OneSAF Killer/Victim Scoreboard Capability For C2 Experimentation

Track: C2 Experimentation

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OneSAF Killer/Victim Scoreboard Capability For C2 Experimentation

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Abstract

Command and Control (C2) is a commander's guidance of his/her forces (command) to accomplish a goal or mission while monitoring the directed movements (control). The U.S. Army Research Laboratory's (ARL) Battlespace Decision Support Team (BDST) is exploring methods of evaluating the effectiveness of a commander's plan or course of action (COA). Part of our research involves the task of identifying metrics to rate a COA. We have modified the One Semi-Automated Forces (OneSAF) simulation to track direct fire hits and vehicle damage throughout simulated battles. One completed experiment ran a OneSAF scenario over 200 iterations and captured data. BDST will analyze the collected data to determine its utility in measuring COA effectiveness. Future applications of tools and techniques developed through this and other experiments will assist the commander as real-world battles unfold.

1. Introduction

Command and Control (C2) is a commander's guidance for his/her forces (command) to accomplish a goal or mission while monitoring the directed movements (control). The U.S. Army Research Laboratory's (ARL) Battlespace Decision Support Team (BDST) is exploring methods of evaluating the effectiveness of a commander's plan or course of action (COA). Part of our research involves the task of identifying metrics to rate a COA.

With unlimited resources, a COA could be developed and played out in a field exercise setting. Data could be collected to track casualties, expenditure of supplies, and whether the intended mission was completed. The COA could be changed as necessary to improve the battle outcome and be executed numerous times. However, unlimited resources do not exist. The rising cost of field exercises has coincided with increased military interest in combat simulation. Computerized combat simulations are relatively inexpensive, and COAs can be executed as many times as required. BDST's Course of Action Technology Integration (COATI) project uses combat simulations for battlefield COA evaluation within the military decision making process.

2.0 Killer/Victim Scoreboard Development

Our current work involves using the simulation One Semi-Automated Forces (OneSAF) to examine battle outcomes. OneSAF is developed under the guidance of the U.S. Army Simulation, Training, and Instrumentation Command (STRICOM). ARL has modified the OneSAF code to provide data on direct fire hits and to track entities throughout the battle. The tracking of direct fire hits provides the basis for establishing a Killer/Victim Scoreboard (KVS) capability in OneSAF. The KVS is a preliminary step in the evaluation of a COA's effectiveness.[1]

2.1 OneSAF Modifications

We modified the existing OneSAF software to write a list of all active simulation entities and direct fire events to two separate text files. The file containing the active simulation entities is named with the simulation start time and a "vt" (for vehicle table) extension. This file tracks all battle entities (e.g., dismounted infantry), not just vehicles. The direct fire information file is named with the same time stamp and a "df" (for direct fire) extension.

The vehicle table file contains the OneSAF internal vehicle table (VTAB) and persistent object database (PO) identifications and the vehicle or entity type. See Figure 1 for a sample of the file. This file was created by modifying the *libcr_local.h* and *cr_create.c* programs in OneSAF's *libsrc/libcreate* directory. All active entities are listed in the vehicle table file.

```
VTAB_ID 1059 PO_VEHICLE 100A13 VEHICLE_TYPE vehicle_US_M1A1
VTAB_ID 1047 PO_VEHICLE 100A23 VEHICLE_TYPE vehicle_US_M1A1
VTAB_ID 1050 PO_VEHICLE 100A21 VEHICLE_TYPE vehicle_US_M1A1
VTAB_ID 1036 PO_VEHICLE 100A22 VEHICLE_TYPE vehicle_USSR_T72M
VTAB_ID 1037 PO_VEHICLE 100A21 VEHICLE_TYPE vehicle_USSR_T72M
VTAB_ID 1039 PO_VEHICLE 100A23 VEHICLE_TYPE vehicle_USSR_T72M
```

Figure 1. Sample Entity List

The direct fire file contains the following information for each direct fire hit: the simulation time; the identity of firer and target; the position of firer and target; the ammunition; the range; a kill thermometer (explained in the following paragraph); and result. Direct fire misses and indirect fire hits or misses are currently not recorded, but will be added in the future. See Figure 2 for a sample of one direct fire hit. We obtained the direct fire information by modifying the *dfdam_tables.c* and *dfdam_tick.c* programs in OneSAF's *libsrc/libdfdam* directory.

