Integration of Simulations, Battle Command, and Technology

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ABSTRACT: *The 2008 SIMCI Combined project resulted in a successful robust demonstration of integration of Battle Command, Simulations, and emerging Technology. The 2009 SIMCI Combined project is being executed by a team from Project Manager Battle Command (PM BC), PM OneSAF, and George Mason University. It will expand the standard, Net-Centric Enterprise Services compatible, web-service interface between simulations and BC which can be re-used readily by many systems. It also will expand the standard Army Net-Centric Data Strategy compliant, JC3IEDM based, mediation capability for BC and Simulation systems to use. The capability provided includes advanced technology support for automated plans, orders, and reports that will reduce training costs and improve tactical operations effectiveness. The products from this project will be incorporated as part of the Battle Command Common Services within the Army BC System by PM BC and fielded as part of the C2 Adapter within OneSAF by PM OneSAF. The tools and reusable components are also being provided to the ArmyCIO/G-6 for standard common Army wide use.*

1 Background

The Simulation to C4I Interoperability (SIMCI) Overarching Integrated Product Team (OIPT) manages the SIMCI program. The SIMCI OIPT was chartered in FY2000 by the Deputy Under Secretary of the Army for Operations Research (DUSA OR) and the Army Chief Information Officer (CIO/G6). The SIMCI OIPT is co-chaired by the Program Executive Officer for Command, Control & Communication Systems, Tactical (PEO C3T) and the Program Executive Officer for Simulation, Training, and Instrumentation (PEO STRI). The OIPT currently includes 33 member organizations representing material developers, combat developers, and policy makers, working across the TEMO, ACR and RDA domains, including the live, virtual, constructive, and test communities. The SIMCI OIPT leadership is made up of a nine-member executive council with a core group for decision making.

The purpose of SIMCI is to achieve full interoperability between Modeling and Simulation (M&S) systems and Battle Command (BC) systems as an integral part of the acquisition process, from capabilities determination through fielding and sustainment. SIMCI provide policy, process, organizational, and technical recommendations to Army Leadership that will improve M&S and BC systems interoperability.

The SIMCI objectives include improving the operational effectiveness of BC systems by:

- Achieving standardized/common interoperability solutions between M&S and BC systems.
- Ensuring alignment (and commonality, where feasible) of M&S and BC systems' standards, architectures, data, components, and services.
- Enhancing future the Army's LandWarNet/Battle Command (LB) capabilities through increased M&S and BC integration and interoperability.

- Institutionalizing interoperability designs and processes for both M&S and BC systems.

Current Battle Command (BC) and Modeling and Simulation (M&S) applications do not share a common data model. Even within the Battle Command domain or within the Modeling and Simulation domain, virtually every instance of each of type of system has its own representation of data which is not common.

The Army and Joint C2 communities are attempting to solve this data model inconsistency by standardizing on the JC3IEDM as the Common Data Model. Legacy systems such as existing BC and M&S most probably will not re-implement their internal data models to be the JC3IEDM.

The SIMCI OIPT funds small projects that address key SIMCI issues/shortfalls. One of those projects provides a standard Net-Centric web-service interface between M&S and BC which will provide improved BC systems operations, training, and testing in Army, Joint, and coalition environments. This project is called the SIMCI Combined Project since it is the integration of three individual projects.

2 Project Description

2.1 2007 Phase 1 Project

The 07 SIMCI funded program combined the efforts of the Common C4I Adapter team with the PM Common Software team to add JC3IEDM support to the Common C4I Adapter as well as interfacing it to the ABCS developed SADI SOAP server via JC3IEDM using a Web Service interface. The objectives of this combined effort were accomplished in the resultant interfaces developed and demonstrated to the SIMCI community at the November 6-8, 2007 SIMCI meeting.

2.2 2008 Phase 2 Project

In its 2008 program SIMCI funded a JC3IEDM Combined Project (JCP). Its goal was to extend currently supported data sets to include Plans/Orders, Tasks, and Materiel, thereby increasing information exchange capabilities between the M&S and ABCS communities. The existing Battle Management Language (BML) solution was leveraged to exchange Plan/Order and Task information. The objective was met jointly by teaming three individual SIMCI projects of PM Battle Command, PM OneSAF, and George Mason university (GMU).

