DEVELOPMENTAL TESTS FOR ARTILLERY ENGAGEMENT SIMULATION

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ABSTRACT

Engagement Simulation (ES) has filled a training need for maneuver forces by realistically assessing casualties and by replacing fixed scenario exercises with free play interchanges where opponents' actual behavior determined exercise results. Artillery was not integrated into ES, however, and the goal of this research was to develop a realistic and inexpensive ES method for training artillery units. A computational system, which used the data actually set on the guns and employed standard fire direction equipment, was designed to select the probable impact point of artillery rounds. This meant that the behavior of artillerymen directly affected the placement of artillery simulators on the ground. Thirty-six simulated missions were "fired" by an artillery battery during a developmental test. Targets on the ground were assigned to a forward observer and simulators were placed based on the computed impact points. Feedback on mission effects was provided. Results indicated that the artillery system improved its speed and accuracy.

INTRODUCTION

Field artillery has presented very specific training problems throughout the history of cannon gunnery. These problems have become more acute in current times because of financial and spacial constraints. In years past, when there was a great deal of open land within the United States, there was generally no problem in obtaining enough space for live fire ranges. As the country has urbanized, range limitations have become severe. You need a great deal of land to fire a live artillery piece, and safety constraints prevent fire into areas where maneuver troops are training. The cost of ammunition also has escalated dramatically during the past decade, and this has led to a limited supply available for training purposes.

Due to the limitations in training ammunition and ranges and due to safety constraints, most of the field training within the US Army has been limited to dry firing exercises where men are required to go through the movements of operating their weapon without any potential for feedback as to the success or failure of their fired mission. Live fire is restricted to several exercises per year. The learning literature in psychology has emphasized the importance of knowledge of results in order to obtain performance improvement. You do not receive this knowledge by dry firing exercises, by gun drills, which involve just moving the dials on the weapons, or by displacement exercises, where you set up the weapon, perhaps dry fire, and then move the weapon to another location to see how fast you can do it. In this type of training environment, the only feedback that personnel receive is generally a critique of what they did wrong. There is no possibility for positive feedback. Simulation methods can be very advantageous in a situation where opportunities for "hands on" training through live fire have become increasingly rare and expensive.

A system has been evolved over the past decade for training combined arms (armor and infantry) forces. Engagement Simulation (ES) is the term generally used to label what amounts to a family of training systems. In the early years, ES focused upon the rifle squad and gradually was improved to include the platoon and the company-team organization. There are several major characteristics of Engagement Simulation as it has been used for maneuver forces. The first is weapons effect signature simulation which produced a simulated flash and bang for each weapon system similar to an actual firing. This provides feedback to the firer and cueing to his "enemy" which means that the firer has to take the same action that he would if he had fired at and revealed his position to an actual enemy. The next and perhaps the most important characteristic of ES is casualty assessment. This is a system for deciding who shall "live" and who shall "die" based upon very precise rules which credibly represent the actual effectiveness of soldiers' weapons. Finally, the characteristic which distinguishes ES from traditional field training is what we call the After Action Review. This is a participant interactive type of exercise which occurs after the field action and amounts to facilitating the communication between the two opposition forces. They can review the action and determine the effective and ineffective behaviors in a noncritical setting.

When ES was first developed, a method was required to simulate artillery to the extent necessary so that ground maneuver forces would know that it existed. The focus was on artillery from the viewpoint of the infantryman rather than from the viewpoint of the artilleryman. The method employed for maneuver forces was both basic and straightforward. An infantry commander, for example, would ask for artillery fire at a particular location; a fire marker control center (FMCC) would plot the location on a map and provide directions to individual fire markers.

They were told to go to the requested location and drop artillery simulators on the ground. The location to which they were sent was the same as the location where fire was requested. This was very unrealistic because it eliminated all effects of artillery processing time and the possibilities for error. These can be considerable, especially on the first round fired. This method did not involve any artillerymen except the forward observer, who if he was assigned to the maneuver commander, could request the fire missions.

The research problem was to develop a method to incorporate the field artillery firing system into an Engagement Simulation training program.

