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DATA COLLECTION IN FIELD COMBAT SIMULATION

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The US Army's Combat Developments Experimentation Center has a "field laboratory" at Fort Hunter Liggett, California. Force-on-force field experiments are conducted in which soldiers engage in simulated combat with representative opposition forces. Computers and instrumentation are employed for real time casualty assessment and automatic recording of the results of engagements. Nonlethal surrogates of future weapon systems have been developed and utilized to bring realism to the experiment. A multi-computer system is used to control the simulated battle. It consists of a mainframe Central Processing Unit and sixteen mini-computers in four stems. Four basic types of instrumentation have been developed to assist data collection in field combat simulation. A position location system keeps track of the location of all players. A timing system tags all events with accurate time for comparative analysis. Sensor systems are used to detect the occurrence of an event, and a data collection system is used to store all the telemetered data. Analyzed data are then provided to other Army agencies responsible for computer modeling, wargaming, or procurement decisions.

I. INTRODUCTION

The U.S. Army conducts field combat simulation about 160 miles south of San Francisco. This activity is carried out by the Combat Developments Experimentation Center on the 166,000 acres of Fort Hunter Liggett, which was William Randolph Hearst's hunting ranch. The Combat Developments Experimentation Center creates a simulation of the battlefield as realistically as possible with operational troops, vehicles, and weapons. The simulation is driven by a tactical scenario. This scenario allows free play between the opposing forces within the limits of safety, realism, and essential control of variables. Future weapon systems and threat systems are often represented by surrogates which simulate their design and operational characteristics. The purpose of these field combat simulations is to provide data either to computer modelers which will be useful in their war games, or directly to decision makers for their use in making decisions concerning weapon systems, tactics or personnel questions.

Field combat simulation is an analogic simulation rather than an analytic simulation. Its fundamental characteristic is the representation of the operational factors and functions involved in ground combat. Of primary importance is its introduction of the human being, i.e., the soldier, into the simulation and the consequent requirement for action and measurement in near real time. The simulation not only provides the shaping of the battle, but provides the basis for performance measurement.

This paper addresses the process and techniques of data collection in the field combat simulation with particular attention to data requirements, operational environment, surrogates, and instrumentation. Some thoughts on future activities in the process are also presented.

II. FIELD COMBAT SIMULATION

Our company supports a unique type of man-machine simulation of combat between opposing forces in the field. These forces may be representative of ground forces, air forces, or various organizational combinations. In a field trial, each force is given a mission to achieve by fire and maneuver. During the trial, players detect and engage each other, report information up a chain of command, and make tactical decisions. Commanders assess incoming reports, adjust their fire and maneuver plans, and direct subordinate units. The challenge of field combat simulation is the physical and mathematical simulation of realistic engagements. In this section, I will describe engagement simulation requirements for direct fire weapons, indirect fire weapons, and other area effect weapons. Then I will discuss the use of surrogates for threat weapons, and for conceptual weapons.

If a firer sees his target, the engagement is called direct fire. The fundamental requirement for direct fire simulation is to identify the target being engaged by a firer. Then it is necessary to recognize the type of round selected by a firer and to simulate its time of flight to the target and its lethality against that type of target. Lethality is a function of various engagement parameters that can be measured in the field and used in the simulation. These include firer-target range, firer motion, target motion, target exposure to the firer, and firer-target aspect angle. A realistic reload time is played between successive shots. Round counts are maintained and players are disabled when they have been declared a casualty or have expended all of their ammunition. In the case of command guided missiles, it is necessary to verify continuous target tracking for a critical period of time prior to impact. Visual and aural cues are a very important requirement. Firers must emit realistic flash, bang, and smoke cues; such cues draw counterfire from the opposing force. Miss cues are provided to both the firer and target. The firer uses the miss cue to adjust his fire, causing the target to seek cover. Kill cues are needed to discourage further engagement of a dead target, and for player motivation.

