



Data Translation to Support the Battlespace Terrain Ownership Project

by Janet F. O'May, Tan Vu, and Andrew M. Neiderer

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14. ABSTRACT The U.S. Army Research Laboratory's Battlespace Decision Support Team is exploring methods of portraying control or power influence in the battlespace. The Battlespace Terrain Ownership project uses resultant data from the successive application of three computer programs to present a graphical display of areas of influence in the battlespace: combat simulation, the data translation process, and the control algorithm and associated display. The first step involves the creation of a combat scenario in One Semi-Automated Forces (OneSAF) Testbed Baseline (OTB) v2.0; OTB provides data on all entities in the battlespace and both direct- and indirect-fire events. The second step is converting this data into a format for the control algorithm. The control algorithm then interprets different factors in the battlespace and provides a visual display. This report addresses the second step, the data translation process.					
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1. Introduction

The U.S. Army Research Laboratory's (ARL) Battlespace Decision Support Team (BDST) is exploring methods of portraying control or power influence in the battlespace. Commanders receive large amounts of information, and a quick visualization of areas of control would provide the Commander another tool for mission planning and execution monitoring. This display would allow the Commander to assess the effectiveness and progression of his/her forces.

BDST began the Battlespace Terrain Ownership (BTO) project with two objectives in mind. The first is that the system would enhance the course of action development process. A Commander or his/her staff would be able to develop a scenario in One Semi-Automated Forces (OneSAF) Testbed Baseline (OTB), and then watch the proposed scenario play out. This would allow the Commander to view possible outcomes, and if necessary adjust the scenario and then replay the mission. Another possible use for BTO would be during mission execution: as information is received from intelligence reports and battlefield sensors, the control picture would be updated. The Commander would have an up-to-date picture of the areas under control by force.

2. BTO Overview

The BTO project combines three components to provide a graphical display of areas of influence in the battlespace. The first component is the combat simulation; the second component is the data translation process; and the final component is the control algorithm and associated display. The first step is to create a combat scenario in OTB v2.0. OTB provides data on all entities in the battlespace and direct- and indirect-fire events. The second step converts the data into a format for the control algorithm. The final process invokes the control algorithm to interpret different factors in the battlespace and provides a visual display of control. This report addresses the second step, the data translation.

To provide data from the simulation to BTO, we modified OTB. The first step was to enable information to be collected for all entities in the battlespace. We modified the source code to print out logistical information from OTB regarding identifying information, entity status, location, and fuel and ammunition supply for all entities. This information is written to a file with a unique timestamp when an update routine is called in OTB.¹ The code changes also provide a quick look-up table of all battlespace entities. The next step was to obtain information

¹ Heilman, E. G.; O'May, J. F. *A OneSAF Data Collection Methodology for Experimentation*; ARL-TR-2663; U.S. Army Research Laboratory: Aberdeen Proving Ground, MD, February 2002.

on all direct-fire events. Again, we modified the OTB source code to provide information as to shooter, target, shooter and target locations, ammunition used (round), dispersion of hit, and outcome. This information is written to a separate file and each event has an associated unique timestamp.² We originally modified OTB v1.0 to allow entity data collection and direct-fire reporting. When the U.S. Army Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) issued a call for OTB enhancements, BDST forwarded their code changes. PEO STRI approved the changes and incorporated them into OTB v2.0.

After the release of OTB v2.0, we made additional changes to the OTB source code. One change was to increase the functionality of the data collection methodology. The original changes allowed data to be collected whenever a certain OTB function call was made. We wanted to be able to control the timing of the data-collection process. We made a change that allowed data collection at a user-defined interval. By a file read at OTB initialization, a user can specify an increment in seconds and OTB will collect data on all battlespace entities at the specified time. If no time is entered, the system defaults to a 1 min collection interval.

A second change made to OTB was to collect data for all indirect-fire events. When an indirect fire occurs, data is collected on the shooter (if available), possible targets, type of ammunition, locations of the shooter and targets, and outcome. A unique timestamp is provided for each indirect-fire event. This information is also written to a separate file for parsing by the BTO data translation process.³

In total, OTB creates four distinct files for each simulation execution. At startup, OTB creates a timestamp variable. This unique variable, “arl_time,” is available as the foundation for all files created. The four files are: “<arl_time>dc” that contains information on all battlefield entities; “<arl_time>vt” is the lookup table for all entities; “<arl_time>df” contains information on all direct-fire events; and “<arl_time>if” has all indirect-fire events.

