Evaluating the Proposed Coalition Battle Management Language Standard as a Basis for Enhanced C2 to M&S Interoperability

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OVERVIEW

Recent developments in Command and Control (C2) to Modeling and Simulation (M&S) interoperability have shown excellent potential to create a standardized approach that will enable a wide range of coalition C2 and M&S systems to interoperate for training and, ultimately, to provide decision support in operational C2 systems. The interest of France, USA, and eight other NATO nations for pursuing this capability has resulted in formation of a NATO Technical Activity (TA) MSG-048, which is performing a technical assessment of standards emerging from the Simulation Interoperability Standards Organization (SISO) Coalition Battle Management Language (C-BML) Product Development Group. This paper describes the latest US effort in C2-M&S interoperability, the Joint Battle Management Language (JBML) project, and explains how JBML products are intended to be used in the MSG-048 TA. A related capability that will be added is Geospatial BML (geoBML) to integrate geospatial products. The results appear to have high potential for a new level of interoperation among C2 and M&S systems in coalitions. MSG-048, informed by initial JBML results and the outcome of the MSG-027 Pathfinder project, has planned a series of experiments to evaluate the utility of the C-BML approach utilizing systems put forward by the nations participating in MSG-048.

1.0 Introduction

A Battle Management Language (BML) is defined as an unambiguous language intended to provide for both command and control of simulated and live forces conducting military operations and situational awareness and a shared, common operational picture. Recent developments in us of BML for Command and Control (C2) to Modeling and Simulation (M&S) interoperability have shown excellent potential to create a standardized approach that will enable a wide range of coalition C2 and M&S systems to interoperate for training and, ultimately, to provide decision support in operational C2 systems [1-8]. In October of 2004 France and the US presented demonstrations to the North Atlantic Treaty Organization (NATO) M&S Working Group showing how a BML and JC3IEDM can enable interoperation of command and control (C2) and simulation systems of multiple nations. As a result, an Exploratory Team (ET-016) was formed to investigate the feasibility of a Coalition BML (C-BML). The Exploratory Team developed a strong rationale for international collaboration in evaluating the potential of C2-Simulation interoperation technology. The Simulation Interoperability Standards Organization (SISO), an international organization with industry, academia and government all represented, is developing the Coalition Battle Management Language (C-BML) to provide a basis for C2-Simulation interoperability [9]. ET-016 concluded that a NATO-based effort could be most effective by providing a separate experimental validation of the potential benefits of C-BML. This recommendation was highlighted demonstration of interoperation between C2 and M&S systems of France and the US, and reported in [10]. In this paper, we continue describing advances in BML, based on US contributions to the C-BML effort and also on the NATO M&S Group's Technical Activity, MSG-048, that is applying the results in experimental validation of C-BML.

This paper draws heavily on publications by its authors in other forums, particularly references [19,20], in order to present the work of JBML, MSG-048, and the emerging SISO C-BML standard to the larger NATO M&S community.

2.0 Background

The Joint Battle Management Language (JBML) activity is contributing significant efforts from the US in support of SISO's C-BML Product Development Group (PDG). JBML is not just "yet another BML" but is intended to become the first contribution to a growing family of standards. While JBML has been developed to solve real requirements of the warfighter in support of exercises and experimentation, it also supports the C-BML standard development process. The project also is intended to support international collaboration within SISO as well as within the MSG-048 TA. To meet all of these goals, JBML has been laid out as a multiphase project which now has reach the end of its Phase 1, which in turn feeds Phase 1 of SISO-C-BML.

3.0 The JBML Project

The goal of this project is to develop a standard Battle Management Language applicable to US Service and Joint Users as an input to the SISO C-BML process. The need to interface Command and Control (C2) systems with Modeling and Simulation (M&S) systems has long been established. However, in the absence of DoD-wide standards for C2-to-M&S interoperability, almost every simulation has a unique C2 interface. The BML effort addresses this need by basing its semantics on the international Multinational Interoperability Program (MIP) data standards. Of particular interest for JBML is that the MIP provides a common, system-independent C2 vocabulary for data interchange.

