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Coalition Battle Management Language (C-BML) Study Group Report

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Coalition Battle Management Language (C-BML) Study Group Report

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ABSTRACT: *The objective of Battle Management Language (BML) is to define an unambiguous language to describe a commander's intent, to be understood by both live forces and automated systems, for simulated and real-world operations. The resulting language is intended to be applicable not only to simulation systems, but also to operational command and control systems, and robotic systems. Within the last three years, multiple papers presented at the Simulation Interoperability Workshops (SIW) have dealt with the need for, and initial work in, Modeling & Simulation (M&S) to Command and Control (C2) Interoperability based on the use of unambiguous mission and task definitions. During the Spring 2004 SIW, a meeting of subject matter experts determined that a detailed evaluation of BML efforts at a Coalition level is necessary and subsequently drafted Terms of Reference (TOR) for a Simulation Interoperability Standards Organization (SISO) Study Group. The TOR for the Coalition BML (C-BML) Study Group was accepted by the SISO Standards Activity Committee and identifies the following tasks:*

- *The Study Group shall conduct a Survey comprising as many international contributions applicable to the Coalition BML effort as possible.*
- *The Study Group shall develop a plan for how these various efforts can contribute to a common Coalition BML specification within a methodological framework.*
- *The Study Group shall formulate a set of Recommendations for a Coalition BML Product Development Group (PDG).*

The Coalition BML Study Group was subsequently formed in September 2004 to address these tasks. The Study Group has conducted a number of face-to-face and teleconference meetings through the year since the Fall 2004 SIW, involving a membership of over 100 persons from 11 different countries. This paper is an executive summary of the full Study Group Final Report. As the Study Group concludes, it recommends that a PDG be formed. The C-BML Study Group has worked closely with the Military Scenario Definition Language (MSDL) Study Group to coordinate both PDG proposals to ensure a consistent set of standards for initialization, tasking and reporting.

1. Introduction

Over a number of years considerable efforts have been made to develop mechanisms to provide interoperability between Command and Control (C2) systems and simulations. Initially, this was predominantly driven by the need to reduce the costs associated with inputting data into simulations that supported C2 training. The development of digitized C2 systems and the opportunity to utilize Modeling and Simulation (M&S) tools for Course of Action Analysis (COAA) and Mission Rehearsal and work on robotic forces has meant that there is an increased requirement for interoperability across these systems. In addition military operations are no longer conducted by single services and a single national force. [2,19] They are increasingly joint down to the tactical level and likely to be conducted within a coalition or alliance such as NATO. This has led to a requirement for multinational interoperability and the development of standards in support of interoperability, such as the Multinational Interoperability Programme's (MIP) Command and Control Information Exchange Data Model (C2IEDM). In particular, a Battle Management Language (BML) is required that enables expression and communication of military plans and orders across multiple national and coalition forces, whether live, constructive, or robotic.

To address this requirement, the Simulation Interoperability Standards Organization (SISO) established a Coalition BML (C-BML) Study Group in September 2004. This paper provides an executive summary of the full Study Group Final Report, documenting its activities, findings, and recommendations. Below, a general overview is given of the SISO C-BML initiative.

1.1 BML Overview

The objective of BML is to define an unambiguous language to describe a commander's intent to be understood and used by soldiers and systems in training and in real-world operations [1]. The resulting language is intended to be applicable not only to simulation systems, but also to operational command and control systems, and robotic systems. Within the last three years, multiple papers presented at the Simulation Interoperability Workshops (SIW) have dealt with the need for and initial work on BML [7,8,9,11,12,17], based on the use of unambiguous mission and task definitions.

The C-BML Study Group was formed in September 2004 under a Terms of Reference (TOR) accepted by the SISO Standards Activity Committee (SAC). The Study Group has conducted a number of face-to-face and teleconference meetings through the year since the Fall 2004 SIW, involving a membership of over 100 persons from 11 different countries. After the Study Group concludes, it is recommended that a SISO Product Development Group (PDG) be formed to carry forward the work to develop standards for description and implementation of the C-BML.

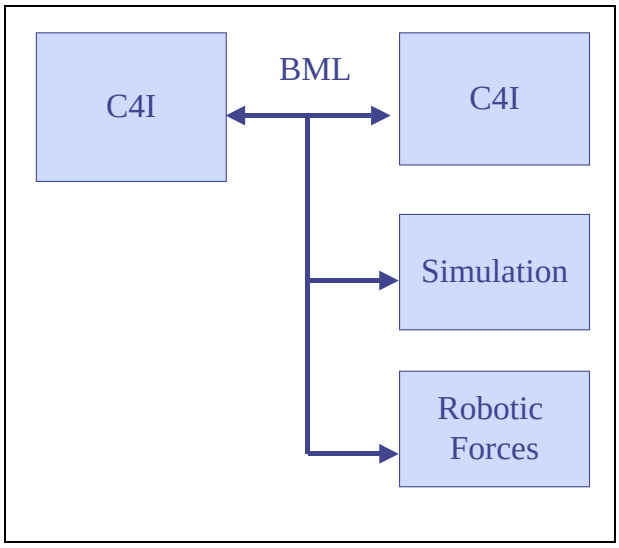

Figure 1: BML Scope

A key recommendation that follows establishing a PDG is initiation of a phased development plan. Rather than attempt to develop a standard that meets all identified needs, the Study Group proposes three phases of development that will provide increasing levels of capability. These are:

Version 1: C2IEDM-based Standard
Version 2: Grammar-based Standard
Version 3: Ontology-based Standard

1.2 Paper Organization

The rest of the paper is organized as follows: Section 2 covers the basic scope and concept of BML; Section 3 introduces the C-BML Study Group and the process it has followed; Section 4 describes a survey of programs relevant to BML standardization; Section 5 gives a literature survey of key references; Section 6 discusses key related SISO standard initiatives; Section 7 gives the proposed Product Development Plan; and Section 8 concludes with C-BML Recommendations.

2. Battle Management Language Concept

The current concept of BML involves the command and control of forces and equipment conducting military operations. It is not intended to be limited to either

simulated forces or real forces (involving human beings). In other words, BML will generate executable descriptions of a mission that can be used by human forces in real operations supported by C2 systems, by simulated forces in simulated operations, and by robotic forces in real or simulated operations. Figure 1 shows the scope of BML.

The "state of the art" of BML can be summarized by three views that address the various aspects related to a BML. Figure 2 depicts these views:

- BML Doctrine: Every term used within BML must be unambiguously defined and must be rooted in military doctrine [1]. In other words the doctrinal view is a glossary that comprises each term and its unambiguous definition. It cannot be limited to a single service doctrine but must allow different doctrinal viewpoints of multiple services and nations to be defined.
- BML Representation: The representation structures and relates the terms defined in the doctrine in a way that they result in the description of executable missions and tasks. A mission is defined by a sequence of tasks that must be executed in an orchestrated manner. Although the current recommendation is to use extensions and enhancements of the C2IEDM, other alternatives should be considered. Artificial Intelligence approaches that support the data structuring process by (semi-)automatic tools, and linguistic approaches used for knowledge sharing among intelligent software agents are promising research areas.
- BML Protocols: To communicate BML representations of plans and orders, protocols are needed. The protocol view standardizes the way the BML description of executable tasks and assigned executing military means is transported from the source system to the target system, which may be another C2 System, a simulation system or a robot. Web standards and grid standards are currently the most promising candidates for these protocols. In particular the use of XML to describe the information exchange requirements is considered to be fundamental because it is the only standard for data description accepted by the C2, simulation and robotic communities [7, 11].

3. SISO C-BML Study Group

In the 2004 Spring SIW, a meeting of subject matter experts decided that a detailed evaluation of BML efforts at a Coalition level is necessary and subsequently drafted a statement of work that was later formalized in the TOR. The TOR identified the following tasks to be performed by the Study Group (SG):

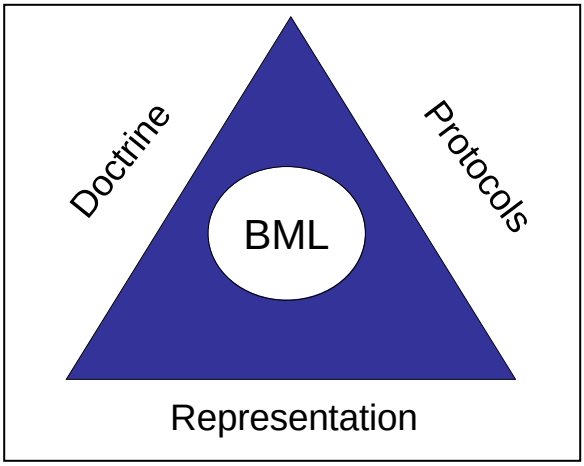

Figure 2: BML Views

- Conduct a **Paper Survey** comprising as many international contributions applicable to the C-BML effort as possible.
- Develop a **Plan** of how the various efforts identified in task 1 can contribute to a common C-BML standard or to a standard framework.
- Formulate a set of **Recommendations** on how to proceed toward a C-BML Product Development Group (PDG).

The following meetings were held during the course of the C-BML Study Group's chartered term:

- Initial SG Meeting at 2004 Fall SIW - *September 2004*
- SG Meeting at I/ITSEC - *December 2004*
- Face-to-Face Meeting at VMASC - *March 2005*
- SG Meeting at 2005 Spring SIW - *April 2005*
- SG Meeting at 2005 Euro-SIW - *June 2005*
- SG Report Meeting at GMU - *August 2005*

In addition, numerous telephone conferences were conducted during the period of study. The key meetings are summarized below.

3.1 C-BML Workshop

A three day face-to-face meeting was held on March 7-9, 2005 at Virginia Modeling Analysis and Simulation Center (VMASC) of the Old Dominion University (ODU) at Norfolk, Virginia that brought together 35 international experts. Five universities (Carnegie Mellon University, George Mason University, Naval Postgraduate School, Old Dominion University, and the University of Texas) participated in the event. Nations represented included Canada, France, Germany, Sweden, United Kingdom, and

the United States. Many of the contributions in section 4 originated from this meeting.