If a firer does not see his target, the engagement is called indirect fire. A forward observer (or remote sensor) may detect a target and report its position to an artillery or mortar section to the rear. He must estimate where a moving target will be when rounds arrive. In addition to this communication between forward observer and firing crew, and the associated errors and delays, indirect and direct fire differ in another important dimension. Indirect fire may affect an area on the ground rather than a single target, particularly when several howitzers are fired in parallel or converging sheafs. Then it is necessary to determine which targets are in this affected area when the rounds arrive. As in the case of direct fire weapons, lethality will also be determined by engagement parameters such as round type and target exposure. Miss cues are needed to tell targets they are in an impact area and to cue a forward observer for fire adjustment. Nuclear, biological and chemical weapons can be simulated like artillery and mortars, even though the affected areas are much larger. Exposure may be measured by the time a target spends in an affected area and its protective state. High explosive and cluster bombs are other area effect weapons. For these it is necessary to measure aircraft position and velocity at weapon release.

Important in any simulation of field combat is the operational environment. At Fort Hunter Liggett there is terrain representative of all but deep desert. There are rolling hills, clear valleys, steep mountains, rivers, lakes, woods, brush, grass and rocks. A controlled airspace above the terrain is provided. Additionally it is an electronically quiet area. All of these characteristics contribute to confidence in the validity of collected data.

III. INSTRUMENTATION

Having discussed the requirements for confidence in the validity of field combat simulation let me now turn to how we meet those requirements. The generation, identification, and collection of data concerning the events on the battlefield are done by means of instrumentation.

Instrumentation systems used for field combat simulation consist of four basic types with control of the simulation resting in a multi-computer system. Position Location Systems record and store data used to keep track of all players in the field experiment. Timing Systems are used to time-tag all types of events with the real time when these events were recorded. Sensor Systems are used to detect the actual occurrence of an event, or to measure a parameter so that the element of data can be collected. Finally Automatic Data Collection Systems gather data, and store the data generated by the other three types of instrumentation. At the Combat Developments Experimentation Center, a variety of systems are used to provide the functions of these four instrumentation types. A brief description of the more common instrumentation systems is contained in the following paragraphs.

The Range Measuring System provides a position location capability and a two-way telemetry link for data transmission and collection to or from any and all player elements. The Range Measuring System performs a major role in two of the functions of instrumentation systems because it is used for both data distribution and collection as well as providing a means of rapidly determining the time correlated position of men, vehicles, and aircraft relative to one another in a field experiment. The Range Measuring System provides data to and accepts data from the Multi-Computer System which is the central data collection and real time control facility for field experiments. The Range Measuring System consists of a master control station (C-Station) communicating to interrogators (A-Stations) which can determine the distance to player-mounted transponders (B-Units) and exchange telemetry data between the Multi-Computer System and the players. Figure 1 shows the Range Measuring System interfacing with field players and the

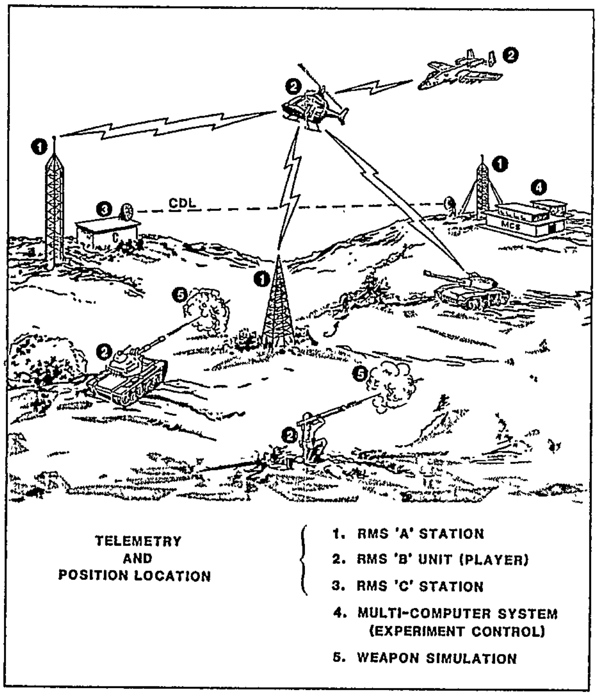

Figure 1. TYPICAL RMS CONFIGURATION

Multi-Computer System during a typical field experiment.