The purpose of this project was to:

- Provide standard NCES compatible web-service interface between M&S and BC which can be re-used readily.
- Provide standard JC3IEDM compliant mediation capability for use by BC and M&S systems.
- Extend currently implemented interoperability to include support for automated Plans, Orders, and Reports.

The objectives of this project are to:

- Build an ABCS Battle Command Common Server Data Mediation Service (DMS) to mediate between the ABCS DDS data format and the US-JC3IEDM data format.
- Incorporate a JC3IEDM mediation service into the C4I Adapter and augment OneSAF to accept electronic automated plans and orders.
- Build a generic Army JC3IEDM Reference Implementation (RI) Web interface, including a publish-subscribe capability, that is NCES compliant for incorporation into the C4I Adapter and the DMS.
- Incorporate the standard Army JC3IEDM Software Development Kit Java Classes into the Reference Implementation (RI) for the C4I Adapter and the ABCS DMS.
- Incorporate the Battle Management Language common method to exchange electronic automated Plans, Orders, and Reports information in the RI for the C4I Adapter and ABCS DMS.

3 Project Leads

- Dr. Stan Levine, SIMCI, Project Architect
- Mr. Ted Troccola, Battle Command Technical Lead
- Ms. Lori Topor, Modeling & Simulation Technical Lead
- Dr. Mark Pullen, Battle Management Language Technical Lead

4 Battle Command (BC) Design and Implementation Plans

The Army Battle Command System (ABCS) community distributes data via the Data Dissemination Service (DDS). The format of this data is specified by the Publish and Subscribe Services (PASS) schemas.

Data providers advertise data while data consumers subscribe to receive information via DDS. To avoid many point-to-point connections, as well as data translations, the data is distributed in the format of the PASS schemas.

Details about how DDS works and the content of the PASS schemas are available on the Army Knowledge Online (AKO) website [6]

Documentation describing which systems publish and subscribe to specific data is also on the AKO [7].

The Army Battle Command System (ABCS) Data Dissemination Service (DDS) Data Mediation Service (DMS) provides a US-JC3IEDM Web Service interface to the ABCS community. One of the primary functions of the ABCS DDS DMS is to mediate between the US-JC3IEDM and Publish and Subscribe Services (PASS) data formats.

4.1 Overview

Currently, Web Services provide the preferred means of communications for distributed systems. The ABCS DDS DMS will be deployed as a Web Service and fielded as part of Battle Command Common Services.

Because the entire ABCS community exchanges data using DDS and the PASS XML schemas define the format of the data distributed in DDS, the DMS acts as a gateway to the entire ABCS community by translating foreign data formats to the internal ABCS format (PASS) that is exchanged within the ABCS community.

Instead of exposing a PASS XML interface, the DMS exposes a Web Service interface that is based on the US-JC3IEDM. This component is known as the US-JC3IEDM Reference Implementation (RI) and was also built as part of the FY08 SIMCI Combined Project.

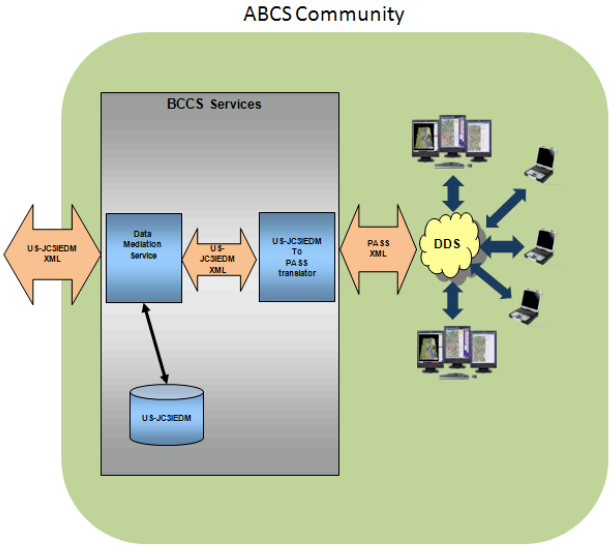

Figure 1. ABCS DDS DMS Architecture

4.2 Architecture

As shown in *Figure 1. ABCS DDS DMS Architecture*, the ABCS DDS DMS consists of two components: the advertised Data Mediation Service and a US-JC3IEDM to PASS translator.

