3CE Modeling & Simulation Environment Reuse for Test and Evaluation

Mark A. Boyd
Trideum Corporation
4946 Research Drive
Huntsville, Alabama 35805
256.704.6100

Andrew W. Gross
Trideum Corporation
4946 Research Drive
Huntsville, Alabama 35805
256.704.6100

Kevin Hope
Tank Automotive Research, Development and Engineering Center (TARDEC)
6501 East 11 Mile Road
Bldg 200, RDTA-RS MS 264
Warren, Michigan 48397
586.574.5004

Robert Mock
Booz Allen Hamilton
1122 North Second Street
Leavenworth, Kansas 66048
913.682.5300

Keywords:
Functional Decomposition; Requirements Definition; Cross Command Systems Engineering Process; Capability Development; Modeling & Simulation Development

Abstract: *In March 2003, the Deputy Under Secretary of the Army for Operations Research (DUSA(OR)) tasked the Program Manager (PM) Future Combat System (FCS) Modeling and Simulation Management Office (MSMO) to ensure compatibility among the respective M&S capabilities of the US Army Training and Doctrine Command (TRADOC), US Army Research, Development and Engineering Command (RDECOM), US Army Test and Evaluation Command (ATEC), and the FCS Lead Systems Integrator (LSI) to support development and acquisition of the FCS Brigade Combat Team (BCT) System-of-Systems (SoS). The engine for this challenge is the Cross Command Collaboration Effort (3CE).*

The purpose of 3CE is to develop a modeling & simulation and data collaboration environment for design, development, integration, and testing of capabilities, systems, and prototypes. 3CE integrates and provides a common environment that is documented in the 3CE Knowledge Repository (KR). The 3CE environment is intended to satisfy the common requirements of all participants conducting test and evaluation.

In FY09, PM FCS BCT is testing Spin Out (SO) capabilities for the Early-Infantry Brigade Combat Team (E-IBCT) to ensure that IBCTs receive these SO capabilities as soon as possible after a series of rigorous test and evaluation activities. The Data Collection, Analysis, Instrumentation, and Simulation (DCAI&S) Working Group (WG), lead by 3CE, is responsible for identifying requirements and integrating DCAI&S solutions to support the FY09 testing events: Technical Field Tests (TFT), Force Development Testing & Evaluation (FDT&E), and Limited User Test (LUT). In order to prepare the test environment, a series of events were conducted to integrate the DCAI&S solutions and capabilities prior to hand-off to the test officer for execution.

Through a series of iterative Integration Events (IE), 3CE reused the FY08 SO-1 M&S federation and integrated new capabilities to satisfy FY09 requirements for a DCAI&S environment supported by a common, reusable M&S environment. This paper focuses on the development and implementation of the common M&S environment developed to support a variety of FY09 SO E-IBCT test and evaluation events, and discusses how this nests within the overall DCAI&S concept, and can assist in supporting future training, testing, and experimentation activities across the FCS Program.

1. Introduction

1.1 3CE Background

In March 2003, the Army Modeling and Simulation Executive Council (AMSEC) meeting recognized that multiple commands were building similar environments in support of the different aspects of an acquisition program. They determined there was a requirement for distributed Modeling and Simulation (M&S) capabilities across Army commands which promoted reuse of M&S investments and application of those across the acquisition lifecycle. This requirement was formally documented in July 2003 by a 2-star level Memorandum of Understanding (MOU) among the US Army Training and Doctrine Command (TRADOC), US Army Test and Evaluation Command (ATEC), and US Army Research, Development and Engineering Command, (RDECOM). The Deputy Under Secretary of the Army for Operations Research (DUSA (OR)) tasked the Program Manger (PM) Unit of Action (UA) Modeling and Simulation Management Office (MSMO) to ensure compatibility among the respective M&S capabilities of TRADOC, ATEC, RDECOM, and the Future Combat System (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 common requirement for distributed M&S capabilities 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.