Range Timing System provides coordinated distributed time, which can be traced to the National Bureau of Standards, to all players who require an on-board timer and to the Multi-Computer System. The Range Timing System receives time information from a Geostationary Operational Environmental Satellite transmission which is in fact a relay link from the National Bureau of Standards Coordinated Universal Time signal. The received signal synchronizes a local master clock which in turn generates a standard time code signal which is distributed by means of an FM radio transmitter to radio receivers on the players. The received time code is used to synchronize a player based clock which in turn provides time in a usable form to the instrumentation on the player.

Sensor systems are used to measure test parameters and detect events. More are under development for new experiments. Specific sensors often need to be developed to satisfy unique or new data requirements.

The most commonly used sensor, in any experiment with lasers simulating live fire, is the sensor which is used to detect the presence of laser energy on the target. Most players in a force-on-force field experiment as both firers and targets are equipped with laser sensors. The laser sensors and their associated electronics are capable of decoding the coded laser pulses and determining the types of firing weapon as well the specific identification of the firer. Information collected by the laser sensors is interfaced to the Range Measuring System B-Units carried by the player, which is then transmitted to the Multi-Computer System by firmware controlled components. These provide a flexible interface for several sensor types, and are changeable with each experiment.

A more complex sensor system is the Engagement Line of Sight System which is used to determine and measure the presence or absence of intervisibility among players in a simulated battle. Analysis of the Engagement Line of Sight System data determines the time periods when the players should have been able to see each other clearly, unobstructed by terrain or heavy foliage. The Engagement Line of Sight System will not detect the presence of smoke or dust which might obscure the line of sight in the visible spectrum. This interrogator/transponder system is based on the propagation characteristics of microwave radio frequencies. If an interrogation message fails to reach a transponder or the response from the transponder fails to reach the interrogator, the absence of line of sight is assumed. The interrogation and response pulses are coded with player identification and time synchronized by a master clock so that data, transmitted via the Range Measuring System, can be used by the Multi-Computer System to keep track of the intervisibility between all players.

Video cameras with recording on-board the player, are another very common sensor system. Although video data are generally not available during the simulation, posttrial analysis of video recordings of the activities of the players can provide information not readily available by any other means. Since video recordings must be carefully time correlated to data taken in real time, it is absolutely essential that coordinated time from the Range Timing System be recorded on the video tape. With proper time correlation, video tapes made from video cameras mounted on and boresighted with a player's main gun can provide valuable insight into the sight picture at trigger pull. Time correlation may also provide information on the search pattern used by the gunner in attempting to identify and acquire a target.

Examples of systems used in data collection have been discussed in necessarily broad terms. In order for instrumentation systems to be useful in real time, it is obvious that they must be interfaced with a complete data collection system. The Range Measuring System and its function of providing data communication has already been discussed. The Multi-Computer System that accepts all the real time data, and assimilates, stores, and processes the data has been mentioned above; now an explanation of some of its major functions is as follows.

The most important functions of the Multi-Computer System are the control of the instrumentation systems and event recording. Without either, the simulation is meaningless nor can it be analyzed. Another important function of the Multi-Computer System in contributing to both the realistic conduct of the force-on-force field experiment and the building of a data base that reflects the results of the experiment is the performance of Real Time Casualty Assessment. This function allows the simulated battle to progress with realistic attrition rates on both sides and provides a chronological record of who was engaged by whom and when. The computer, given the identity of the firer and target and the events of firing and hitting, performs a calculation to determine the distance between the players and then looks up the probability of a kill by that weapon against that target at that distance under the parameters considered in the software for both firer and target (motion, aspect, condition, etc.).