The Field Artillery System consists of three main elements. As previously noted, the forward observer is located with the maneuver units and has the task of calling for fire missions based upon the needs of the maneuver unit commander. He sends these calls to the Fire Direction Center (FDC), where computations are accomplished and the data is sent to the final step in the firing system, the gun battery. The gun battery sets the data on their guns and ammunition and fires the mission. The forward observer observes the incoming fire, makes his adjustments and sends this back through the system. This cycle is repeated until the rounds hit the target. In traditional ES, the FDC and the gun battery itself were not involved in any way.

The methodological problem generated by this research effort was how to get the gun battery and the FDC involved. A concept for solution was to develop a method of determining the terminal effects of the simulated round (the projectile fired from artillery), specifically to locate the most probable impact point of that round. This system had to be as realistic as possible, inexpensive, and implementable on the limited range space where units train most of the time at home station. Weapon signature simulation, which is part of maneuver ES, was not required for the purposes of involving the FDC or the gun battery. What we were most interested in was integrating the performance of people who are directly involved in the artillery firing sequence, so that feedback could be provided on the accuracy and speed of their performance.

METHOD

A standard artillery procedure was already available to provide the basic solution to our problem. This procedure is called replot and is used to determine the location of a target from the data (settings for the guns) that were computed by the FDC and sent to the gun battery. However, as used in standard artillery practice, replot is a relatively time consuming, iterative procedure. It was necessary to simplify this procedure and to acquire the data directly from the gun battery in an accurate and timely fashion. These data had to be sent to a control center, be replotted, and then be sent further forward to fire markers. They could then mark the target, not where fire was requested, but where the fire would have gone given all the inputs of the artillery system.

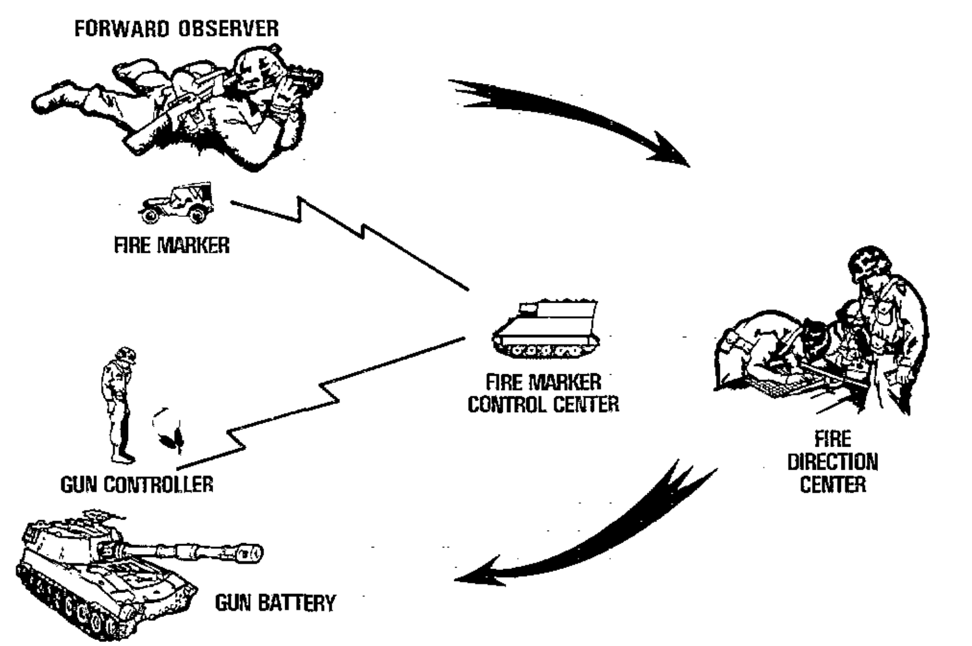

FIGURE 1
THE ARTILLERY ENGAGEMENT SIMULATION SYSTEM

Figure 1. Artillery Engagement Simulation System

The system that was developed is described in Figure 1. Each element of the artillery firing system has a corresponding element in an ES control system. The role of the fire marker, who is in the target area, is the same as it was in the traditional ES except that he is controlled by a fire marker control center (FMCC) which gives him directions based upon computations which will lead him to the most probable impact point. Fire markers are pre-positioned on surveyed points and given a direction and a distance which they can pace off or drive. They then mark their target using "flash-bang" simulators and retire to the closest surveyed point. The work of the fire marker essentially represents the terminal effects of the control system.