1.2 3CE Intent

The intent of 3CE is to identify, develop, and maintain a core set of M&S tools, data, and processes and procedures that provide interoperable connectivity to link the participating organizations, providing a common environment and expertise for the Army to leverage. The end state is an environment that meets the common requirements of all three commands and PM FCS (BCT) (see Figure 1.1) to conduct distributed testing, experimentation, and training in order to assess FCS development and the impacts across Doctrine, Organizational, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF).

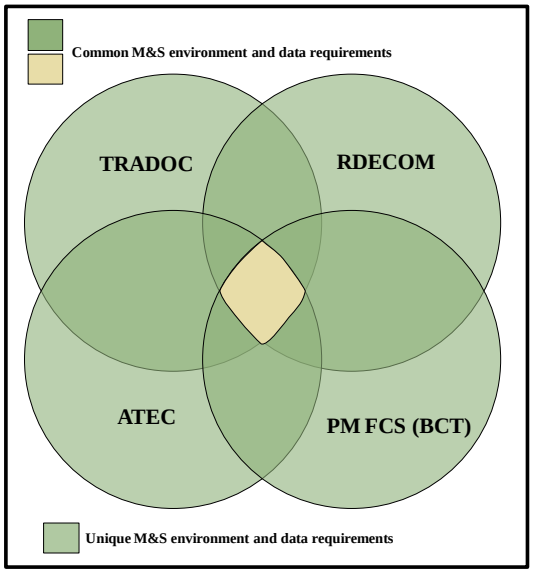

Figure 1.1. Common Requirements

1.3 Spin Out Testing Activities

Each Fiscal Year (FY), the Army has directed PM FCS to conduct a series of Spin Out (SO) test and evaluation events to determine the progress of Systems Under Test (SUT) as the FCS program moves toward its Milestone C decision. Each event has a test lead who designs their supporting M&S and data environment based on their specific analytical, technical and operational requirements. This disparate methodology results in purpose built environments with limited reuse or commonality. These complex environments included facilities, networks, M&S, requirements identification, data collection, instrumentation, data management, information assurance, and Verification, Validation and Accreditation (VV&A). Additionally, analysts and evaluators

are not able to reliably share or compare data across events.

In FY08, PM FCS SO-1 events included a Technical Field Test (TFT) conducted by the Lead System Integrator (LSI); a train-up event and Force Development Test and Evaluation (FDT&E) conducted by TRADOC; and a Limited User Test (LUT) conducted by ATEC. In support of these events, 3CE was charged to integrate a common M&S and data environment that the SO-1 event leads could leverage. The remaining components of each environment were still coordinated separately by the event test lead. While analysts and evaluators were more easily able to use data from across the events, much of the overall environment development remained stove-piped by event.

In FY09, PM FCS Early-Infantry Brigade Combat Team (E-IBCT) test events included three TFTs conducted by the LSI; two train-ups and an FDT&E conducted by TRADOC; and a LUT conducted by ATEC. In support of these events, 3CE was charged to lead the coordination and integration of a common M&S, data collection and instrumentation environment for all events. This effort became known as the Data Collection, Analysis, Instrumentation, and Simulation (DCAI&S) environment. The DCAI&S Work Group (WG) was formed to identify requirements and integrate the DCAI&S environment prior to transitioning it to each executing agency's test officer for execution of their test. While not specified in the title or initial concept, this grew to include end-to-end coordination and integration for facilities, networks, M&S, Command and Control (C2) systems, requirements identification, data collection, data management, instrumentation, information assurance, and Verification, Validation and Accreditation (VV&A).

1.3 DCAI&S

The 3CE Project Director formed the DCAI&S Work Group (WG) in November 2008 at the direction of the SO E-IBCT Council of Colonels (CoC). The DCAI&S WG established several sub-WGs consolidating the functions that previously were performed in a more stand-alone manner (see Figure 1.2).

