Battle Command System Analysis Methodology in the Cross Command Collaborative Effort (3CE) Environment

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ABSTRACT: The Army Modeling and Simulation Executive Council (AMSEC) recognized the requirement for a distributed modeling and simulation (M&S) capability across Army commands in March 2003. A 2-star level Memorandum of Understanding (MOU) among the U.S. Army Training and Doctrine Command (TRADOC), U.S. Army Test and Evaluation Command (ATEC), and U.S. Army Research, Development and Engineering Command, (RDECOM) formally documents this requirement in July 2003. The DUSA (OR) tasked the PM UA M&S Management Office (MSMO) to ensure compatibility among the respective M&S capabilities of TRADOC, RDECOM, ATEC, and the FCS Lead Systems Integrator (LSI) in order to support concept exploration, systems integration, analysis, and acquisition of the FCS Brigade Combat Team (BCT) System-of-Systems (SoS). This initiated the creation of an Army M&S and data environment that satisfies the requirement for a distributed M&S capability for all three commands and the LSI. This initiative is defined as the Cross Command Collaboration Effort (3CE) and is codified in a supporting MOA signed in December 2004.

An initial step in developing a process to establish a consistent set of tools, data and business processes was the 3CE M&S analysis conducted in August 2005. This analysis, sponsored by TRADOC, used a distributed, live, virtual, and constructive (LVC) environment to identify "best of breed" between selected systems for inclusion in the 3CE toolbox. Battle command was one of the functional areas assessed. The team analyzed two battle command surrogate systems. This paper provides an overview of the distributed LVC environment along with the methodology used to conduct the analysis, lessons learned and recommendations on how this process should be used to support future assessments.

1. Introduction

The Army Modeling and Simulation Executive Council (AMSEC) recognized the requirement for a distributed modeling and simulation (M&S) capability across Army commands in March 2003. A 2-star level Memorandum of Understanding (MOU) among the U.S. Army Training and Doctrine Command (TRADOC), U.S. Army Test and Evaluation Command (ATEC), and U.S. Army Research, Development and Engineering Command, (RDECOM) formally documents this requirement in July 2003. The DUSA (OR) tasked the PM UA M&S Management Office (MSMO) to ensure compatibility among the respective M&S capabilities of TRADOC, RDECOM, ATEC, and the FCS Lead Systems Integrator (LSI) in order to support concept exploration, systems integration, analysis, and acquisition of the FCS Brigade Combat Team (BCT) System-of-Systems (SoS). This initiated the creation of an Army M&S and data environment that satisfies the requirement for a distributed M&S capability for all three commands and the LSI. This initiative is defined as the Cross Command Collaboration Effort (3CE) and is codified in a supporting MOA signed in December 2004.

2. The 3CE Environment

End state for 3CE is the development of a cross command Army M&S and data environment used for design, development, integration, and testing of capabilities, systems, and prototypes. 3CE intends to provide a set of common and consistent M&S tools, data, and business processes used by TRADOC, ATEC, RDECOM, and Program of Record Manager in order to allow the Army to develop concepts, prototypes, and test and evaluation methodologies using consistent processes.

To achieve the end state described above and to enable a near-term utilization of an evolving and maturing 3CE environment, 3CE objectives must encompass two perspectives: event execution and capability development. Event execution objectives must enable an M&S environment to support the 3CE supported program of record using existing capabilities available in TRADOC's Battle Lab Collaborative Simulation Environment (BLCSE), ATEC's Distributed Test Environment (DTE), and RDECOM's Modeling Architecture for Technology Research and Experimentation (MATREX). The capability development objectives must enable a collaborative effort to identify, define, and develop a core set of M&S tools, data, and business processes that satisfy the common required environment capabilities of the three Commands and the 3CE supported program of record's materiel developer.

3. Purpose of the M&S Analysis

The purpose of the M&S analysis was to begin the identification and development of the 3CE toolbox consisting of M&S systems, surrogates, models, and tools with specific capabilities to meet force development requirements. The initial step in this process was to develop a thorough understanding of the systems. The process included identifying the requirement for which the system was designed to satisfy, the systems' capabilities and limitations, and redundant capabilities between systems. This information enables a decision on whether or not a particular M&S system, surrogate, or tool should be included in the 3CE tool box. Additionally, this information enables a "best of breed" decision between redundant systems.

