigned to a unit can match the proficiency level of the unit. Matching the difficulty of the METT-T situation with the proficiency of a unit provides a more efficient feedback system by avoiding collective tasks likely to be beyond the competency of a unit.

The use of TSPs also makes it easier to develop turn-key AAR systems, due to the lessons learned about likely performance problems at various levels of proficiency made possible by having many different units execute the same scenarios. It should not be too surprising that input from VTP trainers has been sought and provided regarding ATAFS AAR aids.

Standard Army After Action Review System (STAARS) Concept

The STAARS concept calls for a three tiered approach to providing AAR aids (National Simulation Center, 1996). Tier 1 is a turn-key system that will provide the user with the AAR aids for a specific exercise. Tier 2 will provide the user with a menu of potential AAR aids like the ATAFS system described above does . Tier 3 will help users to create their own AAR aids.

The STAARS Tier 1 system will reduce greatly the effort required to prepare and use AAR aids. The goal of creating a Tier 1 system is made more attainable by the standardization of exercises through libraries of TSPs.

ADDITIONAL WAYS TO SUPPORT INTEGRATION

Enhanced Collection of Exercise Control Data to Support Feedback Functions

The AAR systems make use of data collected from the network data stream to describe what happens in an exercise, but the data stream does not provide all of the information needed to explain what happened. There are many important exercise control events that are not broadcast over the network.

ModSAF and CCTT SAF both contain internal databases with information that might be used to support performance measurement. In the case of ModSAF, this information is contained in the persistent object database (POD), while in the CCTT SAF, this information is contained in the SAF Entity Object Database (Brooks et al., 1996). This information includes the time when a CGF entity detects, recognizes, and identifies enemy entities.
We must make sure that these data are collected and made available to the feedback system.

Much of the information of potential utility to the feedback function that is not carried over the network is displayed in the form of status messages on the screens of CGF workstations. For example, when a ModSAF entity identifies an enemy tank, that information is presented on screen. Certain of the messages displayed in the ModSAF message log are saved in the POD, while others are not. There is a need to compare the data displayed with that saved to the POD to make sure useful feedback data are not being lost.

The information that is currently internal to a CGF might be made available to a feedback system in two ways. First, the CGF might be programmed to transfer files containing information from this database to the feedback system. Second, the CGF system might use the DIS network protocols to send information over the network in the form of PDUs (Institute of Electrical and Electronic Engineers, 1993). For example, when a CGF first detects enemy forces, the CGF might send an Event Report PDU providing such data as the location of the CGF entity having line-of-sight with the enemy element, the location of the enemy element, and the time of the detection.

Another important source of information concerns interventions made by trainers when serving exercise control functions. For example, when a unit has been in a halt position for a long time during a movement to contact exercise, the trainer may try to get the unit moving by placing artillery on the unit's location or by playing the role of a higher headquarters and ordering or pushing the unit to continue its movement. These interventions need to be documented to provide the information needed to interpret the network data stream, but exercise control and feedback systems do not currently collect this information.

Reduce Hardware and Software Conflicts

Appreciation of problems integrating exercise control and feedback systems increased when the ATAFS was introduced into the Fort Knox VTP environment. In the VTP, a two person team is responsible for operating the ModSAF, performing other exercise control functions, and preparing and presenting feedback for platoon level exercises. Prior to the introduction of the ATAFS, a ModSAF data logger, plan view display, and associated out-the-window view of the battle were the tools used to support both exercise control and feedback. That is, the feedback displays were limited to replays of the action from a plan or out-the-window view.

The first integration problem concerned duplication of effort loading unit control measure data. Data on the location, type, and names of control measures had to be loaded separately for ModSAF and the ATAFS AAR system.