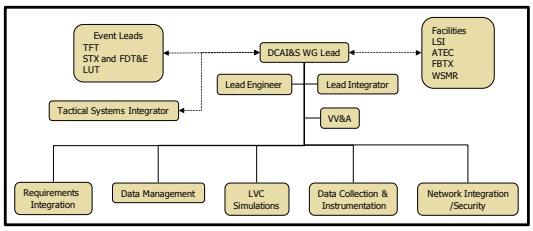

Figure 1.2. DCAI&S Organization

Under the umbrella of DCAI&S, each sub-WG performed their tasks for all FY09 test and evaluation events instead of each area coordinating separately in support of a specific event as was done in previous FYs.

The mission of the DCAI&S WG was to develop a re-usable DCAI&S environment based on the common analytical, technical and operational requirements of all the FY09 test and evaluation events. Even though this effort was bounded by both time and budget, there was still a need to execute a requirements-based systems engineering process that was responsive and enabled the decomposition of requirements to support an integration process. This process provided structured accountability in defining an integrated DCAI&S architecture to support all FY09 SO E-IBCT activities.

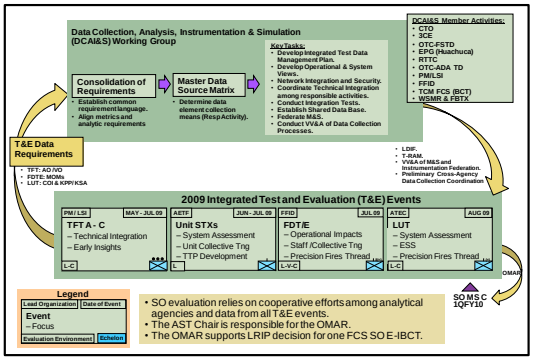

Figure 1.3. DCAI&S Coordination Process

The DCAI&S WG conducted the following two major functions near simultaneously in order to deliver an integrated, requirements driven DCAI&S environment to support the FY09 test and evaluation activities: 1) The Requirements Integration and Data Management teams worked with analysts and evaluators to identify and develop the requirements for all events; 2) simultaneously, the LVC, Data Collection & Instrumentation, and Network teams conducted a number of Integration Events (IE) establishing a re-usable environment to support the tests. Both efforts were able to leverage results from FY08

SO-1 tests since many of the SUT were the same. Once the requirements were formalized, final adjustments were made to the DCAI&S environment in order to support VV&A before transitioning the environment to the event test officers for execution (see figure 1.3).

2. Requirements

The process of identifying common requirements, aligning a common capability, and integrating – testing – verifying the aligned capability to the requirements (see figure 2.1) begins with the identification and consolidation of analytical and evaluator requirements spanning across the Army's major analytic commands, and the program of record.

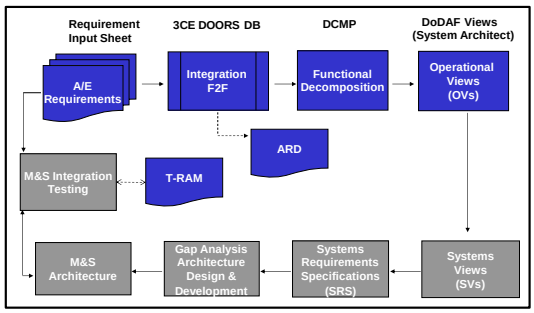

Figure 2.1. Requirements Process

These requirements are acquired from multiple and creditable source documents. Each requirement is verified for validity and integrated through an internal requirements determination process. Each event conducting agency; the LSI, TRADOC, and ATEC has requirement representatives focused on supporting the event executed by their agency. Individual event requirements identified are integrated across activities through a requirements integration workshop. Prior to the workshop, a pre-integration process is conducted to screen, and begin identification of commonality across the activities (see Figure 2.2).

