

FUTURE COMBAT SYSTEMS SPINOUT 1 TECHNICAL FIELD TEST – ESTABLISHING AND IMPLEMENTING MODELS AND SIMULATIONS SYSTEM OF SYSTEMS VERIFICATION, VALIDATION AND ACCREDITATION PRACTICES, METHODOLOGIES AND PROCEDURES¹

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Abstract

As our Armed Forces transform, assisted by the Brigade Combat Team (BCT) Modernization effort, the use of Models and Simulations (M&S) becomes more crucial in supporting major Department of Defense and Congressional decisions, given limited resources and strategic constraints. The Army's program leading the transformation from 2003 to 2009 was Future Combat Systems (FCS) with 14 systems + The Soldier + their network. For Phase 1 (IP1) Spinout 1 (SO1) Technical Field Test (TFT), three live systems (i.e., Non-Line of Sight-Launch System (NLOS-LS), Unattended Ground Sensor (UGS), and B-Kits) participated and were tested in 2008 via a slice of the Current Force (CF) BCT structure. To ensure realistic operational context, a M&S System-of-Systems (SoS) level federation was developed providing virtual and constructive simulation capabilities that enabled holistic testing with complex integration among all entities in a distributed Live-Virtual-Constructive (LVC) environment. This included interfaces to live entities and instrumentation via tactical messages, and constructive representation of platforms, vehicles, and terrain. The M&S federation also provided test control, data collection, and live range interactions.

The foundation for the Accreditation process of the SO1 TFT federation was the Verification, Validation and Accreditation (VV&A) Overlay to the DoD High Level Architecture (HLA) Federation Development and Execution Process (FEDEP). A three-phased V&V process was used that provided component level V&V, initial Federation V&V via multiple M&S integration events, with the final events performed in the FCS Mobile Node. The SO1 TFT M&S Federation developed by the Cross Command Collaboration Effort (3CE) was part of the "common SO1 M&S/tools federation solution" for all SO1 test events.

The Acceptability Criteria were developed via an iterative process, involving the Test Manager and all VV&A Teams, that began with identifying Assessment Objectives associated with M&S for IP1 SO1 TFT that can be traced back to the FCS requirements/capabilities and TRADOC Operational and Organizational documentation. Once the Acceptability Criteria and Metrics (ACM), 9 and 25 respectively, were approved several traceability analyses were conducted with ACMs thoroughly examining the 213 M&S requirements and M&S intended uses developed by the Test Manager. The results helped to form a solid foundation for accreditation assessment providing focus in building the body of V&V evidence and the accreditation methodology.

To verify M&S requirements and objectives the Accreditation Team worked closely with V&V Teams, Test Manager, 3CE and all M&S component developers during all Integration Events to understand functions and capabilities of TFT M&S Federation and each individual component, data, and support tools. This invaluable experience provided insight on data collection and format, terminologies used, and expectations.

Accreditation assessments were conducted to support preliminary and final Test Readiness Reviews (TRR). The Accreditation Assessment rating used was a 5-point satisfaction-risk table developed by Accreditation Team. By the final TRR all requirements were verified, all results validated, and all accreditation metrics and criteria were met successfully demonstrating an Unconditional Accreditation of the SO-1 TFT M&S Federation in support of the SO1 TFT Runs for Record.

Keywords: Models, Simulations, M&S, Verification, Validation, Accreditation, VV&A, Federation, System of Systems, LVC, Live Virtual, Constructive

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1. Introduction and Background

As our Armed Forces transform, assisted by the Brigade Combat Team (BCT) Modernization effort, the use of Models and Simulations (M&S) becomes more crucial in supporting major Department of Defense and Congressional decisions, given limited resources and strategic constraints.