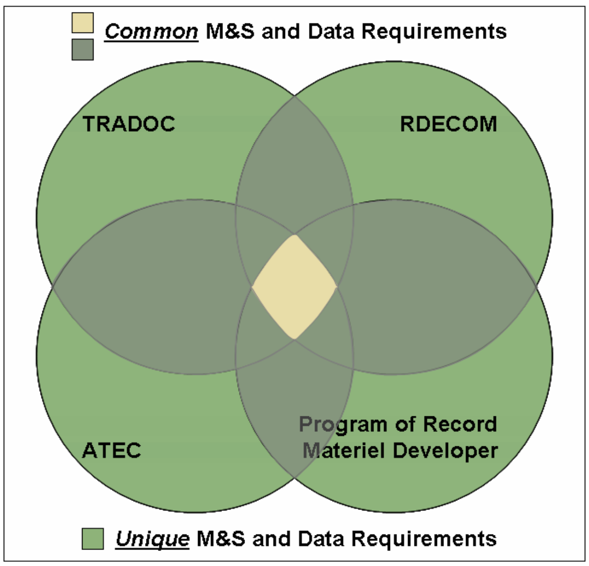

Figure 3.1

An initial screening of M&S systems available to 3CE identified several systems that appeared to perform similar functions. This apparent redundancy initially focused the M&S analysis work on two functional areas: communications and battle command. These functional areas satisfied the shared space for the supported 3CE members as depicted in the "common" M&S requirements area of Figure 3.1. Therefore, the M&S analysis comprised communications effects tools and battle command system (BCS) surrogates. Since the focus of this conference is on battle command related issues, the remainder of this paper will be limited to the battle command system surrogate analysis.

4. Future Force Battle Command

Battle Command is the art and science of applying leadership and decision-making to achieve mission success.[1] Future Forces will be enabled by Networked Battle Command which seeks a more holistic balance between art and science and between deliberate planning, leadership, and decision-making. Previous approaches over-emphasized the science and deliberate planning aspects of Battle Command at the expense of the art, leadership, and decision-making aspects. This approach inadvertently led to command posts that tethered the commander to that location, to an absence of "on-the-move" capabilities, and to multiple stove-piped systems that aided decision making in a narrow view. Two surrogate battle command systems were selected for this initial 3CE analysis: a future force battle command system surrogate and a current force battle command system surrogate. Within this Networked Battle Command environment which our future forces will operate and due to this systems of systems approach, it is critical to have a consistent battle command system when doing concept exploration and making acquisition decisions. If this does not happen, it is possible that a system conducting successful concept exploration in one command would not achieve success during testing in another command.

4.1 Analytic Methodology

There were three phases to the 3CE toolkit analysis. The focus of Phase I was to identify users' requirements for the M&S components and the tools under analysis. The analysis team solicited inputs from the commands that used the respective battle command system surrogates. The requirements provided a way to compare and contrast the systems under analysis. The like requirements provided a way to compare the systems and the unique requirements provided a way to contrast the systems (Figure 4.1). This was the basis for the analytic methodology. The requirements were developed into technical, functional, and operational metrics. These metrics provided the means to analyze the capabilities of the battle command system surrogates. The end product of this phase was the draft Data Collection and Management Plan (DCMP) that laid out the measures of merit (MoM) and data element requirements for the metrics.

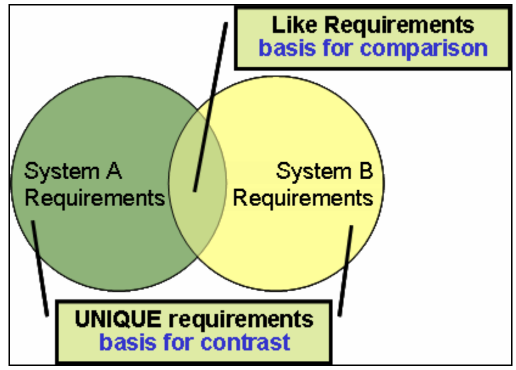

Figure 4.1

During Phase II, the analysis team assessed the data generation and data collection capabilities of the distributed LVC event to satisfy the metrics and finalized the analytic approach. During this phase, the analysis team concluded that it was infeasible to assess the operational metrics. The rationale for this decision is discussed in the Mission Threads section of this paper. The purpose of Phase III was to analyze the battle command system surrogates during the Spirals leading up to the event and during the conduct of the event.

The execution concept of operations to support the analysis is depicted in Figure 4.2. The analysis team collected the technical data before the distributed LVC event or spirals. This data consisted primarily of the system specifications. The analysis team collected the functional data during the spiral test events. This process equates to a bench-test and it enabled a better understanding and validation of the capabilities of the system. Finally, the analysis team evaluated the systems under load, in the context of the distributed LVC environment. This process equates to a field-test and it enables analysis of the system within the context of its intended use. While the analyzed communications systems were distributed, both Battle Command surrogate systems were co-located. Subject matter experts (SME) for the systems were co-located with the systems and available for consultation with the analysis team.