The requirements, defined in the form of a Measure of Merit (MoM), are functionally decomposed to specify the variables to be measured and the available and controllable measurement space for these variables. These functional decomposition elements are documented in a Data Collection Management Plan (DCMP).

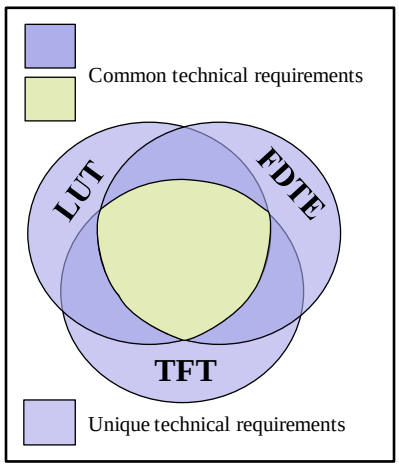

Figure 2.2. Common Technical Requirements

The team then created a set of Operational Views (OV) to help facilitate the understanding of the requirements in an operational context. The OVs are derived from the base requirement in the DCMP and contain a description of the tactical / operational sequence of events, and display the individual data elements and calculation required for the requirement. Essentially, the OVs graphically depict the required data elements and operational context (scenario) to enable the measurement space; and an integrated dictionary of terms of reference. Also embedded in the OVs are the applicable organization structure and the appropriate tasks, which are drawn from the Joint Universal Task List (JUTL) and Army Universal Task List (AUTL). The team used the Department of Defense Architecture Framework (DoDAF) to depict these OVs and descriptions. Specifically, they produced High-Level Operational Concept Graphics (OV-1), Operational Rules Models (OV-6a), and Operational Event-Trace Descriptions (OV-6C) for all requirements.

The team next developed a series of System Views (SV) to depict graphically and textually the systems and their interconnections. Again the team used the DoDAF to construct these SVs and descriptions. Specifically, they produced System Functionality Descriptions (SV-4a), Systems Data Exchange Matrixes (SV-6), Systems Rule Models (SV-10a), and Systems Event-Trace Descriptions (SV-10c) for all systems.

Next the team developed a Systems Requirement Specification (SRS) to link analytical and operational requirements to technical requirements. The SRS is a text based

spreadsheet created from the DCMP, SVs and OVs. It lists requirements for the entire system, provides traceability to data elements in the DCMP, and facilitates an analysis of derived functional requirements to identify existing M&S gaps. Once the SRS is complete, an inventory of M&S capabilities is taken and a technical requirements gap analysis is performed. This analysis is documented in a gap analysis report and identifies where the gaps are in current capabilities and influences the composition of the DCAI&S environment.

Finally the team developed and employed a tool, the Technical Requirements Alignment Matrix (T-RAM), to responsively facilitate requirements accountability. The T-RAM was used to: link technical requirements to analytic requirements providing traceability to the original requirement; link technical requirements to a common framework that categorizes the requirements; show alignment and commonality of requirements across models and simulations; and identify common technical requirements by evaluating common technical data elements to facilitate VV&A of the environment during IEs.

3. Integration and Transition

At the initial DCAI&S planning conference, the event leads and DCAI&S WG leadership used the knowledge and experience they gained from FY08 test and evaluation events to review the emerging requirements for the FY09 testing and evaluation activities. Additionally, the issues from FY08 activities and associated solutions were identified. After reviewing this information with respect to known FY09 requirements, it became clear that the integrated environment for FY09 needed to be more than simply an M&S environment. In order to meet fiscal and schedule constraints, the FY08 M&S environment would need to be closely integrated with data collection, instrumentation and the requirements integration process; the FY08 M&S environment would be reused as the starting point for the FY09 DCAI&S environment.