3.2 Spring 2005 SIW Study Group Meeting

A well-attended meeting of the C-BML Study Group was held at the Spring SIW in San Diego on April 7, 2005. At that meeting, an overall schedule for conduct of the Study Group effort was proposed and approved.

Another outcome of the 2005 Spring SIW was SAC approval of the establishment of the Military Scenario Definition Language (MSDL) Study Group to investigate creation of a standard for scenario definition. This is a separate but related activity to C-BML. The primary purpose of MSDL is to provide initialization to simulation systems independent of simulation and scenario generation tools. The Co-Chair of the C-BML SG was appointed the Vice-Chair of the MSDL SG to maintain close coordination across the efforts of the two study groups and to minimize duplication of effort.

3.3 Euro-SIW Study Group Meeting

The C-BML Study Group met during the European SIW in June 2005 to discuss progress to date and to plan ongoing efforts to produce a final report for the activities of the group. One of the key outcomes of the meetings was closer coordination with the MSDL Study Group and initial work toward a formal grammar for expressing tasks in the 5W (who, what, when, where, why) structure of BML.

4. C-BML Program Surveys

A key section of the C-BML Study Group Report is a survey of programs and initiatives that would benefit from or contribute to a C-BML specification. Below is a brief summary of 18 relevant efforts described in the Study Group Report. In the report, each initiative has a more complete description consisting of: 1) Problem Statement; 2) Solution Proposed; and 3) C-BML Relevance. The organization listed after the project title identifies the contributing organization of the write-up.

4.1 ABACUS Architecture (Raytheon, USA)

ABACUS is a broad coverage aggregate-level simulation that has been interfaced to the BOWMAN C2 system over the past year. BOWMAN is the UK program that provides a digitized radio for the British Army in order to facilitate secure voice and passage of data. The C-BML is seen as a natural and cohesive extension needed for the proposed ABACUS Rebaseline architecture.

4.2 Aide a la Planification d'Engagement Tactique (APLET) (DGA/EADS, France)

Aide a la Planification d'Engagement Tactique (APLET) is a French Ministry of Defence Research and Technology program which investigates the capabilities offered by M&S for use in an exiting French Brigade level C2 system, SICF (Système d'Information et de Commandement des Forces), for COAA [8,9]. The motivation is to make an "APLET BML" format available to the C-BML Study Group as a contribution to the standardization effort. On the other hand, APLET will evolve to take into account efforts of the C-BML Study Group and to make the APLET's BML compliant with the C-BML standard to be defined by the C-BML PDG.

4.3 Army C4ISR and Simulation Initialization System (Applied Research Labs/University of Texas, USA)

The basic concept of the US Army C4ISR and Simulation Initialization System **(**ACSIS) is to rapidly generate initialization data products, with automated tools, for both C2 systems and a federation of simulations. The objective is to reduce C2 data production time from months to a period of time closer to 96 hours. C-BML will allow all the partners of a coalition to share battle management products across the battle space. C2 systems and simulations need to be initialized and synchronized with data contained in these tactical battle management products.

4.4 Base Object Model PDG (SimVentions, USA)

The BOM PDG has developed a set of products within SISO [13,14] for representing reusable components of simulations and simulation environments, and understanding complex systems in a modular form. A BOM is defined as part of a conceptual model composed of a group of interrelated elements, which can be used as a building block in the development and extension of a High Level Architecture (HLA) federation, individual federate, FOM or SOM [6]. Elements of the C2IEDM, which C-BML intends to leverage for C2, can be represented within a BOM. Specifically, the BOM can be used to help capture conceptual model elements reflected in BML/C2IEDM as a reference.

4.5 Command and Control Ontology (VMASC, USA)

This research consists of: (1) defining what is meant by an ontology, in particular an ontology of a referential data model and its intended use; (2) proposing a method for evaluating a referential data model, and its use rules, against that definition; (3) applying that method against the C2IEDM and performing an analysis of the methodology. This work is relevant to the C-BML group

since the findings will identify how an ontological process can leverage the C2IEDM.

4.6 EXPLAIN Project (North Side, Inc., Canada)

The EXPLAIN project is focused on semantic understanding of texts describing military scenarios in a natural language (English), and the generation of simulation scripts based on these descriptions. The goal is to automatically generate BML, or any formal description lending itself to automated processing, from written Operations Orders (OPORDERS), plans, and exercise descriptions.

4.7 Formal Tasking Language Grammar (Mitre, USA)

Ideally, a common tasking language supported by both MSDL and BML will allow BML generated orders to be saved in MSDL format and imported into simulations as part of the simulation scenario generation process. This effort directly and positively impacts the C-BML community by defining a formal unambiguous grammar of military tasks that can be shared among and used to unify the Service, Coalition, and other BML efforts.

4.8 Geospatial BML (US Army Engineer Research and Development Center, USA)

The Engineer Research and Development Center (ERDC) is developing automated terrain reasoning services to support military decision-making. ERDC seeks to abstract and represent terrain and dynamic environment through a rich set of discrete objects (spatial and temporal) with relationships to tactical entities and tasks. A critical requirement to achieve the ultimate goal of ERDC is an extension of BML, designated here as the Geospatial BML (GeoBML), that maps the tactical task-based representations of the BML to the geospatial and temporal requirements of and enablers for the tactical activities to be carried out by live, constructive, and robotic forces.