[1] FCS ORD w/ Change 3 (JROC Approved), dated 14 April 2003.

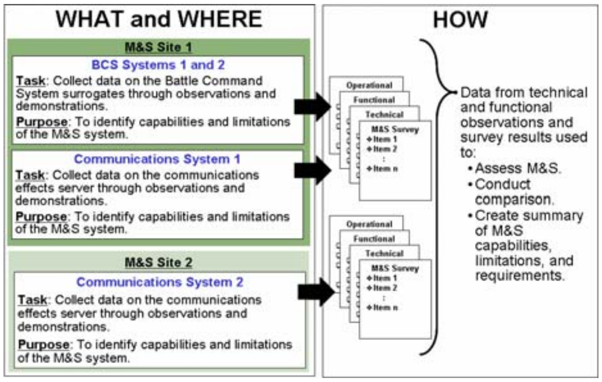

Figure 4.2

The analysis team developed and sent a questionnaire to the respective commands to identify the business processes, policies, and procedures for using these systems. Data gathered by the SMEs were combined with the questionnaire responses to assess the technical and functional capabilities of each Battle Command surrogate system. The plan was to combine these SME and questionnaire results with federation output data to support the operational analysis. However, the conduct of the event did not represent a dynamic operational environment. Consequently, federation output data could not be used to analyze the operational capability of the systems.

4.2 Scope of Comparisons

The scope of the 3CE M&S analytic effort was limited to two functional areas: Battle Command and Communications Effects. The analysis team analyzed two systems within each of these functional areas. As previously noted, this paper focuses on the area of Battle Command. The focus of the analysis was to gather data to address the issues listed in the 3CE Analysis Plan, using the Battle Command DCMP. The DCMP identified metrics, measures, data and data sources for the data needed to analyze the systems. The Analysis Plan and the DCMP were updated following Phases I and II to ensure that the previously identified analytic approach was valid and within the scope of the distributed LVC event.

4.3 Mission Threads

The analysis team identified a series of mission threads to support the operational portion of the Battle Command System surrogate analysis. These threads included Intelligence, Situational Awareness, Fires and Sustainment. The distributed LVC event used a Time Ordered Event List (TOEL) to synchronize and control the event. The analysis team reviewed the TOEL to determine which mission threads could potentially be represented during the event. Mission threads enable the analysis of the operational metrics in the Battle Command DCMP. The analysis team then cross-walked the TOEL mission threads with the Battle Command DCMP in order to identify the specific thread or threads applicable to each metric in the DCMP. The analysis team attempted to collect data on some of these threads during and following the distributed LVC spiral events. A review of the output databases resulted in a conclusion that the collection of the operational data required to support the analysis was infeasible. The primary reason for this conclusion was the fact that the tactical events could not be cross-walked with the entities associated with a mission thread. Furthermore, the static nature of a TOEL sequenced event does not support the dynamic operational conditions required to properly analyze a Battle Command System surrogate.

4.4 Sources of Data

The preferred source for data was from the M&S federation, including the components under analysis during scenario or vignette execution. The analysis team worked with the scenario development team to ensure that the scenario/vignettes created the proper context to support the comparisons. Execution of the scenario/vignettes via the TOEL did not support a dynamic operational environment; therefore, federation output data did not support the M&S analysis along mission threads. The analysis team relied on technical and functional data for analysis. Functional testing, SME interviews, and questionnaires were the primary sources of data for the M&S analysis. The Battle Command system surrogate SMEs were habitual users and event operators of the systems and technicians for the respective systems.

4.5 Comparison Environment

The Battle Command System surrogates were part of a distributed LVC environment. As shown in Figure 4.3, the environment comprised two High Level Architecture (HLA) federations and several Distributed Interactive Simulation protocol (DIS) systems. There were 65 unique federates and 130 total federates. The LVC components were distributed among various nodes/sites across the United States. Gateways translated DIS and HLA messages and a federation-to-federation bridge linked the two HLA federations.