The second component of BTO is the actual data translation for inclusion into the BTO algorithm. The data-translation component is discussed in section 3 of this report. The third component is the BTO algorithm and graphical display. The software dynamically computes power projection as a function of entity location, weapon system effectiveness, combat damage, and probabilities of hit and kill.

BTO currently displays power for seven different categories for two sides. As shown in figure 1, the darkest colors (red and blue) are where the respective sides have greater than 6:1 power. The medium colors are where the sides have greater than 3:1 but less than 6:1 influence. The lightest

²Heilman, E. G.; O'May, J. F. *One Semi-Automated Forces (OneSAF) Killer/Victim Scoreboard (KVS) Capability*; ARL-TR-2829; U.S. Army Research Laboratory: Aberdeen Proving Ground, MD, September 2002.

³O'May, J. F. *Enhancements to OneSAF Killer/Victim Scoreboard Capabilities*; ARL-TR-3758; U.S. Army Research Laboratory: Aberdeen Proving Ground, MD, April 2006.

colors are where control is greater than 1:1 but less than 3:1. The white colors represent where neither side has influence due to weapon range restrictions. Figure 2 is the same control representation placed on three-dimensional terrain.

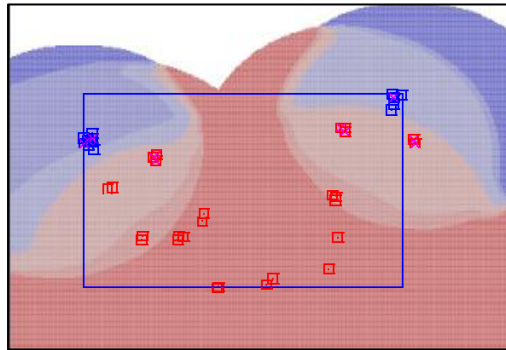


Figure 1. Two-dimensional representation.

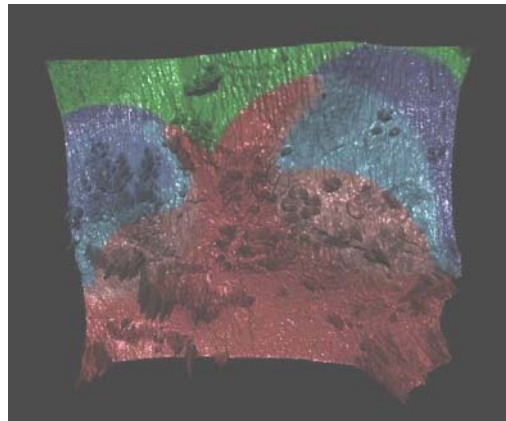


Figure 2. Three-dimensional representation.

3. Software Overview

The data translation software selectively converts the data created by OTB to a format required by BTO for control determination and display. OTB is capable of creating large amounts of data. The amount of data is dependent on the number of entities present in the scenario, the amount of indirect- and direct-fire events, and the user-defined period for data collection. A large scenario with many entities, frequent firings, and data collection points would provide a voluminous amount of data. The data translation software must parse this data quickly and provide it in a concise format for immediate inclusion into the BTO algorithm.

As previously mentioned, OTB is creating four separate files that the data-translation process must track. The first file is the “<arl_time>dc” file. This file contains information on all entities

and their aggregation at the user-specified or default data collection time increment. For example, if a platoon of M1A1 tanks is in the scenario, information will be available on all four tanks plus a roll-up of the platoon. A timestamp is written to the file at the beginning of each time period for data collection. For each entity and associate aggregate, OTB provides the following information: vehicle marking; vehicle; unique vehicle identification number (VTAB_ID); location; status of entity; type and quantity of ammunition on board; quantity of fuel; and awareness of other entities. See table 1 for an example of the information for a platoon (aggregated) and a single entity.

Table 1. Data from "<arl_time>dc" file.