The FY09 schedule of test and evaluation activities drove the requirement for a series of Integration Events (IE) to establish, integrate, and test the DCAI&S environment, and transition that environment to the appropriate test lead for configuration control and execution of their event. The functionality and complexity of the DCAI&S environment increased with each IE. Throughout the five IEs, the primary purpose was to develop an environment capable of addressing the technical requirements that were being identified in parallel to IE execution (see Figure 3.1). For the first three IEs, while requirements identification was simultaneously being conducted, checklists were utilized to verify what technical milestones were being achieved. During IE4 and IE5, the T-RAM tracked which technical requirements had been successfully tested and verified.

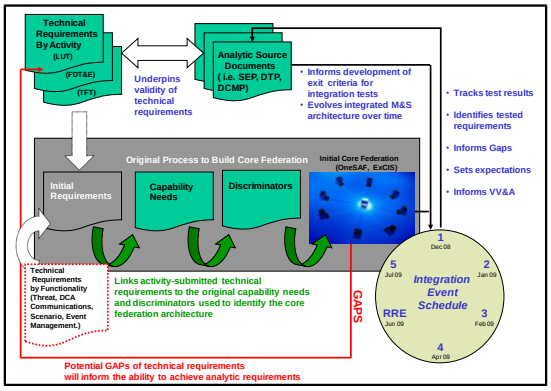

Figure 3.1. Integration Events

The first two IEs focused on identifying issues with and updating the FY08 SO-1 M&S environment to a more integrated DCAI&S environment. The primary purpose for IE1 was to conduct site-to-site network configuration testing between the range locations and Battle Command Complex (BCC) at Fort Bliss (FBTX), Texas, and the Mobile Node (MN) and Test Support Network (TSN) at White Sands Missile Range (WSMR), New Mexico. This facilitated the Technical Integration Groups (TIG) ability to verify what portions of the local networks utilized to support SO-1 in FY08 were still functional and which needed to be re-established.

For IE2, all the applications used to support SO-1 were updated to their current versions. These included One Semi-Automated Forces (OneSAF), Command and Control (C2) Adapter, Extensible C4I Instrumentation Suite (ExCIS), Joint Digital Collection, Analysis, and Review System (JDCARS), Role Player Workstation (RPWS), Digitized Army USMTF/VMF Stimulator (DAUVS), Starship / StarGen, and 3DViz. Additionally, applications known to be required for FY09 were added to the environment. These included Operational Test –

Tactical Engagement System (OT-TES) and Common Range Instrumentation System Rapid Prototyping Initiative / Ground Truth Federate (CRIIS / GTF). The TIG conducted interoperability testing of hardware / software additions and upgrades to verify both simulation and tactical data were successfully passed over the network between the range, MN and BCC.

The third IE served to establish the baseline level of capability for FY09 and focused on integration testing with M&S, instrumented vehicles, and data collection at both the MN and BCC. The TIG verified the transmission of Time-Space-Position Information (TSPI) from the live systems into the M&S federation, and the interactions between live and constructive entities for Real Time Casualty Assessment (RTCA). The instrumentation team installed the instrumentation solution on four High Mobility Multipurpose Wheeled Vehicles (HMMWV) and monitored the real time data feeds from the instrumentation package. After IE3, the data management team continued to review the collected data against the Data Source Matrix (DSM) to determine any data gaps based on analyst and evaluator data requirements.

The final two IEs focused on the requirements, and Verification, Validation, and Accreditation (VV&A) testing of the DCAI&S environment to support the TFT, FDT&E, and LUT. IE4 had several purposes which included: final testing of the DCAI&S environment to support the three TFT events, continuing integration efforts to support FDT&E and LUT, and integration of the data products for the Army's Battle Command System (ABCS). While the appropriate representative worked the integration of the ABCS data products, the TIG executed key mission threads from the TFT scenario and supported the TFT VV&A team. Once testing was completed and the integrated DCAI&S environment satisfied the TFT requirements, all software, hardware and configurations were placed under TFT configuration management and its defined Configuration Control Board (CCB) process for change control.