3.1 History

BML was never seen as an exclusively technical solution; it is an approach to supporting the operational needs and requirements of the warfighter. Using a vocabulary defined both in doctrinal language and in command and control reports was essential. Carey et. al. describe the overall process used to show the feasibility of defining an unambiguous language based on manuals capturing the doctrine of the US Army in [3]. The US Army's Simulation-to-C4I Interoperability Overarching Integrated Product Team (SIMCI OIPT) sponsored the first BML project. They started by analyzing more than 70 doctrinal manuals related to tasking and reporting, beginning with general manuals, such as the Universal Joint Task List as published by the Joint Staff [11]. This work was focused on defining an unambiguous Operational Order which led to using a *5W Structure for BML* to describe military tasks: Who, What; Where, When, and Why.

The US Army BML effort developed a prototype for battalion operations orders that demonstrated the principles of BML in 2003. Under sponsorship of the US Defense Modeling and Simulation Office (DMSO) and the US Joint Forces Command (JFCOM), the Extensible BML (XBML) project was started as a follow-on, with two main objectives: (1) using web technology for the information exchange between the systems' interfaces to create a net-capable prototype; (2) using the Command and Control Information Exchange Data Model (C2IEDM) as a basis to represent the information to be exchanged between the systems. These goals were achieved and the related work was published in [5,6]. The C2IEDM is an earlier version of the MIP's current JC3IEDM data model.

Joint Forces Command (JFCOM) in the US was particularly interested in the XBML project's potential to increase interoperability between C2 systems and simulations of the US military Services. The Air Operations BML (AOBML) effort was supported by JFCOM J7 (Training) to evaluate whether the concepts of BML are applicable to air forces as well as ground forces. To this end, the XBML prototype was enriched by an interface to US Air Force command and control system Theater Battle Management Control System (TBMCS) and Air Warfare Simulation (AWSIM) systems, with the result that BML was shown to be feasible and applicable to air operations. A corollary result was recognition that the object/entity focus of C2IEDM is different from the activity focus of air warfare (e.g. the action of a sortie, which is the main point of interest for air operations). While the first phase of AOBML focused on integrating the systems using Web technology, a second phase was conducted focusing more on the identification of information exchange objects making up the AOBML, as described in [4]. The France-US international effort used the final XBML prototype, as described in [9].

3.2 Related BML Research Activities

As stated above, JBML was envisioned as the first in a family of BML efforts that share a common core, but function individually in their own domains. The work on Ground Forces BML and Air Operations BML is described above. Recently added activities are the work of the Naval Postgraduate School (NPS) on a Navy BML under the JBML project [10] and work supported by Army Topographic Engineering Center (TEC) on geoBML, in which BML concepts are leveraged for terrain reasoning [11-13]. Table 1 summarizes recent and current activities focus on BML, including the NATO PATHFINDER Integration Environment MSG-027 experiments [14]. It is important to distinguish roles: C-BML, as a standardization activity, is not resourced to produce an implementation, whereas the JBML project will deliver both a specification and a reference implementation that can be used to evaluate that specification, and the MSG-048 activity will evaluate the proposed standard in the context of coalition interoperability. The companion PDG Military Scenario Definition Language (MSDL) provides a complementary standard for initializing simulations. While C-BML focuses on the information exchange for tasking and reporting during execution, MSDL focuses on the initialization of systems on a broader basis.