Current Count 1 at Time: 1159281943

MARKING: 100A3

VEHICLE: M1 Platoon

VTAB: 1042

X = 21929.55 Y = 36048.95 Z = 1154.80 CELL = 0

Vehicle Authorized/Undamaged/Catastrophic/Firepower/Mobility

Damage Damage Damage

M1 4 4 0 0 0

Equip/Supplies: Current Lvl/Resupply Lvl/Avg Per Veh

Fuel (Fuel) (gallons) 1475.05 1600.00 350.00

105mm HEAT-T (M456A1) 60.00 60.00 15.00

105mm SABOT APDS-T (M392A2) 100.00 100.00 25.00

7.62mm MG (M240) 10000.00 10000.00 2500.00

.50 Cal MG (M33) 2400.00 2400.00 600.00

66mm OPTICAL SMK (L8A1) 80.00 80.00 20.00

Not aware of any vehicles.

MARKING: 100A33

VEHICLE: vehicle_US_M1

VTAB: 1023

X = 21936.00 Y = 36198.80 Z = 1156.93 CELL = 0

Vehicle Authorized/Undamaged/Catastrophic/Firepower/Mobility

Damage Damage Damage

M1 1 1 0 0 0

Equip/Supplies: Current Lvl/Resupply Lvl/Avg Per Veh

Fuel (Fuel) (gallons) 368.75 400.00 350.00

105mm HEAT-T (M456A1) 15.00 15.00 15.00

105mm SABOT APDS-T (M392A2) 25.00 25.00 25.00

7.62mm MG (M240) 2500.00 2500.00 2500.00

.50 Cal MG (M33) 600.00 600.00 600.00

66mm OPTICAL SMK (L8A1) 20.00 20.00 20.00

Not aware of any vehicles.

The second file created provides a list of all entities in the simulation named "<arl_time>vt." This file contains a unique 4-digit identifier for each entity, the entity call sign, and the entity type. This file also acts as a quick look-up table for entity information. See table 2 for an example of the "<arl_time>vt" file.

Table 2. Sample data from "<arl_time>vt file."

```
VTAB_ID 1013 PO_VEHICLE 100B51 VEHICLE_TYPE vehicle_USSR_BMP2
VTAB_ID 1006 PO_VEHICLE 100B52 VEHICLE_TYPE vehicle_USSR_BMP2
VTAB_ID 1031 PO_VEHICLE 100B22 VEHICLE_TYPE vehicle_USSR_T72M
VTAB_ID 1025 PO_VEHICLE 100B21 VEHICLE_TYPE vehicle_USSR_T72M
VTAB_ID 1039 PO_VEHICLE 100A71 VEHICLE_TYPE vehicle_USSR_T80
VTAB_ID 1038 PO_VEHICLE 100A61 VEHICLE_TYPE vehicle_USSR_T80
VTAB_ID 1026 PO_VEHICLE 100A41 VEHICLE_TYPE vehicle_US_M1
VTAB_ID 1023 PO_VEHICLE 100A33 VEHICLE_TYPE vehicle_US_M1
```

The final two files store information on fire events. The third file, "<arl_time>df," contains a listing of all direct-fire events. This file contains information on the timestamp of the direct-fire event, firer and target unique identification number (VTAB_ID) and location, type of ammunition used, angle of impact, range, dispersion, and result. See table 3 for sample data.

Table 3. Two sample direct-fire records from "<arl_time>df."

```
=====
Time Stamp 1159281988
Firer ID 1022
Target ID 1013
Firer Position: X = 21742.56 Y = 36001.78 Z = 1131.23
Target Position: X = 19157.00 Y = 35316.30 Z = 961.80
Vehicle 1013: Hit with 1 "munition_US_M456A1" (0x48bb0421)
Comp DFDAM_EXPOSURE_TURRET, angle 0.73 deg Disp 4.462900
ft
Kill Thermometer is: Pk: 1.00, Pmf: 0.60, Pf: 0.20, Pm:
0.20 Pn: 0.20
r = 0.395290 kill_type = MF
RANGE 1480.241770
=====
Time Stamp 1159282020
Firer ID 1007
Target ID 1002
Firer Position: X = 3969.41 Y = 44604.75 Z = 1088.75
Target Position: X = 3994.02 Y = 42597.80 Z = 1117.77
Vehicle 1002: Hit with 1 "munition_US_M392A2" (0x48b80421)
Comp DFDAM_EXPOSURE_TURRET, angle -25.09 deg Disp 2.316786
ft
Kill Thermometer is: Pk: 1.00, Pmf: 0.40, Pf: 0.30, Pm:
0.20 Pn: 0.20
r = 0.990576 kill_type = K
RANGE 1507.306901
=====
```

The final file, "<arl_time>if," contains information on every indirect-fire event. Each record contains a timestamp, target entity identification and location, ammunition used, shooter identity and location (if known), location of impact, and result. For each event there may be multiple records, so the timestamp will identify which events occurred together. A record is written for every entity that must assess damage when an event occurs. For example, in table 4, the first three records are for the same indirect-fire event as the last two.