The Data Mediation Service's advertised WSDL is that of the US-JC3IEDM Reference Implementation (RI). As mentioned previously, the US-JC3IEDM RI is a reusable component that was also built as part of the SIMCI FY08 Combined Project.

The second component, the US-JC3IEDM to PASS translator, is responsible for mediating between the two data formats. It acts as a publisher and subscriber to both, the US-JC3IEDM RI and DDS. The data received by the RI is mediated and distributed to the ABCS community and vice-versa.

4.3 Supported Data

The DMS distributes data to the ABCS community using a total of ten PASS data schemas.. A general description of the data mapping is included in Table 1 below. Any ABCS systems that advertise or consume data of these types is able exchange data using the services provided by DMS. Since the DMS is using US-JC3IEDM as its external data standard, these systems are "JC3IEDM compliant".

PASS SCHEMA	US-JC3IEDM DATA
POS-RPT	Friendly/Neutral organizations
ENEMY-SIT	Hostile/Unknown organizations, features and facilities
OBS-POS	Uncorrelated hostile/unknown organizations
GEO-REF	Uncorrelated unknown facilities and features
GRAPHICS	Friendly/Neutral/Hostile non-organizations
TASK-ORG	Friendly Organization Structures
ORG-STAT	Organization Status
IND-WARN	Same or similar mapping as ENEMY-SIT
CTFP	Same or similar mapping as ENEMY-SIT
SIG-ACT	Same or similar mapping as ENEMY-SIT

Table 1. PASS Schema to US-JC3IEDM Data mapping

4.4 DMS in the SIMCI FY08 Combined project

Plan and order information was generated in the ABCS systems, translated to US-JC3IEDM and sent to the M&S systems. The simulation systems acted on the order information and began executing the simulation. The information was then translated back to US-JC3IEDM and sent to the ABCS community. When received, it was translated to the PASS data format and distributed to the ABCS community via DDS.

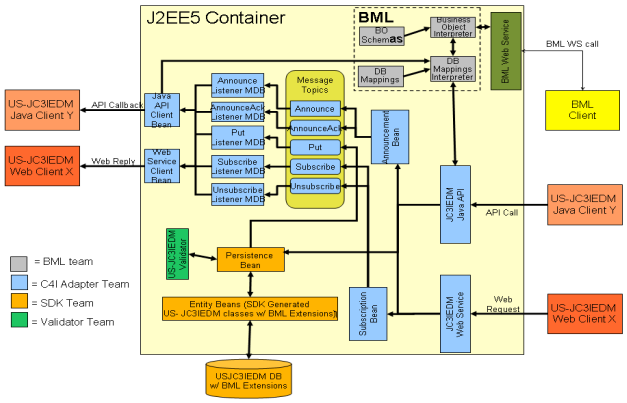

Figure 2. SIMCI JC3IEDM Combined Project SDK RI with Scripted BML Capability

4.5 DMS enhancements in FY09

Although a success, the FY08 effort and demonstration identified areas that required attention in order to ready this solution for fielding.

The DMS's architecture was chosen to enable the simple introduction of other mediators. The plug-in design that was originally implemented was less than optimal. The ability to create mediator plug-ins was not as easy as initially desired, the ability to enable/disable plug-ins was not trivial, and the internal management of mediators was not scalable. These issues will be addressed in this year's effort.

The mapping between JC3IEDM and PASS is developed and maintained by the US MIP community. The FY08 effort identified problems when handling "loggable" JC3IEDM data entities. In order to ensure maximum interoperability with the coalition this module will once again be utilized. However, loggable data entities will be handled differently than non-loggable data entities. This will ensure accurate data when sharing historical data.

Also, security was not addressed in the FY08 solution. The DMS team will be creating web service handlers that support using TS3 security for the web service interface. The handlers will be bundled as part of the RI for use by all future RI users. The DMS team chose to implement this form of security based on requirements for fielding on part of the BCCS.