4.9 Identification of C-BML Need (Ericsson, Sweden)

Four different, but related, topics are identified that address the need for a C-BML: (1) planning for Joint operations; (2) operational Joint command support; (3) assessment of commander's intent; and (4) opponent's intent. The relevance for (1) to (3) is that a C-BML provides the ability for a user to represent intent in the user's own nation/service representations that can be mapped/translated to a C-BML representation and used in C2 or simulation systems. For (4) the C-BML relevance is that without a common language it is a much harder task to represent opponent's intentions.

4.10 Intelligence Modeling and Simulation for Evaluation Scenario Generation Tool (US Army Threat System Management Office, USA)

The Intelligence Modeling and Simulation for Evaluation (IMASE) Scenario Generation Tool (ISGT) has the requirement to support rapid generation of Operational Test threat scenarios for system testing of US Army Intelligence and Electronic Warfare (IEW) Systems. The scenarios are executed using M&S to create a synthetic environment in which to immerse the IEW system under test. Through a capability similar to ISGT's scenario import/export via the ISGT XML schema, ISGT may be able to use BML to link to other M&S and C2 systems, provided that they also know how to manipulate BML. That is, ISGT would be able to export scenario data using BML to populate scenarios for M&S and C2 systems that understand BML. In turn, ISGT would also be able to populate a new scenario by importing BML scenario data generated by M&S and C2 systems.

4.11 Multilateral Interoperability Programme (Defense Modeling and Simulation Office (DMSO), USA)

The aim of the Multilateral Interoperability Programme (MIP) is to achieve international interoperability of Command and Control Information Systems (C2IS) at all levels from corps to battalion, or lowest appropriate level, in order to support multinational (including NATO), combined and joint operations and the advancement of digitization in the international arena. The core of the MIP solution is the C2IEDM. It is a product of the analysis of a wide spectrum of allied information exchange requirements. It models the information that combined joint component commanders need to exchange. C-BML will leverage the C2IEDM logical data model as a basis for XML namespace semantics, grammars (nouns, verbs, adjectives) and ontology work.

4.12 NATO C-BML Exploratory Team (DMSO, USA)

In parallel to C-BML Study Group activities, the NATO Modeling and Simulation Group (NMSG) established a 12 month Exploratory Team (ET-016) on C-BML [19,20]. The team, led by France, held its first meeting in Paris on February 14-15, 2005 with 7 nations represented. It endorsed the requirement for a C-BML and has proposed that a 3-year Technical Activity Program be established. Their recommendations will be submitted to a meeting of the NMSG in October 2005 in Poland. They anticipate becoming users of the C-BML standard.

4.13 Shared Operational Picture Exchange Services (DMSO, USA)

The objective of the Object Management Group (OMG) Shared Operational Picture Exchange Services (SOPES) initiative is to enhance the ability of first responders, government, military and civilian organizations to develop and sustain a complete, timely and accurate awareness of the operational situation. Future versions of the C2IEDM are candidates for the SOPES Information Exchange Data Model. The SOPES Information Exchange Mechanism will specify a general protocol for the exchange of SOPES information that can be realized in any number of specific communications technologies. Thus, SOPES provides a future industry standard for the exchange of plans and orders that can be exploited by C-BML implementers.

4.14 Simulation to Command and Control Information System Connectivity Experiments (Atlantic Consulting Services, USA)

The Simulation to Command and Control (C2) Information System Connectivity Experiments (SINCE) program was initiated to investigate interoperability issues by conducting multinational C2 experiments supported by C2 and M&S systems designed to address the transformation of collaborative planning and interoperable execution in a coalition environment [10]. This is a US-German Army Bilateral Collaborative Project. SINCE currently uses a BML very similar to the US Army's BML (based on the "5Ws") but expanded with "Which" and "How" terms [12]. The SINCE experimentation environment will provide a stable baseline for experimentation, analysis, and evolution of Coalition BML concepts and capabilities.

4.15 SOKRATES (FGAN-FKIE, Germany)

In Germany, FGAN-FKIE has developed a prototype for automatic report analysis, the SOKRATES system [15]. This system takes reports written in natural language as input, parses the reports to store analyzed content into a database, and displays the information on a map. The formal representation used in the SOKRATES system as well as its ontology component are grounded on the C2IEDM. While C-BML uses a fixed frame system (the 5Ws), in contrast the formal representation of SOKRATES is "lexical driven." The pros and cons of these differences as compared to C-BML need to be identified and assessed.

4.16 Task Analysis Leading to BML Vocabulary (AcuSoft, USA)

This project is investigating how the requirements of an order/task can be identified in a common way across the doctrine of a coalition. This effort will provide a methodology for specifying language requirements based on the tasks to be communicated. This applies to real (smart) units as well as robotic and simulated units, with possible addition of terms to the order to specify constraints or requirements to units of varying autonomy.