Table 1. BML Activities

	Specification	Ground	Air	Naval	Implementation	Software Services	International
C-BML	X	X	X	X		X	X
ET-016		X			X		X
MSG-027		X			X	X	X
JBML	X	X	X	X	X	X	
geoBML	X	X			X		
XBML		X			X	X	X
Army BML		X			X		
AOBML			X		X		
MIP/JC3IEDM	X	X	X	X			X

3.3 The Layered Services of JBML

This section provides a description of the Web services implemented as open source Java software in the JBML project. The intention is to provide a reference implementation that can serve as basic infrastructure for the project, and to offer this to the C-BML standards effort. The implementation is based on Web service networking standards [1,2]. Figure 1 provides an overview of the JBML Web service Architecture. The layers are described in detail below.

- The BML Domain Configured Service (DCS) represents the domain-specific language in form of a grammar-based schema that is utilized by implementing Web services.
- The schema defines the DCS in terms of the BML Base Services (BBS) which represent the information element groups that specify information objects of interest such as the 5Ws (who, what where, when, why) and other constructs of interest.
- The lowest layer represents the exchange of JC3IEDM entities. In JBML, these are BML Common Data Access Services (CDAS), which encapsulate SQL transactions against the database.

3.3.1 BML Domain Configured Service

The DCS layer implements BML in a domain context. In the case of an operations order, the transaction at this layer specifies all information about a given task (e.g., who, what, when, where, and why). For a position report, the transaction at this layer will include all information about the updated location (e.g., who, where, when-valid, precision, etc.). The DCS is implemented in the Document-Literal mode by a generic Web service that is configured by an XML schema. Schade and Hieb describe a formal grammar that can be used to represent all individual tasks that are possible in XBML [17,18]. JBML produced a generic XML format that can be used by every BML order, based on the tags given in Table 2. The grammar is based upon the task (the "what") and a syntax is given that describes the task in terms of the military organization that gives the task (the "tasker-who"), the military organization that received the task (the "taskee-who"), a friendly or hostile military organization that is affected by the task (the "affected-who"), specific temporal terms denoting the start and end of the task, as well as geospatial terms, the reason why the task is performed, a label for a specific task and additional terms that may be needed to completely characterize a task