Table 4. Sample data from "<arl_time>if."

```
=====
Time Stamp 1159281995
Vehicle 1005 assessing IF damage with 1 "munition_US_M712"
Entity Location X = 6704.96 Y = 43527.90 Z = 1001.91
Shooter ID 0
Shooter Location X = 0.00 Y = 0.00 Z = 0.00
U No Damage
Detonation Location X = 6875.25 Y = 43639.78 Z = 1004.41
=====
Time Stamp 1159281995
Vehicle 1017 assessing IF damage with 1 "munition_US_M712"
Entity Location X = 6871.36 Y = 43638.90 Z = 1004.30
Shooter ID 0
Shooter Location X = 0.00 Y = 0.00 Z = 0.00
F Fire Kill
Detonation Location X = 6875.25 Y = 43639.78 Z = 1004.41
=====
Time Stamp 1159281995
Vehicle 1004 assessing IF damage with 1 "munition_US_M712"
Entity Location X = 6732.69 Y = 43666.60 Z = 1007.98
Shooter ID 0
Shooter Location X = 0.00 Y = 0.00 Z = 0.00
U No Damage
Detonation Location X = 6875.25 Y = 43639.78 Z = 1004.41
=====
Time Stamp 1159282284
Vehicle 1031 assessing IF damage with 1 "munition_US_M712"
Entity Location X = 7706.91 Y = 39386.50 Z = 976.84
Shooter ID 0
Shooter Location X = 0.00 Y = 0.00 Z = 0.00
M Mobility Kill
Detonation Location X = 7705.84 Y = 39386.56 Z = 976.86
=====
Time Stamp 1159282284
Vehicle 1025 assessing IF damage with 1 "munition_US_M712"
Entity Location X = 7734.64 Y = 39525.20 Z = 974.92
Shooter ID 0
Shooter Location X = 0.00 Y = 0.00 Z = 0.00
U No Damage
Detonation Location X = 7705.84 Y = 39386.56 Z = 976.86
=====
```

The data translation program continually examines all four files as OTB creates them, synchronizes and formats the data from the files, and passes the data onto BTO. The main class for data translation, OneSAF.java, handles this process. All four files previously mentioned are created simultaneously from different routines inside OTB, so the data translation software must constantly poll all files and grab any new data. For data received from <arl_file>dc, the software only puts out new information. If the most recent timestamp shows the same information for all entities as the prior timestamp, no new information is passed to BTO.

The OneSAF.java class interfaces with additional classes that interrogate the four files created by OTB. Each class is declared as an array of objects: Vector<DF_Object>, Vector<IF_Object>, Vector<DC_Object>, and Vector<VT_Object>, respectively. In addition, Vector<StdName_Object> and Vector<PositionRecord_Object> are defined to support translation. “Reading” classes (ReadingDF, ReadingIF, ReadingDC, ReadingVT, and ReadingStdName) are designed to store relevant information in these Java objects using private helping methods. Each of these classes has “get” and “set” methods, typical of object-oriented programming when working with the representation of a class, for accessing private member data.

The data-translation software creates three files that provide the required data to the BTO algorithm. The software parses the data from these four files into a format readable by the BTO algorithm and visualization software and writes the new data in timestamp order. These three files are numbered chronologically. The first type of file created is called a position record, as seen in table 5. A position record will have a 1 in the first position of the first line. The first line also states the file number and the number of entities currently in the battlespace. In the example shown in table 5, this file contains information for 39 entities and is the ninth file written by the data translation software. The second line contains the timestamp of when the data was collected. The next lines present data on the entities. As there are 39 entities in the battlespace, there will be 39 additional lines, one for each entity. For each entity, the following information is provided: call sign; unique identifier (VTAB_ID); X, Y, and Z location; and current health. The health is presented as an N for undamaged, F for firepower kill, M for mobility kill, MF for mobility and firepower kill, or a K for a catastrophic kill.