The computer then performs a Monte Carlo procedure to produce a psuedo-random number which it then compares to the probability of a kill. If the random number is less than the probability of a kill, the target is determined to be killed and is removed from the battle by a message via the Range Measuring System. If the random number is greater, the target is determined to have survived and may or may not be impaired according to predetermined ground rules. Obviously, the determination of the kill probability value is very important. The key to the kill probability value is realism. All kill probability values are carefully coordinated with Army agencies responsible for their determination.

IV. WHAT DOES THE FUTURE HOLD?

Much of the instrumentation discussed here is already slated for change or it is being replaced by new systems, already well along in their development. Such progress will not only improve the quality of data, but also the quantity by changing the methods now in use. The systems in use today for position location, data collection, and processing limit the number of players that can be supported in any field experiment. The experiments are presently conducted in a small geographical area and the quantity and frequency of the data collected are limited by the need to poll each player sequentially by a central data collection system. All this is not meant to imply that good data have not been collected in the past under realistic battlefield conditions, but the growing requirements to simulate more complex battlefield scenarios and collect more data from new, more sophisticated weapons leads rapidly to the need for changes in instrumentation made possible by many new technological applications.

The Mobile Automated Field Instrumentation System currently under development by the Army Training and Doctrine Command will supply much of the new technology needed for progress. When completed, this new system will provide an improved and enhanced capability to conduct fully-instrumented, force-on-force operations with real time casualty assessments and data collection in any geographical area. It will provide position location for each player by using a network of NAVSTAR Global Positioning System satellites and a Global Positioning System receiver on each player which will allow each individual player to determine its own position on the battlefield. Very accurate timing will be provided by the same Global Positioning System satellites which carry a clock synchronized to Coordinated Universal Time. The Mobile Automated Field Instrumentation System will use current lasers and laser sensors to simulate weapon firing, but will perform real time casualty assessment on-board the targeted player and both the firer and target will communicate to a central data collection and control facility via a radio system carried by each player. Because the Mobile Automated Field Instrumentation System will have increased communications and distributive processing capabilities, it will support many more players and collect more data.

There are also several developmental programs ongoing at the Jet Propulsion Laboratory and other places to develop new training aids which will undoubtedly find their way into the test environment in the near future. These systems will add more realism to the simulated battlefield as well as provide new sources for data about the effects of such things as nuclear, biological, or chemical warfare. An artillery airburst simulator which actually fires a very light (100 grams) projectile several hundred meters to where it bursts in the air over live troops is under development at the Jet Propulsion Laboratory. Because this system follows a ballistic profile and provides a "whistle and bang" acoustic signature which is sensed by a detector on each player, it greatly enhances the realism produced by this simulation of indirect fire over the simulation technique used currently. Another program is developing harmless simulants for chemical or gas warfare training. These chemicals handle and act like the real agents in almost every way, but without any ill-effects to the soldiers involved and therefore can provide excellent realism to a simulated battlefield. Instrumentation is also under development which can measure the level of protection provided by tactical devices, such as gas masks, worn by soldiers. The application of this new technology to a test experiment involving a nuclear, biological, or chemical environment scenario is obvious.

The use of Artificial Intelligence is on the horizon for test applications. In the future, opposing forces may consist of robots with expert systems installed which have been "trained" to react according to a doctrine when real battlefield stimulants are encountered. Besides implementing a consistently predictable and repeatable opposition reaction, these systems could also become real targets for live fire. This would be the ultimate verification of simulated battle scenarios. In addition, the challenge of simulating "fire and forget" weapons which utilize on-board Artificial Intelligence must be met with expert systems that can realistically react in the same manner as the real weapon.

A by-product of the changes in test instrumentation may be a standardization of test methods, procedures and hardware. The development cost of the new systems probably will be relatively high and therefore, the cost of duplication of effort in developing non-standard, competing systems may be prohibitive. The result of putting all the improvements in one developmental basket will be much needed standardization. Standardization in instrumentation and data gathering techniques would greatly enhance the exchange of data and expand the use of simulation and surrogates throughout the testing community.

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