The U.S. Army's program leading the transformation from 2003 to 2009 was Future Combat Systems (FCS) with 14 systems + The Soldier + the supporting network. For Phase 1 (IP1) Spinout 1 (SO1) Technical Field Test (TFT), three live systems (i.e., Non-Line of Sight-Launch System (NLOS-LS), Unattended Ground Sensor (UGS), and B-Kits) participated and were tested in 2008 via a slice of the Current Force (CF) BCT structure. To ensure realistic operational context, an M&S System-of-Systems (SoS) level federation was developed to provide virtual and constructive simulation capabilities that enabled holistic testing with complex integration among all entities in a distributed Live-Virtual-Constructive (LVC) environment. The federation included: interfaces to live entities and instrumentation via tactical messages; constructive representations of platforms, vehicles, and terrain; test control, data collection, and live range interactions.

2. Constraints

When Army Leadership decided that the M&S Federation supporting the SO1 TFT required Accreditation, there were many constraints regarding the SO1 test events already in place. Although the Accreditation Team was not involved from the very beginning, the team was able to work within the "constraints" framework and make a positive impact. Some of the "constraints" in place were:

1. VV&A roles and responsibilities

A different organization was responsible for each test event; therefore, a different organization was responsible for accrediting the M&S that supported a given test event.

2. Essential FCS documents (e.g., plans and requirements documents)

The initial draft of V&V Plan was started before the Accreditation Team came on board.

3. Planning and Execution Test Schedule

Less than one year was scheduled to conduct the SO1 TFT Accreditation Assessment. The Accreditation Team's involvement began after everyone else.

4. There were 307 Test Requirements generated by Test Manager, the Lead System Integrator (LSI), the contractor that executed the SO1 TFT event. Once the Acceptability Criteria (AC) and Metrics (ACMs), were finalized and approved, they were analyzed against the 307 Test Requirements². The Accreditation Team identified 94 as being necessary for the test event but outside the VV&A scope leaving 213 identified as M&S Requirements.

5. M&S Federation, M&S support tools, and data integrated by the Cross Command Collaborative Effort (3CE)

The 3CE Group was responsible for defining "the M&S Common Solution" for all the SO1 Events (i.e., TFT, FDT&E, LUT and Train-up). The 3CE addressed M&S issues and requirements, defined the M&S architecture, and performed M&S integration and testing.

3. Accreditation's Team Approach Used to Accredite the M&S Federation

The approach followed was the Federation Development and Execution Process (FEDEP), but was tailored to fit the needs and requirements of the BCT-M Program. As stated earlier, 3CE developed the M&S Federation and also led the integration events.

The Acceptability Criteria were the "heart and soul" of the M&S Federation Accreditation because they address the suitability of the M&S Federation for the current intended specific use and guided the collection of V&V artifacts. Before developing the Acceptability Criteria, a solid understanding of the supported test event was acquired. The Acceptability Criteria were developed based on three converging elements:

1. Program and Technical Path – The Program factor was based on the test Assessment Objectives (AO) that were traced through System of Systems (SoS) Engineering and Integration (SSEI) Integrated Product Team (IPT) documentation back to FCS Program requirement documents. Specifically, the 31 AOs for the SO1 TFT were reviewed and analyzed. Only 10 system-oriented AOs were identified as being associated with M&S.

² The SO1 TFT Test Requirements were identified in the Technical Requirements Alignment Matrix (T-RAM), which showed the link to the Objective System Test Requirement Document (OSTRD) via a Requirements ID (RID) number.

The Technical factor was based on the 307 Test Requirements, developed by the Test Manager, to support the test event. The list of 307 Test Requirements were analyzed against the initial set of Acceptability Criteria Metrics, and many were identified as not applicable (NA) or outside the VV&A scope though necessary for the test event. Therefore, out of the 307 Test Requirements, 213 were determined to be “true” M&S Requirements. The analyses conducted on the AOs and Test Requirements helped to refine and shape the Acceptability Criteria and Metrics.

2. Policy Path – The Policy Path was based on DoD, the Army, and Command-oriented policies. The specific policy guides supporting this test event were: DoD 5000.61 (DoD); DA PAM 5-11 (Department of the Army); and ATEC Reg 73-21 (HQ Army Test and Evaluation Command). From these policies, three additional and essential criteria were identified: configuration management, data pedigree (i.e. obtained from an authoritative source); and federate components communication amongst themselves.