The kill thermometer determines the outcome of the direct fire. Values are assigned to a continuum of the following probabilities: no damage (Pn), mobility kill (Pm), firepower kill (Pf), mobility and firepower kill (Pmf), and total or catastrophic kill (Pk). When a

[1] Heilman, Eric G., and Janet F. O'May, *OneSAF Killer/Victim Scoreboard Capability*, US Army Research Laboratory Technical Report, 2002 (currently in publishing).

random number is generated to represent a kill probability, the value is plotted on the kill thermometer. A value that exists between two probabilities indicates the next highest result. For example, in Figure 2, the kill value is 0.904125. The value for Pmf is 0.90 and 1.0 for Pk. The result of this direct fire will be a total or catastrophic kill (Pk).

```
Time Stamp 997294867
Vehicle ID 1060
Firer ID 1046
Projectile 1143670816
Firer Position:  X = 27091.00  Y = 30013.00  Z = 834.68
Target Position:  X = 23801.81  Y = 29406.17  Z = 827.96
Vehicle 1060: Hit with 1 "munition_USSR_Songster" (0x442b0820)
Comp DFDAM_EXPOSURE_TURRET, angle 40.76 deg Disp 2.775700
ft
Kill Thermometer is: Pk: 1.00, Pmf: 0.90, Pf: 0.90, Pm: 0.70 Pn: 0.70
RANGE  3344.706870
r = 0.904125 kill_type = K
```

Figure 2. One Direct Fire Data Point

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2.2 KVS Capability

The KVS enables the expedient collection and evaluation of data from OneSAF simulations. The tabulation of the ammunition with associated outcome results provides insight into a unit's effectiveness. While the KVS is currently being used only for OneSAF simulations, future work will incorporate battlefield monitoring with other simulators.

3.0 Experiment

COATI has placed a great significance on calibrating the course of action process through the use of combat simulations. In fact, the continuation of the COATI project requires an increased understanding of combat simulation: specifically, the collection of simulation data to classify types and meaning. Without this knowledge, we cannot estimate advantages resulting from the incorporation of combat simulation into a tool for the battlefield.

The current experiment is aimed at exercising new capabilities we have incorporated into the OneSAF combat simulation: namely, those of the status data collection suite[2] and the Killer/Victim Scoreboard (KVS). Experimental data will enable us to better understand

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2 O'May, Janet et al., "Effects of Combat Simulation Variance on Course of Action Development," Proceedings of the 6th International Command and Control Research and Technology Symposium, 2001.

the operations of OneSAF through an in-depth examination of entity interactions through multiple reenactments of a single combat scenario. Experimental goals include the development of non-traditional combat metrics, a better understanding of simulation operations, and a method for the depiction of the battle situation at any given time.

3.1 Scenario Development

Driving the experiment was a battle scenario. Our scenario results must range across the set of possible outcomes to enable a better assessment of battle metrics. In support of a mathematically intense treatment of collected data, we developed a scenario that from the same initial conditions produces varied combat outcomes through multiple operations.

Scenario design occurred over a weeklong period. The sensitivity of the OneSAF simulation to vehicle placement, weapons efficiency, armor damage reflection capability, and behavioral options became apparent early in the process. For example, the placement of a vehicle with its flank armor visible to the enemy often resulted in vehicle destruction before it could affect battle outcome in any significant manner. During that time, we ran over 80 repetitions of 42 prototype scenario designs before capturing a scenario that produced a battle with consistently varied outcomes.

The experimental scenario featured a company-sized attack on a prepared defense. The terrain represented typical Southwest Asia desert, reflecting current conflict areas. Since our KVS and data collection capabilities are currently rudimentary, we examined only direct fire entities and combat.

The attack was made from a company position featuring a two-axis advance across a river to seize a vital crossroad located in a town to the south. Enemy forces had time to prepare a defense against these likely attack routes and have placed their vehicles in a multiple defense band layout. If the attacking force could seize the objective below the town, they could deny the use of the town to the enemy, disrupt his communications, and if enough strength were present, be prepared to operate behind his lines.

The attacking force organization consisted of an under-strength company-level unit with M1 main battle tanks. Having some experience with the more modern vehicle performance within OneSAF led us to believe that a more manageable scenario might be constructed using older equipment. In fact, our initial insights were substantiated, as we had to place twice the number of vehicles on the defense to produce acceptable scenario results. We chose 13 older M1 tanks as the attacking force. See Figure 3 for a list of all battle entities.

The M1s were split into two groups. The attack in the East was designed to initially seize the town and then push to the railroad junction in the south. The attack in the West was to initially seize the railroad bridges intact and then push to the railroad junction south of the town. While two different attack routes were traversed by different platoons, the single objective unified the battle at the company level.