5 Modeling & Simulation (M&S) Design and Implementation Plans

As noted above, current Battle Command and Modeling and Simulation applications do not share a common data model; virtually every instance of each of type of system each have its own representation of data which is not common. We are addressing this using the JC3IEDM as a common model for data.

Legacy systems such as existing BC and M&S most probably will not re-implement their internal data models to be the JC3IEDM, however. This would require tremendous time and money and would provide little value add for the legacy systems that have few, if any, new requirements to fulfill (i.e. are in Maintenance mode). If a capability existed such that different data model implementations (BC and M&S) could be translated to a common implementation of the JC3IEDM, and a "standard" translator from the JC3IEDM to the target data model representation (JVMF 6017, Simulation one FOM representation, etc.) were available, tremendous reuse of translation code could be available for other applications with requirements to interface to the same target data model representation. In addition, future BC and / or M&S applications that had requirements to interface to the target data model would be able to "talk" to the legacy applications via the common JC3IEDM interface.

The purpose of the Modeling and Simulation JC3IEDM plan is to build a Common JC3IEDM application that enhances the maturity of the tools and services available to access the JC3EDM, as well as enhance the maturity of the actual data model itself. In addition, the purpose of the M&S plan is to build translators and tools that can be reused or enhanced by M&S applications in addition to Battle Command systems in order to be JC3IEDM compliant and to natively interface to external systems via the JC3IEDM. The C4I Adapter team is responsible for building the JC3IEDM Reference Implementation as shown in Figure 2.

The design of the JC3IEDM Reference Implementation (RI) (Figure 2) uses current industry standards such as Service Oriented Architecture (SOA) and J2EE, is publish / subscribe based, and has been designed and implemented with reuse and extensibility as two driving requirements. The RI specifically has been built so that any application that has the need to interface to the JC3IEDM will be able to use and enhance the RI to suit its unique requirements. Much effort has been expended on ensuring a loose coupling (facilitating maximum reuse by disparate applications), while still providing rich JC3IEDM functionality.

The RI has been built, integrated and tested in cooperation with the other teams as shown in the preceding diagram. This has enabled early feedback and robust test by external users, thereby hardening the RI in the process.

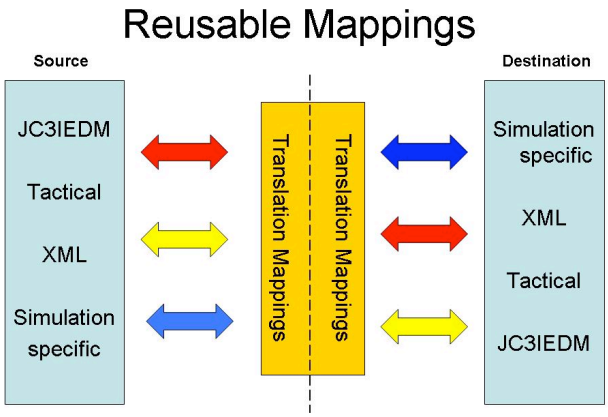

Figure 3. Mapper Generator

The C2 Adapter also includes a Mapper Generator Application which allows creating translation mapping via a GUI (Figure 3). These translation mappings are the runtime code that is executed to transform the input data into the desired output data. The GUI displays the "to" and "from" data models and allows dragging and dropping from the input source to the destination source, including reusable and extendable "converters" between the data sources that come into play when the form of the parameter needs to change (such as modification to the format of the date-time group, or string to integer, or more complicated converters).

As part of the JC3IEDM effort, the Mapper Generator is being enhanced so that part of the Translation Mapping files can be reused, greatly enhancing the reusability of the translation mappings. For example, when a Mapper file is created to translate between the OneSAF Object Database (ODB) to the JC3IEDM database, another user who wanted to be able to create the same JC3IEDM interaction could "re-use" the mapping to the JC3IEDM and insert its own source data as the "from" interaction. As more and more translation mapping files are created to map to and from the JC3IEDM, users who also required creating these same JC3IEDM database interactions will be able to easily reuse and modify the resultant code created via the Mapper Generator application.