Prior to the fire marker ever getting any instruction, the system is driven by what happens in the gun battery. The forward observer calls his mission to the fire direction center (FDC); the FDC does its computations and sends the data to the gun battery; crews set the data on the guns and dry fire their weapons. At that point, control personnel, who remain out of the way of the gun crews, must examine the gun sights and the ammunition very quickly, obtain the data elements, and send this data to the fire marker control center (FMCC). The FMCC performs replot in two ways. First, they use a tradional plotting board approach, which has been available for years but never used in this manner for ES, and as previously indicated is very time consuming. Also, they use a TI59 calculator with a special program that was developed in this research project to perform replot. The reason for doing it two separate ways was to provide cross-checks for accuracy and to evaluate the two methods. When the two plots agree, the data is sent to the fire markers. When the two plots disagree, it is necessary to find and resolve the error prior to transmitting the data. Once the targets are marked, the job of the forward observer, part of the artillery firing system, is to correct his initial call for fire. He therefore provides feedback (especially if he thinks he is not getting what he has asked for) on a continuing basis to the battery through the FDC so that a performance feedback loop exists.

<u>Developmental Tests</u>

In the fall of 1979, a developmental test of artillery engagement simulation was accomplished. Participants in the test included an artillery firing battery, from a direct support artillery battalion, two sets of forward observers, an FDC, and enough personnel drawn out of the battalion to provide for gun controllers, an FMCC, and fire markers. Personnel in the control system were selected because their control tasks were similar to their regular military duties. They were trained in these tasks during a three-day period. All equipment in the developmental test was equipment which is currently standard within a field artillery battalion. Fire markers were issued "flash-bang" simulators which they used to mark the targets on the ground, and communications were set up using standard tactical radios and telephones for the control system so that the FMCC could transmit probable impact points to the fire markers, and could receive the gun data from the controllers in the gun battery.

A tactical setting was written which included scenarios designed to provide a representative array of tasks involved in operating a direct support artillery battery. There were no maneuver troops available; a researcher, who had served as an Artillery Officer, role played as the maneuver company commander. He moved with the forward observer teams, and designated targets during attack and defense missions. During the developmental tests, 36 missions were fired. Each mission consists of an initial call for fire plus all adjustments. This led to 82 separate firings of the battery over approximately a three-day period. All missions were during daylight operations in relatively clear weather.

The procedure for obtaining gun data from the battery was accomplished by randomly checking one of the six guns in the battery, and data were sent forward to the FMCC. Every gun crew was made aware of the fact that its performance could potentially affect the results of the entire battery. Gun controllers were instructed to stay out of the way of the gun crew and to establish a professional relationship with the crew chiefs, such that the data that was sent forward had credibility for the crews, i.e., if the crew did not respect the gun controller's professional ability, the system would not have had any face validity.

RESULTS

The performance of the control system was very important in terms of evaluating the overall training program. The time data were collected using electronic stopwatches from the initial call for fire through final marking of targets. Complete data were collected on 24 missions out of the total 36. Table 1 describes the responsiveness of the control system over those 24 missions by breaking the missions down into four blocks of six missions each and computing the median for each mission. Gun controller delays appear to be minimal from the first series of missions, and do not appear to change appreciably over the four mission blocks. The fire marker control center does improve somewhat over the four blocks. However, the biggest improvement can be seen with the fire markers who begin with an average response time of over three minutes and get their response time down to almost two minutes. By the fourth mission block, it can be seen that the median delay was slightly over three minutes for the control system. The median increase in the third block was primarily a function of fire marker performance, which may have been related to the trafficability of the terrain.

Table 1

MEDIAN CONTROL SYSTEM RESPONSIVENESS
(SECONDS)

Mission Block	Gun Controllers	FMCC	Fire Markers	Overall
I	31.0	108	216.5	377
II	28.0	86	177.0	291
III	31.10	87.5	247.0	354
IV	27.5	67.0	129.5	208.5

The performance of the fire marker was related to the distance that he had to travel. A linear regression analysis provided a regression equation: $t=84.07 + 0.87d$. The Pearson correlation between distance and time was 0.73, which was significant ($p<.01$).