Attacking Forces (By attack route):

One Company (-)
East Attacker: 5 M1 Main Battle Tanks
West Attacker: 8 M1 Main Battle Tanks

Defending Forces (By defending Battle Position):

One Mixed Battalion (-)

WEST	
Band 1:	2 T-80 Main Battle Tanks
	3 BMP-2 Infantry Fighting Vehicles
Band 2:	2 T-72M Main Battle Tanks
	3 T-72M Main Battle Tanks
	2 T-72M Main Battle Tanks
Band 3:	2 T-72M Main Battle Tanks
Band 4:	2 T-80 Main Battle Tanks
EAST	
Band 1:	3 BMP-2 Infantry Fighting Vehicles
	2 BMP-2 Infantry Fighting Vehicles
Band 2:	3 T-72 Main Battle Tanks
Band 3:	1 T-80 Main Battle Tank
Band 4:	1 T-80 Main Battle Tank

Figure 3. Scenario Table of Entities

The defense was based on more modern Russian equipment and was built on progressive bands of defense designed to break up a coordinated attack on the town. Each band featured a vehicle mix designed to stop the attackers with minimal loss to the defenders. The infantry vehicles were situated in the first band to provide long-range stopping power via their anti-tank missiles, while the tanks in the successive bands provided increased firepower options for both long and close-in fighting.

The layout of the battle is shown in Figure 4. The attack represents an attempt by the friendly commander to flank the town and cause it to be abandoned by controlling key terrain to the south. In actuality, the defensive posture causes this attack to be a frontal assault against a prepared defense along both attack routes. The attacker faces the worst-case scenario with an unfavorable combat power ratio. Specifically, there are two defenders for every attacker, all of whom are oriented in favorable aspect for the attack.

The battle can be split into two interlocking parts: the eastern battle through the town and the western battle to flank the town. These battles are sufficiently geographically spread to be independent, until the latter stages when the eastern attack progresses to engage western defense bands 3 and 4. In an optimal situation for the attacker, this occurs as the eastern forces reach the company objective. Both attacks feature a contested river crossing, an unfavorable mission for the attacker, early in the battle. The rest of the battle occurs on flat ground with the exception of the town in the western attack.