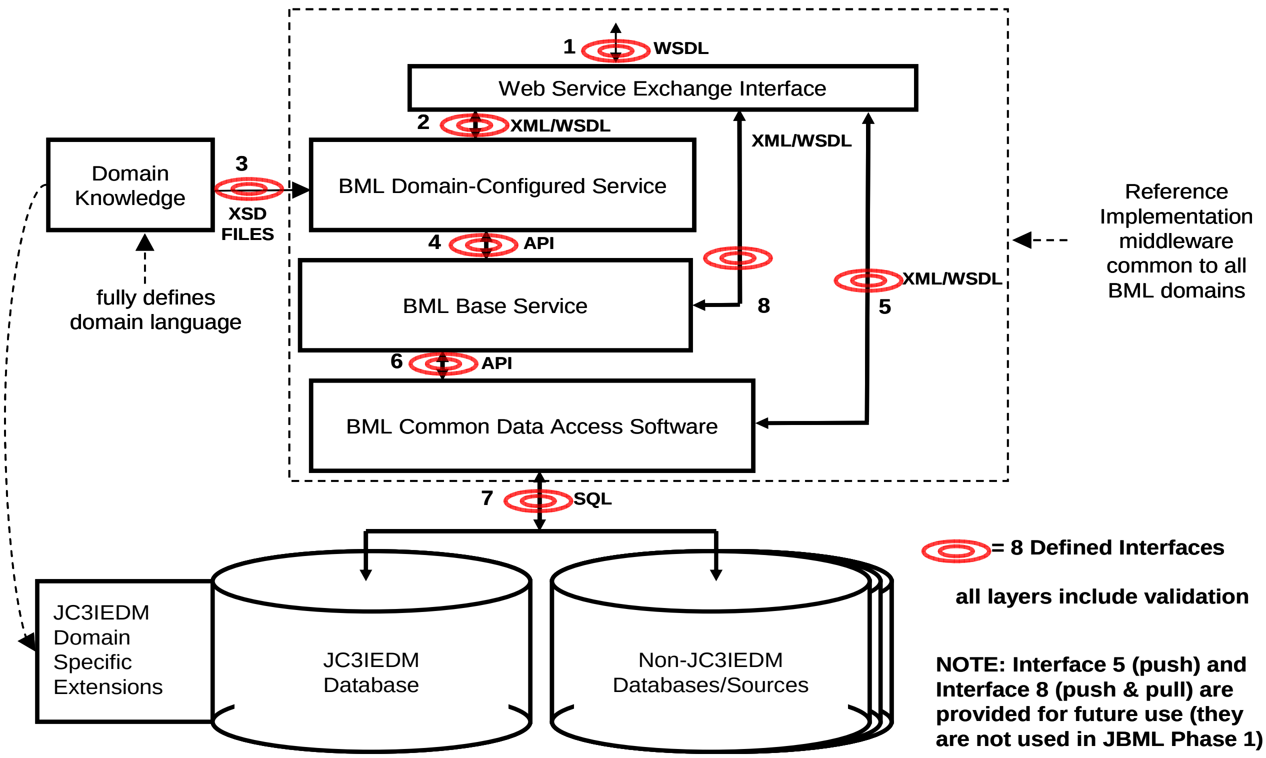

Figure 1: JBML Architecture Overview

Table 2: BML Primitives proposed in [17, 18]

<command> (verb)	<tasker-who>
<taskee-who>	<affected-who>
<what> (action)	<where>
<start-when>	<end-when>
<why>	<label>
<modifier>	

3.3.2 BML Base Service

The BBS provides composite BML elements such as Who, What, When, Where, and Why. These are composite in the sense that they implement a composition of multiple JC3IEDM tables. Other BBS elements may be introduced for new and existing BML domains as required. The BBS accesses all of the database tables relating to the composite element through the software that implements the Common Data Access Services (CDAS) described below. Our JBML specification at this layer will identify the information objects exposed by the database tables to be updated for each BML information element (who, what, etc.) and the validation conditions to be applied. The BBS lower level interface (6) exercises the CDAS API.

The close relationship of BBS and the primitives in Table 2 is intentional; JBML uses these primitives as composites. The user of JBML provides inputs to the DCS layer, not to the BBS services. However, in order to support continued research in expanded BML, the JBML software has an option to expose the BBS as a Web service.

3.3.3 BML Common Data Access Service

The purpose of the CDAS is to provide a mechanism for the BBS to both read and update the database tables directly. Within the current implementation of JBML, there are two higher level interfaces to the CDAS. One is an internal interface (6), defined as a software API. This interface is active in both directions (write and read). The second (5) is defined using a WSDL and XML/SOAP based. For JBML use, this interface is be configured for one-way (pull only) access, to be used for inspecting (reading) database tables. However, the CDAS software also offers the option of exposing a two-way interface so that the JC3IEDM representation of the data can be exchanged with systems capable of using this interface. This interface will be included in JBML's proposed C-BML specification, which will define the JC3IEDM entities used and a standard XML format to access them. The CDAS lower level interface (7) provides an SQL based capability to access database tables representing the JC3IEDM entities.

3.4 JBML Results to Date

JBML performed a demonstration on 3 May 2007, using a scenario involving a Joint Task Force located in the Caspian Sea Area. The Joint Task Force was tasked with a Joint Urban Operation described in a Joint Operations Order that drove an Air Battle Plan, a Maritime Operational Order, and a Ground Operational Order (OPORD). Each of these was processed into a common, extensible and vetted XML schema based JBML Web service. This information was then converted and used to drive two linked Joint Semi-Automated Forces (JSAF) simulations, as shown in Figure 2.