4.17 UK Research into BML (QinetiQ, UK)

The BML concept and US Army implementation of BML were evaluated to determine its adequacy as an enabling technology to support interoperability [3,4]. As this was an assessment of the utility of a BML no solution was proposed, but in summary it was found that it was technically possible to represent a large fraction of a UK Brigade OPORD in an existing (US) BML format, which in turn was based on a slightly enhanced version of C2IEDM. As a result of the assessment a number of recommendations were made to the UK Ministry of Defence regarding the development of a C-BML standard including participation in the SISO C-BML development and the NATO C-BML activities, as well as developing a BML demonstration capability.

4.18 XML-based Tactical Language Research (Naval Postgraduate School, USA)

The Naval Postgraduate School (NPS) Modeling, Virtual Environments, and Simulation (MOVES) Institute is conducting research in a number of programs related to employment of M&S and Web-based technologies in tactical systems. A key area of work is information representation in the various systems and mechanisms for efficient and effective information interchange across systems. Two of the representative efforts include: (1) Naval BML, extending current Army and Air Force centric BML approaches to represent Naval plans and orders; and (2) Autonomous Unmanned Vehicle (AUV) Workbench, including the Autonomous Vehicle Control Language (AVCL) as a representative BML for robotic forces. A key requirement of these (and other) efforts is a well-defined language for representing the commander's intent and conveying orders to operational forces, be they live, constructive, or robotic. A C-BML standard will provide the basis for unambiguous expressions upon which autonomous agents and automated decision-support systems can provide support to warfighters across the ever-more important joint and coalition operations.

5. Literature Survey

Over the past decade there have been a number of initiatives to create a common language for interactions between Battle Command systems and M&S systems. Provided below is an abbreviated list of key publications that support the need for, as well as the initial concept and feasibility analysis of, a Battle Management Language standard. The initial references are to the Command and Control Simulation Interface Language (CCSIL) initiative. Interestingly, the first papers predate both the HLA and the establishment of SISO. After CCSIL the SISO C4I Track sponsored a Study Group to develop recommendations for C4I to Simulation Interoperability. This Study Group produced a report that both surveyed common approaches and made recommendations. After the Study Group report, several initiatives were started in parallel in different countries concerning BML. These and other references are included in a complete bibliography in the final Study Group Report.

1994

Dahmann, J. S., Salisbury, M., Booker, L. B. and Seidel, D. W., "Command Forces: An Extension of DIS Virtual Simulation," MITRE Informal Report, Twelfth Workshop on Standards for the Interoperability of Defense Simulations, 1995. (http://ms.ie.org/cfor/diswg9409/diswg9409.pdf)

This is the first paper that mentions the future development of CCSIL and how this standard would be used in the DARPA Synthetic Theater of War (STOW) 97 Program.

1995

Salisbury, M., "Command and Control Simulation Interface Language (CCSIL): Status Update," MITRE Informal Report, Twelfth Workshop on Standards for the Interoperability of Defense Simulations, 1995. (http://ms.ie.org/cfor/diswg9503/ diswg9503.pdf)

Groundbreaking work on structuring an Army Operations Order. From the document:

"**Why Is This Difficult?**
People often ask why the existing standard message sets used by the military services are not sufficient for this task … In most cases, the standard message sets rely heavily on free text fields where a human can input natural language to convey the essence of the order or situation. … The current state of natural language interpretation software is not sufficient to support our requirements. The current set of CCSIL messages focuses on providing highly structured, yet flexible formats for the types of information normally conveyed using natural language."

1997

MITRE: DARPA STOW ACTD version of the CCSIL documentation (http://ms.ie.org/cfor/)

The complete documentation for the CCSIL Specification. Highlights are the representation of the US Army's Operation Order and the Air Force's Air Tasking Order.

Hieb, M. R., Cosby, M., Griggs, L., McKenzie, F., Tiernan, T., and Zeswitz, S., "MRCI: Transcending Barriers between Live Systems and Simulations," Paper 97S-SIW-197, 1997 Spring Simulation Interoperability Workshop.

Modular Reconfigurable C4I Interface (MRCI) was a general C4I interface developed as part of STOW 97. MRCI used CCSIL as the simulation standard for Command and Control messages and translated between CCSIL and common C4I Message Formats (such as USMTF or OTH-Gold). This provided a proof of concept that it was possible to create unambiguous messages representing complex orders for simulations.

1998

Carr, F. H. and Hieb, M. R., "Issues and Requirements for Future C4ISR and M&S Interoperability," 7th Conference on Computer Generated Forces and Behavioral Representation, 1998.

This paper developed a "Technical Reference Model" for C4I to Simulation Information Exchange. Exchange of Order information is explicitly called out as one of the main Information Exchange areas in the model.

Kleiner, M. S., Carey, S. A., and Beach, J., "Communicating Mission-Type Orders to Virtual Commanders", Paper, Proceedings of the 1998 Winter Simulation Conference.

An innovative look at expressing commander's intent in a structured format. This was the basis for the future US Army Battle Management Language work.

2000

Timian, D. H., Hieb, M. R., Lacetera, J., Tolk, A., Wertman, C., and Brandt, K., "Report Out of the C4I Study Group," Paper 00F-SIW-005, 2000 Fall Simulation Interoperability Workshop.

This report provided a firm foundation for subsequent standardization efforts in C2 to Simulation Interoperability. Non-standard Order formats are mentioned as a key area for future standardization efforts.