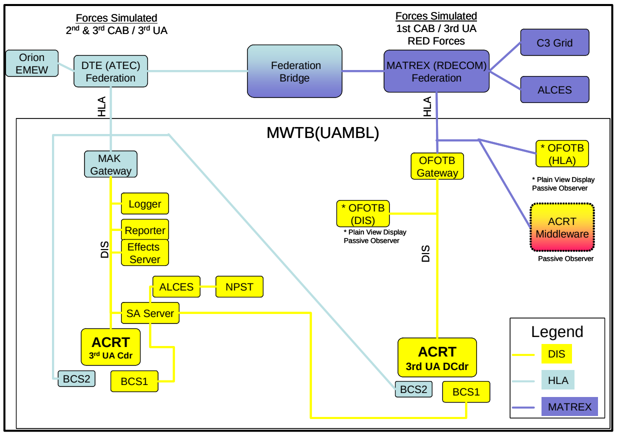

Figure 4.3

4.6 Summary of Analytic Results

There were minimal discernable technical differences between the two battle command components. The primary technical difference deals with the mechanism each uses to exchange data within a simulation-driven federation. One system used the DIS protocol to exchange information, while the other system used HLA.

Table 1 provides a summary of the battle command comparison results from a functional standpoint by summarizing the specific SME ratings based upon the MoM defined in the DCMP. In this table, each system was given a Green (G), Amber (A) or Red (R), or a combination (e.g. G/A or A/R), rating based on its ability to satisfy the study issues and corresponding MoMs. A rating of Green indicates the system fully met all of the MoMs for that area. A rating of Amber indicates the system met the MoM but not fully. A rating of Red means that the system did not have that capability. A combined rating such as G/A or A/R means that the system partially met some of the areas while not having capabilities in others. As stated in previous sections, the SMEs consisted of a combination of operators and technicians with the lead SME making the final determination of the rating.

Overall, BCS1 met more of the battle command surrogate requirements identified for the comparison. This is not surprising since the primary source of requirements for this examination and the development of BCS1 was based upon Future Force BCS requirements. BCS2 was designed to replicate Current Force capabilities in support of Army testing requirements (i.e. FBCB2). The team was unable to develop a more robust data collection capability to examine BCS2's unique capabilities since the development requirements for BCS 2 were not readily available to the analysis team. The one exception was the requirement to send and receive tactical messages (USMTF and JVMF). BCS2 performed those functions well while BCS1 did not have this capability.

Table 1: Functional Area Results

Area of Examination	BCS1	BCS2
COP Functionality	G	A/G
Intelligence Functionality	A/R	R
Fires & Effects Functionality	A/R	R
C2 Functionality	A/R	A/G
Collaboration Functionality	A/R	R
Mob/CM/Surv Functionality	A/R	A/R
Sustainment Functionality	A/R	A/R
Maneuver Functionality	A/R	A/R
Training Functionality	R	A/R
Stimulate Tactical Systems	R	G

5. Lessons Learned

As a result of executing the M&S analysis, there were numerous lessons learned that can be categorized as process improvements and technical challenges.

5.1 Process Improvements

With respect to the process, the three phased approach for the analytic methodology should be maintained; although there is room for improvement across all the phases. During planning, the systems under analysis, as well as the required capabilities, must be identified up front and have the support of all participants. Roles and responsibilities associated with the analysis must be clearly defined, and care must be exercised in the selection of systems for analysis to avoid examining dissimilar systems. All user requirements for each of the functional areas must be identified up front. Since this is the basis for the analytic metrics, this is critical to the success of the analysis. Without a clear identification and understanding of the user requirements for which the system was intended to satisfy, one cannot achieve an acceptable assessment of the systems. If all of the users are not represented by the set of requirements utilized to derive the metrics for the analysis, there may be analytic bias. Furthermore, the analysis must account for unique user requirements to highlight the unique and often user specific capabilities that the system provides the user in addition to common requirements that provide the basis for comparing systems. During Phase I, identifying valid user requirements from documented sources and gaining the consensus of the users on the metrics for the analysis is paramount. To ensure the environment supports the analysis, operational requirements (mission threads) must be identified early and data/ scenario requirements must be coordinated with the applicable working groups.

During Phase II, the Analysis team must verify that the data collection mechanisms and data repository structures are sufficient to meet DCMP requirements. They must also verify that the event environment will provide the means to employ the system under analysis within the context for which it was intended to be used. These are prerequisites to initiating Phase III. This validation of the analytic approach requires the involvement of all user representatives, to include all stakeholders agreeing to the scenario and ensuring it supports the analytic approach.

During Phase III adequate time and resources must be dedicated to the technical, functional and operational testing outlined in the DCMP. Also the data collected and archived in databases must be properly formatted, readily available, and usable by the analyst to support post-event analysis and reporting requirements.