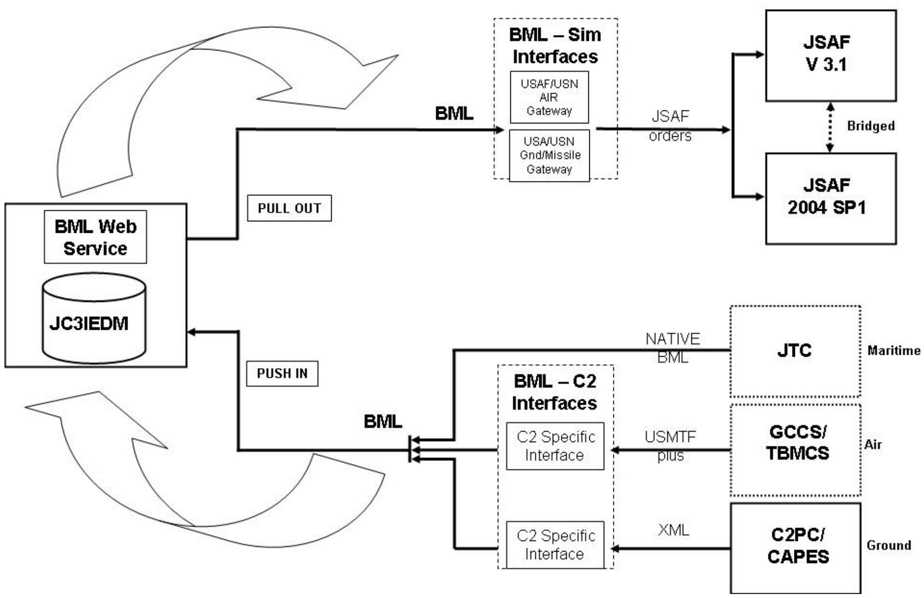

Figure 2: JBML Demonstration Configuration

A Graphical User Interface (GUI) was used to produce files containing Maritime orders for Tomahawk cruise missile strikes. The output files were produced in native BML and used for input to the BML Web Service during the exercise. The original intent was to integrate this GUI with the JC3IEDM-based Tactical Collaboration (JTC) system, a surrogate/prototype C2 system that has operated as a client to GCCS in Navy exercises/experiments. However, JTC software was not available for use in the demonstration. A graphical user interface was used to generate the JTC information.

A Theater Battle Management Core System (TBMCS) was used to produce files containing Air Tasking Order information for both Air Force and Navy Air missions. These files were produced before the demonstration and were used for input to the BML Web Service during the exercise since the TBMCS was not available for use. The Air Tasking Order information (USMTF and other formats) contained in the TBMCS files were converted to a BML compliant format. In the future, this function could be performed as part of the TBMCS or any other system that had the capability of producing Air Tasking Orders.

The Ground Operations Order was created by the Combined Arms Planning and Execution System (CAPES) injector on a USMC Command and Control Personal Computer (C2PC). This was done during the demonstration. The Ground Operational Orders were converted from XML to BML. In the future, this function could be performed as an injector in the C2PC or as part of any other C2 system capable of producing Ground Operational Orders.

The Air, Maritime, and Ground BML information was pushed into the BML Web Service which was hosted as part of a JC3IEDM compliant server. The Air Force and Maritime Air Tasking Order information was pulled out of the BML Web Service and converted to a JSAF compliant format and pushed to the JSAF. The Cruise Missile Maritime Order and the Ground Operational Order information was pulled out of the BML Web Service and converted to a JSAF compliant format and pushed to the JSAF. The two JSAF systems (different versions) were linked and displayed consistent simulation information.

Most of the simulated units acted as intended during the demonstration. However, there were a few anomalies with aircraft and missiles that did not execute the Orders as planned. The Orders information provided by the system files was compared with the resulting information stored in the JSAF files. The information was exactly the same. This proved that the conversion software and the BML Web Service executed their functions as designed and that the anomalies were created internal to the JSAF.