3. Intended Use Cases Path – The Intended Use Cases Path was based on the Detailed Test Plan that identified the test cases to be executed during the test. Before finalizing the Acceptability Criteria and Metrics, the test cases were reviewed and analyzed against the Intended Uses looking in-depth at the specific Use Cases or test scenarios and how the M&S was applied.

From these three converging paths, three Traceability Analyses Matrices were developed:

1. Acceptability Criteria Metrics (ACMs) to the Assessment Objectives (AOs);
2. ACMs to the 307 M&S Test Requirements, defined by the Test Manager; and
3. ACMs to the Intended Uses (IUs).

From these traceability analyses conducted six benefits were derived as follows:

1. Helped to refine and shape the Acceptability Criteria (AC) and the Metrics (ACMs);
2. Resulted in identifying 213 requirements as being “true” M&S requirements;
3. Provided the essential underpinning for the Accreditation Assessment methodology, including how best to present the traceability and support of the V&V evidence in a top-level

Accreditation Assessment summary format;

4. Served as useful template to present top-level Accreditation Assessment summary in the most test related context, from the customer’s and user’s perspective, supported by the M&S requirements traceability matrix;
5. The ACMs and the Test Requirements Traceability Analysis were deemed “priceless” by both the V&V and Accreditation Teams. The Traceability Matrices were the “backbone” of the Accreditation Assessment methodology providing a solid foundation to explore and present the data from multiple perspectives: Acquisition Decision maker, Test Manager, Test evaluator and M&S SME.
6. These rigorous Accreditation activities allowed 9 Acceptability Criteria and 25 Acceptability Criteria Metrics to be approved for the SO1 TFT M&S Federation.

Some of the V&V activities proved to be of great help to the Accreditation Team including the development of two standardized forms:

- V&V M&S Federation, federates, components, and support tools Description Form - standardized format of V&V documentation that described in detail what the M&S component brought to table and how it would be used. These forms were completed by the component developers.
- V&V Artifact Log Form - described the M&S requirement in detail, data collection events, verification method & status, ACMs supported, procedure and results. The log forms were completed by the V&V Team. The form provided standardized format as part of V&V process and documentation supporting the M&S Accreditation.

4. Results

The SO1 TFT M&S Federation was part of the “common SO1 M&S/tools federation solution” for all SO1 test events. However, each test event had different responsible organizations, test objectives, applications, and M&S requirements. Based on these differences and required updates to the SO1 M&S Federation to support subsequent tests, per AR 5-11, a separate accreditation of the federation

was required for each intended use, in this case, for each test event.

The Accreditation, V&V and Independent V&V (IV&V) Teams participated in the SO1 TFT Federation Integration Events (IE) in order to understand the federation and its components and to verify the M&S requirements and objectives. The IEs were also used to validate the M&S requirements and Assessment Objectives of the SO1 TFT M&S Federation. The IEs, which took place from October 2007 to January 2008, served as the final V&V events to ensure that all problems identified during earlier IEs were fixed and to demonstrate that the SO1 TFT Federation functioned as expected in support of the SO1 TFT. Due to software delays, the final acceptance event was the TFT Dry Run which took place in February 2008, just days before SO1 TFT execution.

The Preliminary Test Readiness Review (PTRR) was held on 25 January 2008 and the overall recommendation presented by the Accreditation Team was to continue with TFT as scheduled, because MET was anticipated by the Test Readiness Review (TRR).

Additional testing was completed, and data were collected during the TFT Dry Runs, 13 - 19 February 2008.

The TRR was held on 22 February 2008. The overall accreditation status at the time of the TRR was “Met” for the following reasons:

- All requirements were verified;
- All results were validated; and
- All Acceptability Criteria were Met.

There were no outstanding Accreditation issues. All M&S capabilities needed for SO1 TFT were successfully demonstrated prior to the TRR. Acceptability criteria metrics were sufficiently met to support a favorable accreditation recommendation prior to SO1 TFT TRR.