IE5 focused on the final testing of the DCAI&S environment to support the FDT&E and LUT. It culminated in an end-to-end load test which was executed in parallel with one of the FBTX stationed unit's training events. At the beginning of the integration event, the DCAI&S WG and the unit participating in the FDT&E each ensured their respective environments were integrated and operational for the load test. For the DCAI&S TIG, this meant verifying interoperability of M&S, instrumentation, and data collection; while the unit addressed ABCS integration and trained with their soldier and vehicle instrumentation kits. Once the two groups completed their required testing, a load test was conducted, and any remaining requirements and VV&A tests were completed. After the completion of testing, the DCAI&S environment was placed under FDT&E configuration management and its defined CCB process for change control.

Transition of the DCAI&S environment to test leads occurred twice during the execution of FY09 SO E-IBCT test and evaluation schedule. Two transitions were required because of: a change in the version of OneSAF, a change to the data collection system, and the addition of another instrumentation system. At the end of IE4, the environment was transitioned to the LSI for execution of the TFTs. At the end of IE5, the environment was transitioned to TRADOC for execution of the FDT&E. Since the environment used for the FDT&E and LUT was the same, there was no requirement to conduct another transition to ATEC for execution of the LUT.

4. Conclusion

In today's test and evaluation environment, M&S is an integral part of a much bigger integrated environment that also often includes digital data collection and instrumentation. Increasingly, test and evaluation activities are conducted under resource constraints. This drives test agencies to reuse as much of an environment as is appropriate for them to meet their requirements. While each test and evaluation activity is based on a specific set of requirements, it is likely that significant portions of established M&S, data collection and instrumentation environments can be reused. The ability to reuse the environment reduces the risk associated with developing unique environments, saves integration time and the associated dollars.

An aggressive FY09 test and evaluation schedule coupled with fiscal pressures led to the establishment of the DCAI&S WG. Responsibility for establishing and managing the DCAI&S WG was assigned to the 3CE Project Director based on 3CEs established cross

command processes, procedures, and capabilities. The 3CE processes and procedures facilitated the development of a reusable DCAI&S environment resulting from the common analytical, technical and operational requirements of all the FY09 test and evaluation events.

The requirements identification and integration activities conducted to reuse M&S between the FY08 and FY09 test and evaluation activities maximized the interoperability, flexibility, and adaptability of M&S capabilities and added other required capabilities to support activities across the commands and the FCS program. The FY08 SO-1 M&S test and evaluation environment was an integral part of the FY09 SO E-IBCT DCAI&S test and evaluation environment, and was the key enabler to facilitate meeting fiscal and schedule constraints, and delivering a requirements driven solution to test conducting agencies. It is highly unlikely that this could have been done without using the FY08 M&S environment as a start point.

5. Way Ahead

The baseline DCAI&S environment established to support FY08 and FY09 SO test and evaluation activities becomes more robust and established each year. The success of using 3CE processes and procedures to establish, maintain and adapt the environment to meet requirements is now being recognized outside of the FCS program as a means to conduct responsive and efficient integration activities for test and evaluation events.

In FY10 and beyond, it is expected that this reusable DCAI&S environment will be the starting point for the test and evaluation activities that will be conducted as PM FCS transitions to Program Executive Office (PEO) Brigade Combat Team Modernization (BCTM) and conducts Increment 1 and 2 test and evaluation activities.

Additionally, there is applicability for this environment and the associate processes and procedures to support programs and test agencies through the Joint Capabilities Integration Development System (JCIDS) process. These include PM Ground Combat Vehicle, Joint Program Executive Office (JPEO) for Joint Tactical Radio System (JTRS), and PM Soldier Weapons.

6. References

[1] Army Knowledge Online, 3CE Knowledge Repository Homepage, Data Collection, Analysis, Instrumentation and Simulation Working Group Collaboration Page: https://www.us.army.mil/suite/page/594386.