5.2 Technical Challenges

The fundamental technical lesson learned is a recurring one for many complex federations. Insufficient time and resources are allocated for integration testing and analytic data collection verification. If an event is executed in spite of missing critical testing gates, the environment is often technically unstable or provides sporadic operability, especially in complex environments. Under these conditions, it is nearly impossible to ascertain and isolate which systems work and how they perform. The architecture and components must be fully operational during testing. For example, during the distributed LVC event used in the conduct of this analysis, there were several technical difficulties that were not identified until the conduct of the event. This was a result of incomplete end-to-end testing during the spiral events leading up to the event. These technical issues resulted in an incomplete assessment of the battle command systems. Also, when linking HLA and DIS federations there are significant challenges that arise that cause the data trail to be difficult to follow (i.e., different HLA and DIS entity IDs for the same entity). This entity ID inconsistency, along with federation components periodically going down, left gaps in the data and did not support the analytic requirements. Along these same lines, there must be a coordinated, well integrated database system designed, developed, and tested prior to execution. The data repository used during the distributed LVC event segregated the tactical, DIS and two HLA federation messages and there was no straight forward way to integrate and synchronize those messages. This made it extremely difficult and time consuming to conduct end-to-end mission thread analysis. The data repository must be centralized or must provide a means to synchronize results, while providing all users with remote access and shared products and services. In order for the data to support analysis, consistent time stamping and entity identification mechanisms across the federation are required.

Lastly, the varied business practices of the organizations involved in this event required detailed upfront planning to reconcile these differences. For example, some agencies required a rigid TOEL to support their analysis while other agencies required a more dynamic operational environment for analysis. The M&S analysis described in this paper requires both methods in order to support the functional bench-testing and the operational mission thread analysis. If the event designers do not understand or account for these analytic requirements, the conduct of the event will not support the analysis, which is the purpose of conducting the event.

6. Recommendations

As the 3CE environment matures, there will be a need for future M&S/ toolkit analyses. These and other types of cross-command analyses must be well defined and all stakeholders must have a thorough and complete understanding of the requirements. This includes well defined data elements. As part of defining these requirements early, the selection of systems for analysis should include all similar models/tools to establish a robust comparative analysis environment. The analytic methodology of analyzing the M&S systems and tools from a technical, functional and operational perspective should be maintained and improved upon, while ensuring that the architecture, scenario and data collection requirements satisfy the analytical objectives. During the technical and functional portions of the analysis, a static or bench-testing environment for each system is preferred. During the operational phase, each system should perform in its "normal" or intended operating environment under various conditions of load to demonstrate its functionality, reliability, and stability. The scenario and data collection schema must support the comparative analyses by setting the conditions for the analysis team's analysis. Lastly, the stability of the federation must be improved in order for the analysis team to understand and isolate cause and affect activities in the scenario relative to the systems under analysis and to capture usable data to support the final analysis. SMEs must be resourced to be in the correct place at the correct time to provide objective support of the analytic effort.

A few aspects that were not specifically addressed in the DCMP, but are critical to consider during a analysis such as this are cost, user training, and a vision of the future for the M&S system. Costs not only include hardware, software, licensing, and integration (all were accounted for in the technical portion of the DCMP for this analysis), but cost consideration must also account for the sunk costs of programs in development and training costs of bringing a new system into the environment. More importantly are the costs associated with improving a system selected during a "best of breed" M&S analysis to account for capability gaps previously covered by the non-selected system. Since it may require significant resources to improve even limited functionality deficiencies in an M&S system, the cost for these improvements should be closely examined and should be one of the key parameters considered prior to selecting one system over another. Lastly, is the consideration of "how does the model or tool fit with the future vision of the environment?" One should not be short-sited in planning and developing an M&S and data environment and should consider the long range goal of the environment in the conduct of the M&S analysis.

7. Conclusions

This initial 3CE M&S analysis provides a process and methodology for future efforts. Although the original intent of this comparison was to determine a "best of breed", it was realized that these systems were developed for their respective sponsors/commands for a specific purpose. Consequently, the unique user requirements for each of the systems made it infeasible to select one system to fulfill both missions. Furthermore, to recommend a "best of breed" without fully realizing the implications due to the inability to completely evaluate the systems properly would have been ill advised. This effort did provide insights on a methodology and executable process, and just as importantly, provided a better understanding of the capabilities and limitations of the systems analyzed in this environment, as well as the dynamics of conducting a distributed LVC event with several agencies with distinct and often varied methods of doing business. It also highlighted how these systems can work together in the future to achieve certain objectives and how, with further analysis, systems can be used more efficiently. With the many initiatives occurring to develop the future battle command system, this process will be able to be implemented to determine a consistent system within the 3CE environment.

8. References

[1] Future Combat System Operational Requirements Document with Change 3 (JROC approved), dated 14 April 2003.

[2] The Networked Battle Command System Users' Functional Description (UFD), dated 9 April 2004.

Author Biographies

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