The overall recommendation presented by the Accreditation Team was an Unconditional Accreditation of the SO-1 TFT M&S Federation in support of the SO-1 TFT Runs for Record. The “Accreditation Decision Memorandum for Record (MFR)” dated 22 Feb 2008 officially authorized the use of the SO1 TFT Federation in the SO1 TFT Test for Record.

5. Lessons Learned

The lessons learned fall into three categories: operational / implementation; process; and the combination of the two categories.

Operational / Implementation

- Participate in Integration Events and Dry Runs,
- Develop Traceability Matrices,
- Develop relevant Acceptability Criteria and Metrics,
- Expand Intended Uses to include Metrics, and
- Leverage resources and VV&A documentation where possible.

Process

- Start early – planning & working with complete VV&A Team,
- Engage all stakeholders early,
- Coordinate the staffing and approval requirements,
- Develop Accreditation standardized formats,
- Refine V&V standard forms to better support Accreditation, and
- Establish an Accreditation process that can be used in subsequent tests, if possible.

Both Categories: Operation / Implementation and Process

- Encourage Team work, and
- Use a collaborative environment – to make information sharing and internal reviews easier.

6. Sharing VV&A Forms/Formats Developed

The SO1 TFT VV&A Team developed 5 forms and /or formats that were proven useful regarding V&V and Accreditation activities. Further the usefulness of these forms and formats, listed below, have been substantiated via support to other test and demonstration events:

1. M&S Federation, federates, components, and support tools form



V&V Form
Description for M&S f

2. V&V Artifact Log form



V&V Activity Log -
Blank Form.doc

3. Acceptability Criteria Traceability to M&S Requirements Matrix



Traceability Analysis
Matrix form.xls

4. Accreditation Assessment (AA) Summary



M&S Accreditation
Assessment Summary

5. AA M&S Intended Use Summary



Accreditation
Assessment Intended

7. Conclusion

This paper presents the Accreditation activities conducted on the M&S Federation supporting the SO1 TFT to ensure realistic operational context. An M&S System-of-Systems (SoS) level federation was developed to provide virtual and constructive simulation capabilities that enabled holistic testing with complex integration among all entities in a distributed Live-Virtual-Constructive (LVC) environment.

Specifically, this paper discussed how the Accreditation Team:

1. Dealt with constraints;
2. Developed the Accreditation Criteria and Metrics based on the convergence of three paths: Program and Technical Path; Policy Path; and Intended Use Cases Path;
3. The three Traceability Analyses conducted and their benefits;
4. Identified two standardized forms developed by the V&V Team that were found to be most helpful;
5. Summarized the results of the Accreditation Assessment to support readiness reviews;
6. Provided the summarized Accreditation results presented at readiness reviews;
7. Identified lessons learned; and

8. Provided blank forms and formats that would be useful for the conduct of V&V and Accreditation activities supporting any test or demonstration events.

8. References

DoD Directive 5000.61, “*DoD Modeling and Simulation (M&S) DoD Verification, Validation, and Accreditation (VV&A)*”

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Briefing - “*Accreditation Assessment for the Test Readiness Review (TRR)*” dated 22 February 2008

“*Accreditation Report for the Modeling and Simulation Federation Supporting the Future Combat Systems (FCS) System of Systems Development and Demonstration (SDD) Integration Phase 1 (IP1) for Spin Out 1 (SO1) Technical Field Test (TFT)*” dated 3QFY09

9. Authors' Biography

DEBRA RIDGEWAY is an Operations Research Systems Analyst with over 27 years of experience, of which 10 years has been focused on Modeling and Simulation policies, use and implementation. Her experience was gained working at the Army Materiel Systems Analysis Agency; the Soldier and Biological, Chemical Command; HQ Army Materiel Command; and HQ DA, G-3/5/7. Currently, Debra is matrixed from the HQ Developmental Test Command (HQ DTC), to support the PM Combined Test Organization, PEO-Integration. She is responsible for accrediting M&S Federations supporting Technical Field Test and laboratory demonstration events.

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