2001

Carey, S., Kleiner, M., Hieb, M. R. and Brown, R., "Standardizing Battle Management Language – A Vital

Move Towards the Army Transformation," Paper 01F-SIW-067, 2001 Fall Simulation Interoperability Workshop.

This paper laid out the key concepts and principles for development of an Army Battle Management Language. The idea of using the emerging C4I standard databases to disambiguate orders was developed in this paper

2002

Carey, S., Kleiner, M., Hieb, M. R. and Brown, R., "Standardizing Battle Management Language – Facilitating Coalition Interoperability," Paper 02E-SIW-005, 2002 European Simulation Interoperability Workshop, London, England.

Extension to Joint and Coalition Operations of the BML concept described in 01F-SIW-067.

2003

Khimeche , L., and de Champs, P., "Courses of Action Analysis and C4I-Simulation Interoperability," 03F-SIW-028, 2003 Fall Simulation Interoperability Workshop.

Innovative work on using C2IEDM for exchanging C2 information between Simulations and C2 Systems.

2004

Hieb, M. R., Sudnikovich, W., Tolk, A., and Pullen, J. M., "Developing Battle Management Language into a Web Service," 04S-SIW-113, 2004 Spring Simulation Interoperability Workshop.

Paper that describes how the US Army's BML Proof of Principle demo was standardized (by using the C2IEDM) and made extensible (through XMSF protocols).

Khimeche , L., and de Champs, P., "M&S in decision support for Courses of Action Analysis, APLET," 04F-SIW-006, 2004 Fall Simulation Interoperability Workshop.

Recommendation to standardize of C2IEDM for implementation of C-BML and discussion of BML in the context of a COAA system.

Mayk, I. and Klose, D., "Experimenting with C2 Applications and Federated Infrastructures for Integrated Full-Spectrum Operational Environments in Support of Collaborative Planning and Interoperable Execution," Proceedings of the 2004 Command and Control Research and Technology Symposium (CCRTS), June 15–17, 2004, San Diego, CA.

Description of the US-German Collaborative Program SINCE which has done extensive development of their own BML, using the 5 Ws and adding "Which" and "How".

Sudnikovich, W., Hieb, M. R., Kleiner, M. and Brown, R., "Developing the Army's Battle Management Language Prototype Environment," Paper 04S-SIW-115, 2004 Spring Simulation Interoperability Workshop.

Paper describing the US Army's BML Proof of Principle demonstration, focusing on representing US Brigade/Battalion/Company Operations orders.

Tolk, A., Hieb, M. R., Galvin, K., and Khimeche, L., "Coalition Battle Management Language," Paper 04F-SIW-103, 2004 Fall Simulation Interoperability Workshop.

Proposal for development of a BML for Coalition Activities.

Tolk, A., Hieb, M. R., Galvin, K., and Khimeche, L., "Merging National Battle Management Language Initiatives for NATO Projects," Paper 12 in Proceedings of the RTA/MSG Conference on "M&S to address NATO's new and existing Military Requirements", RTO-MP-123, Koblenz, Germany, October 2004.

Proposal to NATO to form a C-BML Technical Area.

2005

DeMasi, L., Dobbs, V. S., Ritchie, A. and Sudnikovich, W. P., "Implementing Battle Management Language: A Case Study Using the Command and Control Information Exchange Data Model and C4I-M&S Reference Object Model", Paper 05S-SIW-068, 2005 Spring Simulation Interoperability Workshop.

Work in structuring BML in the C2IEDM using the 5 Ws.

Khimeche , L., and de Champs, P., "APLET's Courses of Action Modeling : A Contribution to CBML," Paper 05S-SIW-018, 2005 Spring Simulation Interoperability Workshop.

Description of French use of a BML and recommendations when supporting a COAA system.

Perme, D., Tolk, A., Sudnikovich, W. P., Pullen, J. M., and Hieb, M. R., "Integrating Air and Ground Operations within a Common Battle Management Language," Paper 05S-SIW-154, 2005 Spring Simulation Interoperability Workshop.

Paper that shows how the XBML prototype can be extended to the Air Domain from the Ground Domain by reusing the 5Ws and C2IEDM implementation.

Roberts, J. D., and Sudnikovich, W. P., "Achieving Higher Levels of Interoperability Between M&S and C2 systems Through Application of BML to the SINCE Program," Paper 05S-SIW-055, 2005 Spring Simulation Interoperability Workshop.

Detailed explanation of how BML affects simulation behaviors from a US-German Collaboration.

Tolk, A., and Blais, C., "Taxonomies, Ontologies, and Battle Management Languages – Recommendations for the Coalition BML Study Group," Paper 05S-SIW-007, 2005 Spring Simulation Interoperability Workshop.

Paper giving specific recommendations for C-BML development within SISO.

Tolk, A., Diallo, S., Dupigny, K., Sun, B. and Turnitsa, C., "Web Services based on the C2IEDM – Data Mediation and Data Storage," Paper 05S-SIW-019, 2005 Spring Simulation Interoperability Workshop.

Paper detailing how the XBML work can be standardized further in the area of prototols with C2IEDM-based Web Services.