During the 82 firings of the exercise, the FMCC transmitted only one error to the fire markers. Five other errors were corrected in cross-checks by the two computers, the one using the board and the other using the calculator in the FMCC. It was found that the calculator method was more accurate in computing the most probable impact point, because it was a precise mathematical procedure. The board plotting involves certain perceptual limitations of the operator. Fire marker accuracy was analyzed for the first time in this exercise. There is no way of knowing precisely whether or not it is comparable to previous ES exercises. The mean cumulative mission error for fire markers was about 75 meters. The mean error per shot was somewhat less than that, about 48 meters. This is within the burst radius of the type of artillery employed, 155mm howitzers, and therefore is not considered extreme.

The critical test of any training system is how it affects the behavior of the individuals or organization being trained. The most important aspects of artillery system performance are speed of delivery and accuracy. Data were collected on these variables for 36 missions.

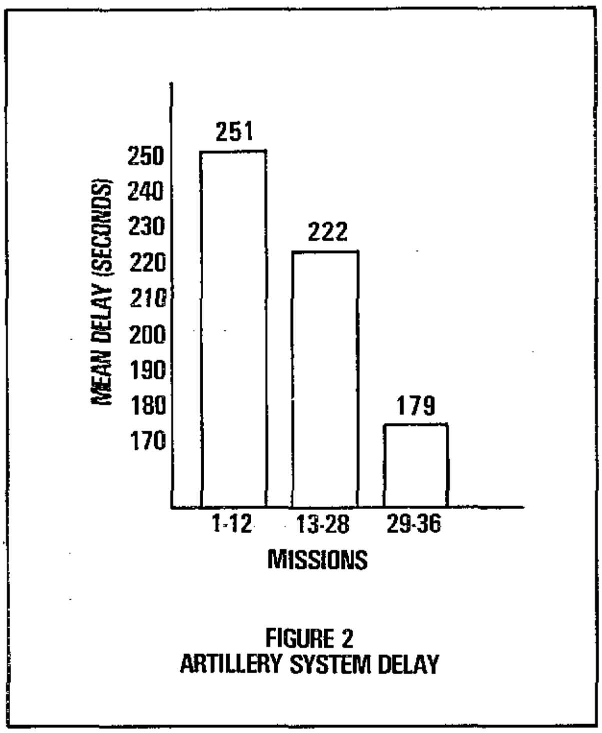

Figure 2. Artillery System Delay

The 36 missions fired during the exercise were divided into three blocks of 12 missions, and the mean delay for a call for fire until the first round was delivered on target by the artillery system was computed. These delays did not include the control system time which was subtracted from the overall delay. Figure 2 describes the change in system performance from the first through the third mission block. As can be seen, there is a considerable improvement. The system gets faster as training progresses.

The accuracy of the artillery firing system was determined by the distance between the coordinates requested by the forward observer, who is part of the system, and the impact coordinates computed by the FMCC. Again, any error produced by the control system was not included in these computations.