No JSAF operators were needed to interpret the orders being received since they were directly imported into the JSAF files. The resulting operation was an improvement both in accuracy and a reduction in operating cost due to the reduced need for operators.

4.0 MSG-048 Plans

The MSG-048 TA plans are to assess and improve current C-BML specifications performed under the auspice of the JBML programme and SISO C-BML PDG. In order to align national knowledge and to share a first common experience among Nations, it was decided to perform a first demonstration made of national voluntary contributions. This demonstration will provide NATO military audience with a first proof of concept and will open the path to reduce risk for an operational based demonstration that will conclude the TA works in 2009. The demonstration will be hosted on the NATO booth during the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) in November, 2007.

The architecture depicted in Figure 3 is made of the following systems

- C2PC or CAPES (USA): this is a workstation-based C2 system, developed by the US Marine Corps and also used by the US Army. It features and architecture supporting *injector* modules that can manipulate and display external data. The US Army has adapted its CAPES system to serve as a planning module for C2PC. Following the injector architecture, a BML module also could be added such that C2PC would “speak” BML as a native language. (At present it is interfaced to the BML Web service by a software module.).
- ISIS (The Netherlands): the Integrated Staff Information System is one of the first applications that resulted from the Royal Netherlands Army (RNLA) C2 Support Centre development towards a generic, configurable and distributed Command and Control information system in an evolutionary process. This system is the baseline for a suite of C2 applications that will provide staff sections, vehicles and individual combatants with a common operational picture. It is a configurable application platform and information system that provides generic functionality to support the C2 process. It supports the users in building and maintaining a COP that provides adequate Situational Awareness.
- NORTaC (Norway): it supports C2 in the Norwegian army at brigade level and below, in planning operations and to maintain situation awareness. NORTaC-C2IS also coordinates use of indirect fire weapons. It is integrated with tactical communications networks, military messaging systems, GPS, and can exchange information with allied forces through a MIP (Multilateral Interoperability Programme) gateway. Other interfaces are with BMS (Battlefield Management System), Link 16 and CTIDP (Common Technical Interface Design Plan – artillery). The system has been used in large national and multinational exercises.
- C2LG (Germany): C2 Lexical Grammar is the system provided by FGAN and that implements the C-BML grammar. C2LG defines a doctrinally-based set of terms that may be used and a set of rules based in military doctrine that define how these terms are combined. The set of terms will serve as lexicon, and the set of rules constitute the production rules of BML.
- SCIPIO (France): it is a full command post training system developed for the Army staff brigade and division training center. SCIPIO provides 3 major key capabilities. The first one is an Automated simulation control based on command agents. The second is C4I integration providing formatted reports sent to C2IS according to the procedure as well orders usable elements transmitted to the command agents under controllers checking. The last includes warfare modeling with high level automation where High level entities are able to command and control their assigned subordinates. SCIPIO includes HLA interface using a dedicated FOM, RTI 1.3 NG and is also compliant to the IEEE 1516.
- JSAF (USA):this is a constructive simulation that represent objects down to individual platforms and persons. It was developed and is maintained by the US Joint Forces Command (JFCOM), which makes it available to US allies. It can represent a very wide range of land, air, and maritime elements. JSAF can function in HLA federations and also can be linked to other simulations (including other instances of JSAF) by the DIS protocol. The JBML project has developed interfaces between JSAF and BML.
- JC3IEDM Visualizer (NATO): JC3IEDM/JBML Vizualiser is a C2 system surrogate following the recommendations of the Multilateral Interoperability Programme (MIP) and is developed by VMASC under NATO funding. It is an open source visualizer performing the display of the following

information:

- units (platoon, company, battalion, regiment, brigade, division, corps) at their current location using MilStd2525b icons
- control features such as coordination lines and coordination rooms associated with actions and tasks (borders, objective areas of attack, etc.)
- additional information for items selected (such as current activity for units, assigned units for control features, etc.) as text in a popup or a separated window
- order of battle (limited to units) as a hierarchy for a selected root in a separate window

The information is provided in a database that is MIP compliant and accessible via C-BML web services retrieving data.