[2] Department of Defense Architecture Framework Version 1.5, Volumes I and II, 23 April 2007.

[3] FCS – TRADOC Interoperability Team Charter. 2005 Document Number 786-00000XXXXX, 30 August 2005.

[4] Harkrider, Susan; Mock, Robert. 2009. A Rapid Systems Engineering Process for M&S Events.

[5] Johnson, Eric**;** Hobson, Brian. 2007. Functional Requirement Decomposition and Analysis Enabling Cross Command Tool Design, Development, and Integration**.**

[6] ”Memorandum of Agreement (MOA) Among the US Army Training and Doctrine Command (TRADOC) Futures Center (FC), the US Army Test and Evaluation Command (ATEC), the US Army Research, Development, and Engineering Command (RDECOM) and the Program Manager, Unit of Action (PM UA)”. December 2004.

Author Biographies

MARK A. BOYD, a Senior Program Manager with Trideum Corporation, has over 22 years of experience as a field artillery and modeling and simulation officer in support of the US Army. He holds an M.S. degree in Modeling, Virtual Environments and Simulation from the Naval Postgraduate School. His current assignment is to support the Cross Command Collaboration Effort (3CE) where he is the lead for the User Support Group (USG). His current focus is as lead engineer for the Data Collection, Analysis, Instrumentation & Simulation (DCAI&S) Work Group in support of the FY09 FCS Spin Out (SO) Early-Infantry Brigade Combat Team (E-IBCT) test and evaluation activities. Previously he was the chief of the Fort Lewis Mission Support Training Facility, and the director or the US Army Alaska Battle Command Training Centers.

ANDREW W. GROSS, a Senior Analyst with the Trideum Corporation, has over 10 years of experience in modeling and analyzing complex management information systems (command and control) and combat development problems as an Operations Research Analyst in support of the US Army. He holds an M.S. degree in Operations Research from the Florida Institute of Technology. His current assignment is as the technical lead for the User Support Group (USG) of the Cross Command Collaboration Effort (3CE). In this assignment, his effort includes serving as the integration events lead for the Data Collection, Analysis, Instrumentation & Simulation (DCAI&S) Work Group in support of the FY09 FCS Spin Out (SO) Early Infantry Brigade Combat Team (E-IBCT) test and evaluation activities. Prior to his current assignment, Mr. Gross served as the Test Design and Analysis Working Group lead for the Joint Battlespace Dynamic Deconfliction (JBD2) Test Event and the technical lead for the Combat Service Support (CSS) Battle Lab Collaborative Environment (BLCSE).

KEVIN M. HOPE, an NH-III civil servant with the Tank Automotive Research, Development and Engineering Center (TARDEC), has over 10 years of experience as a Computer Engineer. He holds a B.S. degree in Computer Engineering from Kettering University. His current assignment is to support the Cross Command Collaboration Effort (3CE). He is the lead for the Data Collection, Analysis, Instrumentation & Simulation (DCAI&S) Work Group's Live Virtual Constructive (LVC) Team in support of FY09 Future Combat System (FCS) Spin Out (SO) Early - Infantry Brigade Combat Team (E-IBCT) test and evaluation activities. He also provides Modeling and Simulation management and technical support to the Program Executive Office (PEO) Ground Combat Systems (GCS) Mine Resistant Ambush Protected (MRAP) program at TARDEC.

ROBERT K. MOCK, a Senior Analyst with Booz Allen Hamilton, has over 23 years of experience as an aviation officer and senior operations research analyst in support of the US Army. He holds a B.S. degree in Biology from the University of South Dakota and an M.S. degree in Management from Webster University. His recent efforts have focused on the identification, development, decomposition, and management of requirements, enabling technology design and development for a distributed modeling and data environment Mr. Mock had a distinguished military career with the US Army where he served in various positions concluding as a senior military analyst with the US Army TRADOC Analysis Center (TRAC) at Fort Leavenworth.