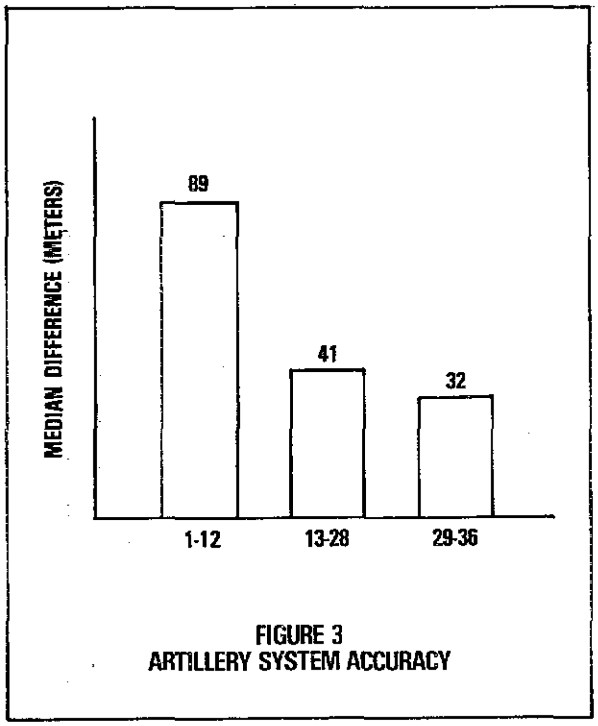

Figure 3. Artillery System Accuracy

Figure 3 describes the change in accuracy from the first mission block of 12 missions through the third mission block. As can be seen, the greatest improvement occurred between the first and second mission blocks. By the third mission block, accuracy was well within the burst radius of one round of artillery, which means that the unit was performing in a very creditable fashion.

The training system will not be successful if the trainees resist the training. An evaluation of the artillery engagement simulation system would not be complete without some input by the participants. Figure 4 describes some selected items of information that were requested from the artillerymen, who participated in this exercise. They were asked to respond on an eight-point scale from strong disagreement to strong agreement concerning some statements about their training. An average or mean response higher than midpoint of the scale indicates some level of agreement and those below the midpoint indicate some level of disagreement. As seen in Figure 4, the gun controllers had credibility with the crews, and on the average crews felt that the information about their performance made the training more interesting. They also indicated that the controllers did not get in their way while they were doing their

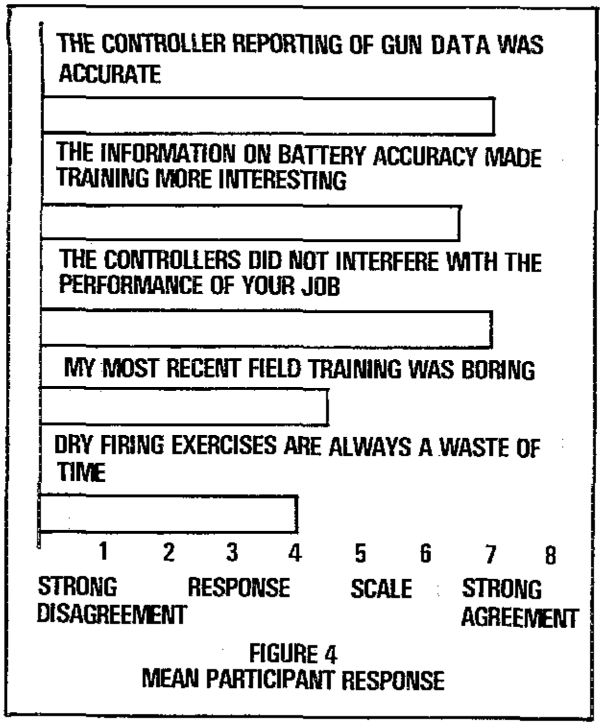

FIGURE 4
MEAN PARTICIPANT RESPONSE

Figure 4. Mean Participant Response

jobs. Two scales that were introduced to see whether or not negative responses were possible indicated that while people did not disagree strongly, they were at least ambivalent to statements such as "my most recent field training was boring," and "dry firing exercises are always a waste of time." Informal comments by forward observers indicated that they considered the accuracy and speed of the artillery engagement simulation system comparable to live fire, because live fire introduces many delays due to safety constraints. They liked the training method better than other non-firing methods such as the subcaliber mortar range, which is very responsive to weather and wind conditions.

CONCLUSIONS

While this method for integrating artillery ES into a larger simulation training system has not been attempted with maneuver troops due to budgetary constraints, it is believed that the method is functional and will serve to add realism, both for artillerymen and for maneuver commanders. The beauty of this method is that it employs no additional equipment other than what is already in an artillery battalion, and requires few personnel to run it. There's still no technological solution for marking targets other than the one that has been employed over the last ten years, having a man drop a simulator on the ground. Fire markers must be carefully trained or they won't perform in an accurate and timely fashion. Developmental tests have led to the point where there is now an ES training program that involves actual artillerymen on the ground using their standard equipment. This is a big step forward. Hopefully, in years to come, a validational effort can be mounted in conjunction with maneuver troop exercises.

ABOUT THE AUTHORS

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