Winters, L., and Tolk, A., "The Integration of Modeling and Simulation with Joint Command and Control on the Global Information Grid," Paper 05S-SIW-148, 2005 Spring Simulation Interoperability Workshop.

BML is used as a key component in a use case of "COAA on the GIG".

6. Related SISO Initiatives

As new standards are proposed to SISO for development it is important to evaluate how they fit with existing and emerging SISO standards. The C-BML study group has identified two areas that will require coordination as a C-BML standard is developed. Members from both of these areas have participated in C-BML Study Group activities.

6.1 MSDL Study Group

The MSDL was developed for the US Army, in particular for the simulation system OneSAF Objective System (OOS), as a well-defined structure for describing the initialization data for military scenarios [5]. As a standard, MSDL is not being developed only for simulation. The intent is for MSDL to define military scenarios that are independent of the application of that scenario. MSDL relies on military standards for data types, enumerations, precision, and other common elements. MSDL has been expressed in an XML-based data interchange format that enables C2 planning applications to interchange the military portions of scenarios with simulations and other applications.

There is obviously an overlap between BML and MSDL interests. However, while BML focuses on the description of executable tasks and assigned military entities, MSDL targets the initialization of simulation (and potentially also C2) systems with military scenarios consisting of a description of the initial state of a military situation including planned actions (e.g., planned air missions, fire missions, ship-to-shore movement, etc.).

During FY05 a primary activity of both C-BML and MSDL Study Groups has been to identify the scope and coordination points between C-BML and MSDL and to define the alignment activity and schedule [16]. Major Kevin Galvin is both the Co-Chair of the C-BML Study Group and the Vice Chair of the MSDL Study Group to facilitate inter-group communications. In the latter part of FY05 C-BML and MSDL meetings were coordinated, and there was cross-participation in these meetings.

Additionally both groups plan to coordinate in developing a common tasking grammar specifying the syntax and semantics of assigning a task to a subordinate (entity or organization) by a superior (entity or organization). This tasking grammar is needed for initialization and during execution. This is further described in Section 7.1, the Product Development Plan proposed for C-BML.

A diagram showing the conceptual relationship between the proposed C-BML and MSDL standards is shown in Figure 3. On the left side is initialization, where C-BML formatted orders are included in an MSDL formatted scenario. On the right side is execution, when C-BML orders and reports are exchanged. In the middle are the various types of entities executing the scenario, which could include operational units.

6.2 BOM PDG

The BOM PDG was described in Section 4.4 and is one way to make a future C-BML standard usable in HLA federations [6]. Development of a set of C2IEDM BOMs would be useful in the Version I C-BML development.

7. C-BML Development Approach

A key recommendation of the Study Group is initiation of a phased development plan when the PDG is established. Rather than attempt to develop a standard that meets all identified needs, the Study Group proposes three phases of development. This is essential both in scoping the effort and also to produce a Version I standard that is usable by the community as soon as possible.

7.1 Phased Approach

The C-BML Study Group recommends the development of a standard as well as accompanying guidance products. The development will be conducted in close cooperation and collaboration with the standardization efforts of the

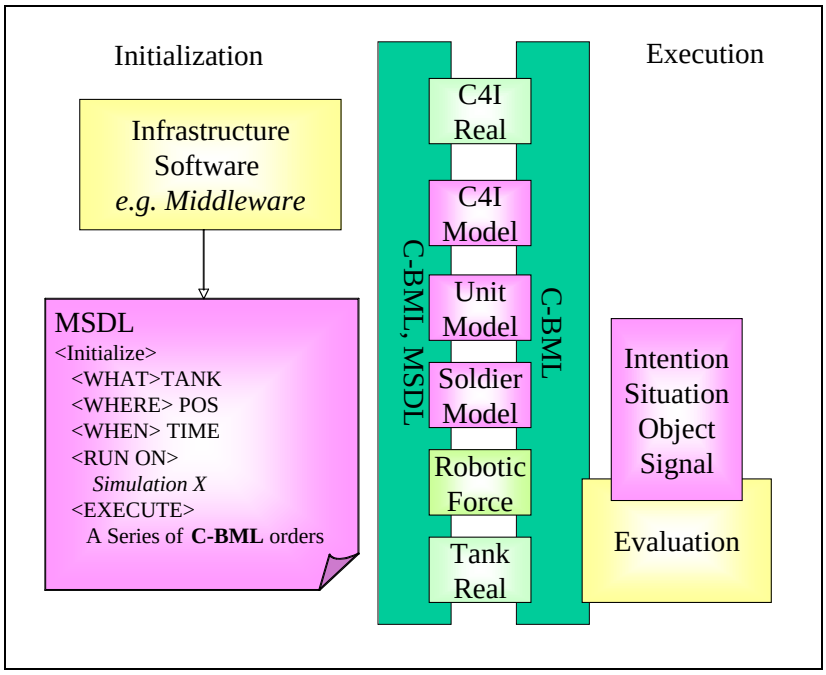

Figure 3: Relationship between C-BML and MSDL Standards

MSDL PDG as described in the previous section. Furthermore, support of the BOM PDG products will be evaluated and considered for use.