The second type of record written is a direct-fire record. This record will have a 2 in the first position of the first line. Also on the first line is the number of the file. In the example shown in table 6, this direct fire record was the tenth file written. The second line has the following information: the timestamp from the fire event; the unique identified of the target; the identification of the firer; the X, Y and Z of the target; the X, Y and Z of the shooter; and the result of the fire event. In the sample shown in table 6, the target with the VTAB_ID of 1001 located at X=3966, Y=42459, and Z=1149 was catastrophically killed by the entity with a VTAB_ID of 1012 at location X=4040, Y=44793, and Z=1095.

Table 5. Example of a position record.

1 (9) - 39 entities					
1150734291					
100A71	1039	15082	36317	963	N
100A61	1038	10090	36745	940	N
100A62	1037	10006	36515	938	N
100B43	1036	19825	36853	996	K
100A63	1035	11090	36402	945	N
100B42	1034	19784	36988	994	N
100B12	1033	16990	36821	941	N
100B13	1032	17086	36718	938	N
100B22	1031	7707	39387	977	N
100B11	1030	16983	36622	936	N
100B41	1029	19690	36812	989	MF
100B02	1028	8241	42192	945	N
100A81	1027	4528	40193	1042	N
100A41	1026	22057	36053	1171	N
100B21	1025	7735	39525	975	N
100B03	1024	8408	42303	942	N
100A33	1023	21936	36199	1157	N
100A32	1022	21927	35999	1154	N
100A31	1021	21832	36103	1144	N
100A34	1020	22023	35895	1164	N
100A82	1019	4501	40055	1041	N
100A92	1018	6571	41190	991	N
100B33	1017	6871	43639	1004	N
100A13	1016	3419	44850	1112	N
100A93	1015	6738	41301	987	F
100A91	1014	6599	41329	991	N
100B51	1013	19157	35316	962	N
100A14	1012	3672	45039	1118	N
100A12	1011	3609	44913	1108	N
100A24	1010	6010	45440	1195	N
100A23	1009	5757	45250	1138	N
100A22	1008	5947	45314	1180	M
100A11	1007	3546	44786	1103	M
100B52	1006	19029	35376	959	N
100B32	1005	6705	43528	1002	N
100B31	1004	6733	43667	1008	N
100A21	1003	5884	45187	1144	N
100A51	1002	3994	42598	1118	N
100A52	1001	3966	42459	1149	N

Table 6. Example of a direct-fire record.

2 (10)									
1150734397	1001	1012	3966	42459	1149	4040	44793	1095	K

The last record created by the data translation software is an indirect-fire event. This record will have a 3 in the first position of the first line. In the sample shown in table 7, this record is the 16th record written. The information provided is: timestamp of the indirect-fire event; unique identifier of the target; unique identifier of the shooter if available; X, Y, and Z location of the target; X, Y, and Z location of the shooter if available; and result of the indirect-fire event. In the example in table 6, target 1009 located at X=6381, Y=43498, and Z=1007, received a firepower kill as a result of the indirect-fire event. In this example, there is no information on the shooter which would indicate damage from possibly a mine.

Table 7. Example of an indirect-fire record.

3 (16)										
1150734689	1009	0	6381	43498	1007	0	0	0	F	

We developed the data-translation software using Java 2 version 5.0 (J2v5.0). The translation application is synchronized with the other two BTO (OTB and the BTO algorithm and visualization software) components to eliminate any user intervention. One reason we selected J2v5.0 for implementation was the large number of thread-related classes to maximize processing capability. This in combination with application of asynchronous JavaScript and XML(Ajax) technology in a Web 2.0 environment during display should allow for a near real-time BTO.

4. Conclusion

The data-translation software developed at ARL provides a means to interrogate and parse large amounts of data to feed the BTO algorithm and visualization software. While the system currently uses data from a combat simulation, the algorithm can be adapted to incorporate real-time battle information from sources such as Blue Force Tracker, intelligence gatherers, and sensors. The display provides a quick overview to a Commander on areas controlled by forces. BTO would provide a technique for quick assessment of force progression for the Commander of the future and a methodology for real-time visualization of control of the battlespace.

List of Symbols, Abbreviations, and Acronyms

ARL	U.S. Army Research Laboratory
BDST	Battlespace Decision Support Team
BTO	Battlespace Terrain Ownership
OneSAF	One Semi-Automated Forces
OTB	OneSAF Testbed Baseline
PEO STRI	Program Executive Office for Simulation, Training, and Instrumentation

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