- JBML database (USA): this is an enriched version of the JC3IEDM database accessible via web services which implement an enhanced version of the JBML Schema.

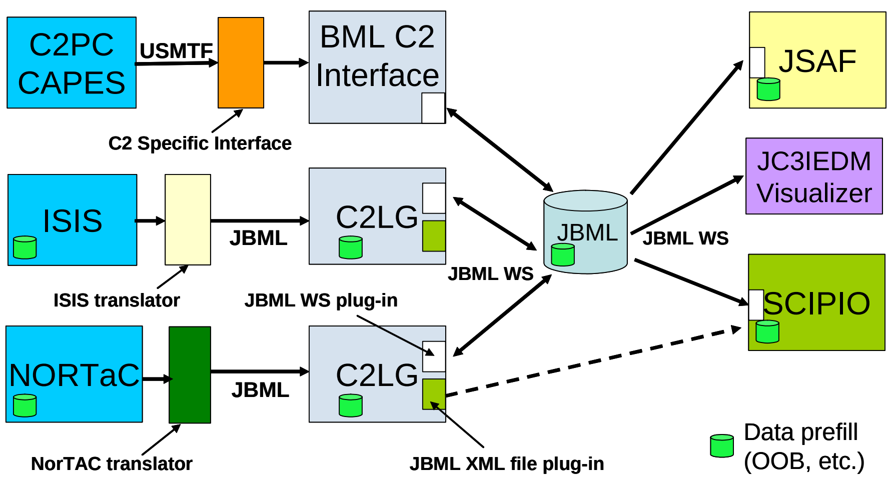

Figure 3: MSG-048 2007 Demonstration Configuration

National C2 systems (C2PC/CAPES, ISIS and NORTaC) are used to design courses of action. The plans defined with ISIS and NORTaC are sent to C2LG for enrichment and for translation into C-BML grammar before being stored in a JBML database accessible via Web services. When plans are fully completed with C2PC/CAPES, a BML C2 interface translates the orders into C-BML grammar and stores the information in the same JBML database using web services. Simulations JSAF and SCIPIO both read the database and run the desired plans automatically. At this stage no reports are generated by the simulation and the scenario is land centric but is extendable to include more complexity for further demonstrations. The Caspian Sea region is used as a common baseline scenario.

The TA is now in the process of validating interoperability of their systems with the JBML Web services, by operation over the Internet. They plan to test all of the systems together in this mode during the month of October, 2007, in preparation for assembling the final configuration at I/ITSEC.

The UK's immediate plans to become involved with the NMSG 048 C-BML experimentation program are centred on the use of ALPS, a MIP-compatible simulation of an army-focused C2 application, and JSAF (customised to incorporate UK equipment, units and behaviours and, in this form, widely used in the UK) for its M&S capability. A vignette from the MSG-048 I/ITSEC 2007 scenario will be implemented. Currently the UK often uses M&S systems to stimulate C2 systems in a training or mission rehearsal environment and is therefore particularly interested in the second phase of C-BML which will define how information returned to the C2 environment is specified. Longer term aspirations are to incorporate operational C2 systems, of which Bowman/ComBAT and JADOCS are representative examples, and to extend the variety of M&S applications. In parallel with this, a survey of UK requirements for C-BML will be conducted, the results of which will be used to assist the future development of C-BML

5.0 Conclusions

Strong progress continues in BML development. The developments of the JBML project will support a well-informed standards effort in SISO C-BML. Moreover, the JBML products (schema and open source Web services) will provide the nucleus of the MSG-048 demonstration. This in turn will bootstrap MSG-048 experimentation in 2008 to move C2-Simulation interoperation from the realm of "one-off" demonstrations to a capability for continuous operation that can validate the utility of BML for coalition operations.

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