The C-BML standard will be developed and delivered in versions having increased capability corresponding to each phase. For all versions, the Study Group recommends using C2IEDM and its successor (Joint Consultation Command and Control Information Exchange Data Model - JC3IEDM) as a basis for C-BML reference implementations and standards. Each version of the C-BML Standard will have:

- A Data Model;
- An Information Exchange, content and structure specification;
- An Information Exchange mechanism specification; and
- Guidelines.

The Study Group agreed that a guideline product, which explains C-BML use and comprises examples, must accompany every standard product version. Furthermore, every version extending or replacing an earlier version will specify a migration procedure.

The proposed development phases for the C-BML standard will begin in parallel. The phases are described below (and assume an April 2006 start date):

- Version I (April 2006-2007): Version 1.0 will specify a sufficient data model to unambiguously define a set of military orders using C2IEDM as a starting point and extending as necessary so that they can be interpreted by C2, M&S and Robotic systems. The C-BML Standard will describe a data model in a subset of C2IEDM, an Information Exchange, content and structure specification in the form of an XML schema and an Information Exchange mechanism specification embedded into a Web Services Description Language (WSDL) document. This standard, including recommended guidelines, will be finalized in April 2007. An initial version of the C-BML XML schema will be evaluated by the parallel NATO C-BML effort (see Section 4.12).
- Version 2 (April 2006-2008): Version 2.0 of the C-BML Standard will introduce a grammar (syntax, semantics and vocabulary) as part of the Information Exchange, content and structure specification. The objective is to formalize the definition of tasks such that they are rigorous, well documented and parse-able. The grammar will be extended to accommodate “reports” after a tasking grammar is defined. The need for a grammar for tasking and reporting is seen as a common requirement for both the C-BML and MSDL efforts and this could be conducted by establishing a joint C-BML/MSDL Tiger team for this task. The standardization will include recommended guidelines applicable to C-BML and MSDL to be finalized in April 2008.
- Version 3 (April 2006 – April 2010): Version 3.0 of the C-BML Standard will develop a battle management ontology to enable conceptual interoperability. The standardization, including recommended guidelines, is planned for completion by April 2010. While the Study Group realizes the potential of ontology-based solutions it is also recognized that current approaches require additional research and agreement on processes outside of SISO to ensure effective and applicable solutions.

Although a phased approach outlined above is considered the best mechanism to deliver each version of the C-BML Standard the Study Group recognizes that underlying research is not constrained by this schedule and will occur from the outset of establishing the PDG, hence the start dates for each phase are the same. The Study Group recommends establishment of these phase-specific

subgroups when the C-BML PDG is established in order to carry out research in support of each phase.

While the C2IEDM is considered the best initial information hub currently available, it will potentially need extensions to meet the requirements of the M&S community. Studies described in [5,19,20] show that the resolution needs of simulation systems are not met in all areas. This requires identification of the necessary extensions through coordination with the MIP.

7.2 Supporting Analyses

In addition to the group activities conducted during the year, a number of individuals and small teams have worked to advance C-BML concepts through separate analyses and developments that have been described in various conference papers and presentations.

In [18], the authors discuss a number of standards and their application to C-BML. As a result of their investigation, the following recommendations were made to the C-BML Study Group:

- BML should initially focus on the exchange of military command and control data, in particular the unambiguous description of executable tasks, their composition into missions, and – where applicable – the assignment of executing military means.
- The C2IEDM should be used as the base vocabulary and structure to express the necessary elements to describe tasks, compose them into missions, and assign executing organizations down to single weapon systems, platforms, or persons [see also 8]. The subset of C2IEDM used to express C-BML statements should be standardized as the initial *representation view* of BML.
- As every data element already is documented in detail, including the source of the definition used, the C2IEDM subset establishes a core for the glossary to become the initial *doctrine view* of BML.
- An XML tag set extracted from that used for the coalition namespace of the US DoD XML Repository should be applied as the initial *protocol view* for BML. In addition, more work is needed to evaluate or define applicable standards addressing ontology specifications in support of describing doctrines for BML.

The above recommendations identify near-term concerns to be addressed by the C-BML Study Group. In addition, refer to [18] for a broader set of recommendations.

8. Conclusions and Recommendations

The work of the Coalition BML Study Group has established the need for a comprehensive standard for a Battle Management Language that will promote interoperability and effective employment of C2 and M&S systems across Coalition operations. Recent and growing employment of robotic systems in warfare is creating a new challenge for integration with C2 and M&S systems. Training exercises across Joint and Coalition forces carry a critical requirement for integration of live, constructive, and robotic forces through a standard Battle Management Language [1,2]. The work of the SISO Coalition BML Study Group has laid an operational and technical foundation for movement toward development of this standard.

The following recommendations are made:

- SISO should establish a PDG in order to move forward in development of a C-BML standard.
- A phased approach as described in this paper should be taken to the development of the standard.
- The PDG should be separate from a proposed MSDL PDG in the first phases but as work on developing a Tasking Grammar matures, these two efforts may be merged so that one standard is eventually derived that provides for the full scope of C-BML.
- Promote full engagement of the C2 community to ensure joint ownership and full participation in development of the standard.

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