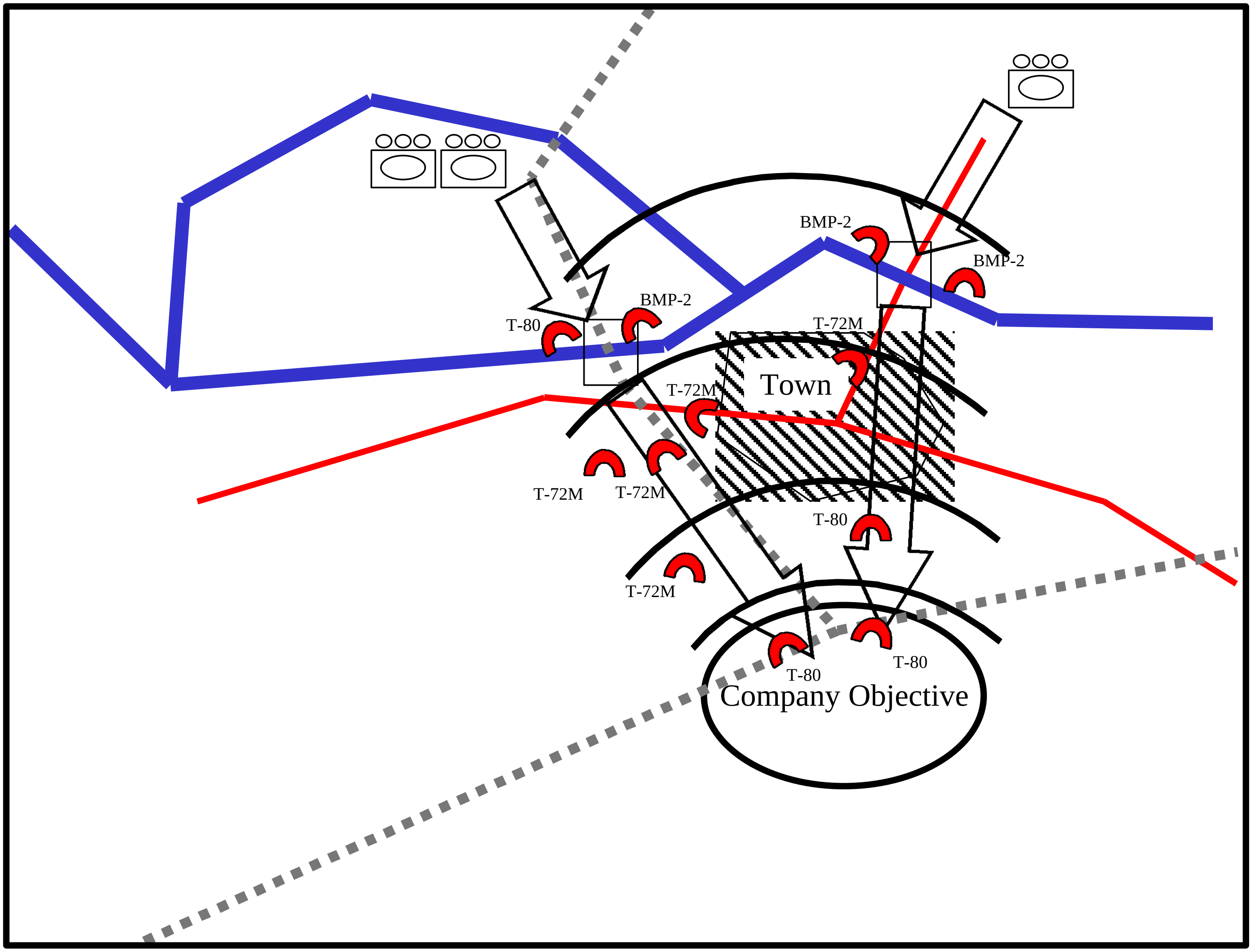

Figure 4. Battle Layout

The bands of defense provide a useful metric to gage the battle progress. We could easily track the progress of the battle by noting the number of bands penetrated by the attacker. We created a scoring system in which the basis value of each attacking vehicle, ¼ point, was multiplied by the number of the band penetrated to show terrain control. (A ¼ point was used for each vehicle so that a platoon equals one point.) The total score for the scenario is the summation of each vehicle's modified point value. Further, since capability for continued operations must be considered, if no attacking vehicle remained operational after the objective was occupied, then the entire score was halved.

The scenario score could range from a low of zero, when all attackers are eliminated prior to the penetration of band 1, to a high of 13, when all attacking vehicles occupy the objective fully operational. To date, our scores have ranged from a low of 1.375 to a high of 13. The measure indicates the scenario can provide a rich set of data showcasing the diversity of OneSAF behaviors and force interactions.

3.2 Execution

Following the scenario development, our next step was the actual experiment. We ran OneSAF on multiple systems to allow maximum usage. All OneSAF scenarios were executed on either SGI® or Sun Microsystems® computers. We executed 231 scenarios over a period of three months. A central repository was created for data storage and subsequent processing. The actual time for each scenario execution varied from 28 minutes to more than 90 minutes. BDST personnel supervised all scenario runs, ensuring accurate data collection and providing insights on battle outcome.

3.3 Data Tabulation and Analysis

As the scenario executions were underway, we began work on developing the software to parse and tabulate the large amount of data. The software was developed using the Bourne Shell Script language. This provided a way for any UNIX system to run the data tabulation. We identified a set of 435 data fields for future analysis. Data was collected at three time slices during the battle when 10%, 25%, and 40% of the M1 ammunition had been expended. The data fields included vehicle appearance, number of rounds expended, average range for ammunition used, number of side impacts, and distance to the objective for the three M1 platoons at each time. Also information was collected at the end of the simulation for number of M1s on the objective, number of M1s undamaged, and the final score. The shell scripts collect the required fields in an ASCII file for input to multiple statistical analysis software packages.

The detailed statistical analysis is currently underway. Preliminary findings will be presented at the Command & Control Research & Technology Symposium, and final results will be available by contacting the authors.

4.0 Conclusion

As we complete the OneSAF KVS experiment, BDST will focus on the development of improved combat metrics. Traditional land combat metrics rely on two main features, force attrition, and objective attainment. While these metrics do tell us about the combat, they do not indicate everything necessary to evaluate a COA. Other relevant factors, such as a unit's combat effectiveness or supply status, may be helpful in determining important aspects of a battle outcome. A battle is often part of a continuing campaign, so an understanding of ammunition effectiveness or the outcome of applied tactics and techniques could also determine a COA’s efficiency.

The KVS was designed for data collection to support the development of non-traditional metrics. Information collected through the application of a KVS will provide a wealth of data for the computation of such new metrics. While the use of the OneSAF KVS is only a beginning step towards establishing new metrics to determine a COA’s efficiency, it is a step in the right direction. Future applications of tools and techniques developed through these and similar experiments will assist commanders as real-world battles unfold.

Acknowledgements

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Acronyms

ARL	Army Research Laboratory
BDST	Battlespace Decision Support Team
C2	Command and Control
COA	Course of Action
COAA	Course of Action Analysis
COATI	Course of Action Technology Integration
KVS	Killer/Victim Scoreboard
PO	Persistent Object
OneSAF	One Semi-Automated Forces
STRICOM	Simulation, Training, and Instrumentation Command
VTAB	Vehicle Table