The JC3IEDM Reference Implementation as well as the Mapper Generator application will be configuration managed and available via PM OneSAF, which is a GOTS open-source application available to valid government organizations when a Distribution Agreement has been signed with PM OneSAF. The model for OneSAF enhancement is that organizations which require enhancements to the OneSAF code base are encouraged to become "co-developers," working to augment their additional functionality using the open source OneSAF code base and redelivering their updates back to the base program to be merged into an upcoming OneSAF release. It is anticipated that the JC3IEDM tools and applications that get "rolled back" into the OneSAF code base will greatly enhance the reusability and richness of the JC3IEDM applications available for new or existing JC3IEDM users to use.

6 Battle Management Language (BML) Design and Implementation Plans

6.1 BML Schema and Web Services

A significant goal of the Simulation and C2 technical communities for some years has been the ability to communicate plans, orders and status information unambiguously and with semantic coherence among C2 and simulation systems without human intervention. Toward this end, the Battle Management Language (BML) concept has been developed over the past several years in a sequence of projects beginning with the original SIMCI BML proof of principle and extending through the Joint Battle Management Language (JBML) proof of concept, as described in [1]. The JBML project demonstrated use of BML involving ground, air and maritime C2 systems (two of them operational military systems) that provided orders to two interoperating versions of the Joint Semi Automated Forces (JSAF) simulation. The JBML schema is structured around the C2 Lexical grammar (C2LG) introduced by Schade and Hieb [2]. The JBML Web Services were used in 2007 for a complex, multinational demonstration of C2-simulation interoperability as decribed in [3].

In the 2008 SIMCI Combined project, the JBML Web Services were replaced by an improved design, the Scripted BML Web Service [4], as shown in Figure 4.

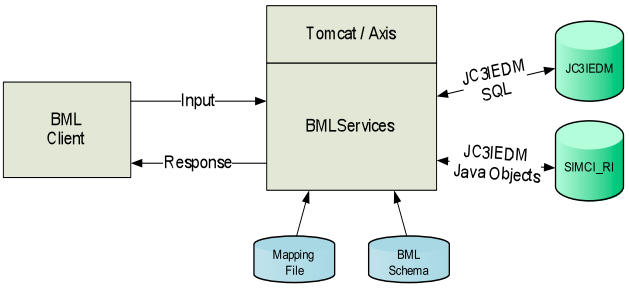

Figure 4: Scripted BML Web Service

The Scripted Web Services subsequently were used by the NATO MSG-048 Technical Activity in a particularly compelling demonstration, where three national C2 systems interoperated with three national simulation systems, with both Orders and Reports exchanged via BML as shown in Figure 5 and described in [5]. MSG-

048 was chartered to investigate and validate the capability of BML to function in a coalition environment. The configuration of Figure 5 was their second experiment and demonstration of such a capability. It was assembled in only four months from initial agreement by using the Scripted Web Services, slightly enhanced to meet MSG-048 needs, as an open source Reference Implementation, accessed over the Internet from GMU.