The second integration problem encountered concerned using the ATAFS to monitor radio traffic. Due to the fact that the ATAFS processes information as it received and before it is played over a speaker, visual and auditory displays tended to fall behind real time. This delay could result in exercise control problems if the trainer was not responding to radio messages in a timely manner. The solution to this problem was to turn down the volume on the ATAFS and let the trainers use their normal exercise radio network for monitoring the exercise and communicating with the unit. This did not prevent trainers from using the ATAFS to generate AAR aids automatically, including the synchronized collection of radio traffic.

The third and most severe problem concerned the need to interact with two separate systems during an exercise. Although lead trainers in the VTP are not responsible for operating the ModSAF, they are responsible for monitoring the tactical situation and deciding when and how to intervene in the exercise. ModSAF entity status messages useful in performing this function are displayed on ModSAF screens. Further, the VTP trainers also prefer to use an out-the window view to monitor the exercise, and the ATAFS does not have such a view. The bottom line was that VTP trainers were expected to use three different display tools during the exercise, and the trainers chose to use those they considered to be most directly supportive of exercise control functions.

An additional conflict problem arises from the fact that the procedures for using the ModSAF differ from those for using the ATAFS for such common functions as zooming in on a particular location and changing time during replays. This lack of common procedures between exercise control and feedback systems results in an excessive operator training requirement.

One means of reducing conflict is to reduce the extent to which a trainer must interact with separate exercise control system and a feedback system. One group of VTP trainers at Fort Knox suggested putting ModSAF and the ATAFS AAR system on the same platform. This solution is not practical due to the substantial data processing loads associated with each of the exercise control and feedback functions. Fortunately, other methods are available that act in combination to reduce exercise control and feedback system hardware/software conflicts.

The Simulation Training Integrated Performance Evaluation System (STRIPES) AAR system has made progress integrating exercise control and feedback functions by porting the ModSAF Plan View to STRIPES. This action brought three benefits. First, it brought new analytical capabilities to the AAR system, because it included the capability to call up status information on individual entities. Second, it helped to avoid a situation where exercise staff must learn how to use two different plan views . Third, the STRIPES includes both a plan view and an out the window view.

Another approach being explored is to reassign exercise control and feedback functions between or among work stations in a way which creates a minimum of conflict. One specific example of this approach is to overlay the observations prompts from ATAFS on the ModSAF screen and then transfer these observation data to ATAFS at the end of an exercise to support the automatic generation of AAR aids. In this way, the user does not interact directly with the ATAFS work station during exercises.

SUMMARY

Exercise control and feed functions are linked by the METT-T situation; the purpose of exercise control is to make sure the METT-T situation supports the exercise objective, and the purpose of feedback is to assess the performance of a unit as a function of the METT-T situation. Exercise control and feedback are also linked by their competition with each other for the time of exercise staff.

The DIS environment increases the degree of competition between exercise control and feedback. The use of CGF adds many control duties during exercises, while efficient use of DIS requires pushing more AAR preparation activities into the exercise period.

As we move towards more intelligent CGF and add the capability for CGF to communicate directly with manned units, we free up the trainer from certain exercise control tasks. The Army's ongoing move towards providing libraries of structured scenarios and automation of AAR preparation under the Warfighter XXI program offers the potential of helping to integrate exercise control and feedback functions while reducing the trainer's workload.

Certain information developed within the exercise control function that can support the feedback system is not currently available to feedback systems. This information includes "cognitive" and "perceptual" activities on the part of the CGF, and it includes interventions made by the exercise staff that are not documented .

The move towards automation of AAR aid preparation has the potential to support timely AAR aid preparation without pulling exercise staff away from exercise control functions. At present however there are key tactical events that only a subject matter expert can reliably identify, so we cannot free the trainer from providing input to an AAR system completely during exercises. However, we might release trainers from the need to interact with both an exercise control system and a feedback system during exercises. For example, the ATAFS screen prompts might be ported to ModSAF and/or CCTT SAF allowing the exercise controller system to be used for collecting data on the time of key exercise events. These data could then be loaded into ATAFS after an exercise to support the preparation of AAR aids. Moving towards a digital data stream for communications will also allow more information to be provided by software.

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