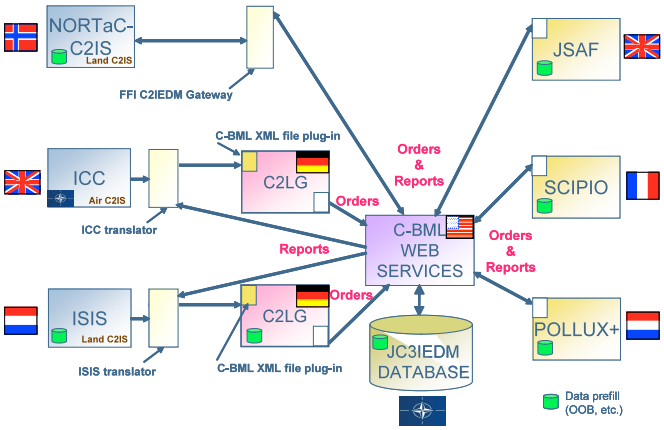

Figure 5. MSG-048 I/ITSEC Demonstration Configuration

The line of development leading to the JBML Schema and Web Services has continued. Significant developments include a geospatial BML (geoBML) [6] sponsored by TEC. GeoBML schema and services are being combined with the JBML work in a new project called Integrated BML (IBML), also sponsored by TEC. The goals of IBML are (1) to integrate the JBML and geoBML schemas and Web services, (2) to include support for Situational Awareness (SA) reports, and (3) to ensure that the resulting schema and Webs services are extensible and consistent with the C2LG grammar. While IBML is being developed for geospatial use, it is open source software that also provides a significant enhancement for other activities such as the SIMCI-JCP and NATO MSG-048. The IBML schema includes transition support for the original JBML capability as extended for MSG-048; the digitized US Army Operations Order (OPORD) Schema as developed for geoBML, including a basic operations order and Fragmentary Order (FRAGO); and a Reports schema. Primary input for the OPORD and FRAGO schemas are being developed by ACS, while MSG-048 has provided primary inputs for the Reports schema..

The GMU C4I Center also is participating in the SIMCI JCP to provide a BML capability. The target here is a capability to create and validate BML Business Objects composed of multiple JC3IEDM entities (i.e. database tables). Whereas the JBML Web Services were coded in the Java language based on IDEF1x diagrams that define the mapping process, the IBML Web Services provide a scripting environment where the mapping information is coded in machine-readable XML files. The scripting environment, in turn, is composed of Java code using the SAX and DOM parsers that are available, open source, as part of the Java support environment. The scripted BML Web Service will be available as open source software on GMU's BML web site.

The Army BML Architecture and MSG-048 projects are planning to use the Scripted BML Web Services produced by the SIMCI-JCP [7]. As a result, future changes and enhancement to BML Web Services will require only changes to the schema and the associated XML script. This will expedite the development process and also will simplify validation of the service design. In addition to the scripting capability, the Scripted BML Web Services will replace the previous JBML database access layer with the SIMCI-JCP System Development Kit (SDK) Reference Implementation (RI), incorporating a publish/subscribe mechanism and JC3IEDM validation as described above and shown in Figure 2.

7 Demonstration

The project demonstration was held on 19 November 2008. The Demonstration diagram is shown in Figure 6.

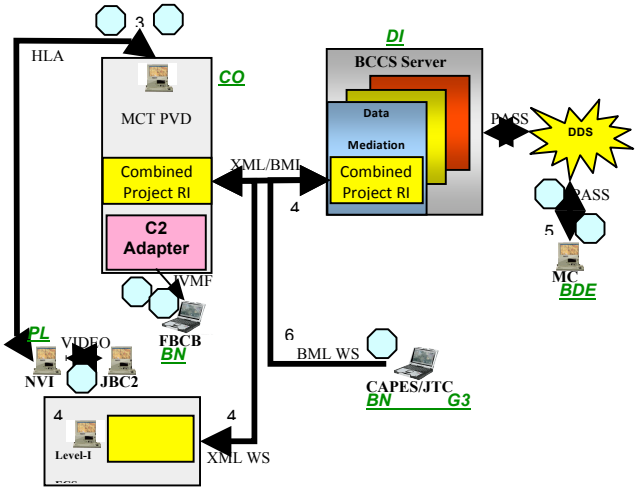

Figure 6. Combined Project Demonstration Configuration

The steps of the Demonstration are as follows:

0 – All systems are Pre-initialized with the Task Organization – DIV – BDE - BN – CO – UAV Plt

1 - OneSAF sends starting location and materiel information for all Friendly Units

A - Location information will be received by the FBCB2 (via JVMF)

B - Location and Material information will be received by MCS via the RIs, JC3IEDM, DMS, and DDS

2 – CAPES/JTCW tasks UAV Recon PLT to go to and recon area of operation through OneSAF RI to OneSAF

3 – OneSAF moves 1 UAV to area of operation

A - OneSAF sends UAV PLT LDR position reports to FBCB2 by JVMF

B - OneSAF sends UAV position reports to MCS through the RIs, JC3IEDM, DMS, and DDS

C - OneSAF notifies NVIG of UAV movement through HLA and NVIG simulates the video feeds on the JBC2S

4 – OneSAF creates 12 UAV sensor reports (4 UAVs sensing 3 enemy units each)

A – OneSAF sends the reports to the FBCB2 (via JVMF) and through the RI to the ***Level-1 FCS Fusion Surrogate*** RI via XML WS

B – ***Level-1 FCS Fusion Surrogate*** correlates the 12 reports into 3 enemy units

C – ***Level-1 FCS Fusion Surrogate*** sends the correlated report through the DMS RI, JC3IEDM, and DDS to the MCS

5 - MCS sends CTRL Measures via DDS through the DMS, JC3IEDM, RIs, to OneSAF

6 – The CAPES/JTCW orders OneSAF unit (1 Company) to move and attack (the order includes the route to take and when to start)

8 Summary/Conclusions

The project will transition many products:

- The modifications/extensions to the C4I Adapter capabilities (including the RI) will be included in C4I Adapter employment managed by PM OneSAF.
- The DMS (including the RI) will be fielded by PM BC as part of the BCCS within the ABCS system of systems.
- The tools and reusable components (including the RI) will be provided along with the JC3IEDM SDK for standard common Army use.
- Planning for integrated CM and processes for the maintenance of products and documentation will be included in standard Army processes.

This project is being executed by a cross functional team from PM OneSAF, PM BC, and GMU. This project will result in standard interfaces for BC to M&S interoperability that will support both current capabilities and future capabilities. It will support more efficient and effective transition to NCES and Army JC3IEDM compliance. It has been estimated that this project will provide for significant cost savings as a result of becoming a standard M&S to BC interface standard.

Acknowledgments

The authors of this paper are only a fraction of the team responsible for the success of this effort. All team members need to be recognized, in particular the following individuals: John Roberts and Adam Ritchie, ACS Inc.; Cheryl Cirigliano and Christopher Parr, Viecore FSD Inc.; Brad Norris, Noah Guilbault, and Eric Tichi, Northrop Grumman; Douglas Corner, Samuel Singapogu, Nicholas Clark, and Priscilla McAndrews, GMU C4I Center.

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[9] AKO website with documentation describing which systems publish and subscribe to specific data: https://www.us.army.mil/suite/folder/9868500

Authors' Biographies

STAN LEVINE is a Research Professor with the Center of Excellence in C4I at George Mason University. He also serves as a senior consultant to several Army organizations in the areas of information system technologies, architectures, System of Systems acquisition, and interoperability. He has over 33 years experience in systems acquisition. He holds a BSEE and a MS degree in Physics from Monmouth University, and a PhD in Engineering Management from Madison University. He is a recipient of the Army's three highest Civilian Service Awards. He is also a member of the Federal 100 top executives who had the greatest impact on the government information systems community.

TED TROCCOLA leads several projects at Viecore FSD Inc and is Viecore FSD's main point of contact for the US Army's PM Common Software. He is the lead for the US MIP Block 3 software development team, the ABCS DDS DMS team, and is leading the SIMCI Combined Project effort. He has been very involved with the MIP program and overall data interoperability issues at PM Common Software for the last 6 years. He has 15 years experience in software and information technology projects.

LORI TOPOR is the Lead and PM for the OneSAF and Common C2 Adapters (used by multiple programs including OneSAF, WARSIM, SECore, CACCTUS, FCS Legacy Force), to interface tactical C2 devices with simulations. The Common C2 Adapter is being augmented in the SIMCI world for JC3IEDM interoperability. She has over 27 years experience in software development and program management, the last 14 of which have been in the simulation industry. Ms. Topor has a BS in Computer Science and Mathematics from the University of Southern Mississippi.

J. MARK PULLEN is a Professor of Computer Science at George Mason University, where he serves as Director of the C4I Center and also heads the Center's Networking and Simulation Laboratory. He holds BSEE and MSEE degrees from West Virginia University and the Doctor of Science in Computer Science from the George Washington University. He is a licensed Professional Engineer, Fellow of the IEEE, and Fellow of the ACM. Dr. Pullen teaches courses in computer networking and has active research in networking for distributed virtual simulation and networked multimedia tools for distance education. He has served as Principal Investigator of the XBML, JBML, and IBML projects.