submitted to the IEEE/SISO
Simulation Interoperability Workshop - Spring 2008

NATO MSG-048 Coalition Battle Management Initial Demonstration Lessons Learned and Way Forward

Dr. J. Mark Pullen and Scott Carey
C4I Center
George Mason University
Fairfax, VA 22030, USA
+1 703 993 3682
{mpullen, scarey}@c4i.gmu.edu

Nicolas Cordonnier
THALES Communications
DLJ/TCF/UCR/JC2/SIS/SIM
1-5 avenue CARNOT
91379 Massy Cedex France
nicolas.cordonnier@fr.thalesgroup.com

Lionel Khimeche
Délégation Générale pour l'Armement (DGA)
16 bis, avenue Prieur de la côte d'or
94114 ARCUEIL CEDEX France
+33 1 42 31 95 46
lionel.khimeche@dga.defense.gouv.fr

Dr. Ulrich Schade
FGAN-FKIE
Neuenahrer Straße 20
53343 Wachtberg, Germany
+49 228 9435376
schade@fgan.de

Nico de Reus and Nanne LeGrand
TNO, Oude Waalsdorperweg 63
The Hague, 2509 JG
The Netherlands
+31 70 3740236
{nico.dereus, nanne.legrand }@tno.nl

Ole Martin Mevassvik
Norwegian Defence Research Establishment, FFI
PO Box 25, NO-2027 Kjeller, Norway
+47 6380 7423
ole-martin.mevassvik@ffi.no

Sergio Galan
ISDEFE
28006 Madrid, Edison, 4, Spain
+34 91 512 14 81
sgcubero@isdefe.es

Lieutenant Sabas González Godoy
Spanish Army
Prim, 6, 28002 Madrid, Spain
+34 91 780 3588
sabas@et.mde.es

Michael Powers
US Army Topographic Engineering Center
7701 Telegraph Road
Alexandria VA 22315, USA
+1 703 428 7804
Michael.W.Powers@erdc.usace.army.mil

Major Kevin Galvin
NITEworks
Brennan House PO Box 87,
Farnborough, Hampshire, GU14 6YU, UK
+44 1252 385720
kevin.galvin@btinternet.com

Keywords:
Coalition Operations, Command and Control, Simulation, Web Services, C2 Grammar

ABSTRACT: *The NATO Modeling and Simulation Group Technical Activity 48 (MSG-048) was chartered in 2006 to investigate the potential of a Coalition Battle Management Language for multinational and NATO interoperation of command and control systems with modeling and simulation. In its May, 2007 meeting, MSG-048 decided to undertake as its first technical project a multinational demonstration, using the US Joint Battle Management Language (JBML) phase 1 prototype Web services as central infrastructure. The demonstration was presented at the I/ITSEC'07 and consisted of three different operational national C2 systems interoperating with three different national simulations, supported by the JBML Web services and an open source C2 visualizer from the US, and the C2 Lexical GUI from Germany. In all, eight software systems from six nations successfully interoperated. This capability was achieved in only six months, based on use of an Internet Reference Implementation that all parties could use to test from their home laboratories, along with a high level of cooperation among technical personnel and military subject matter experts from all participating nations. This paper will provide an overview of the interoperation technology and component systems used in the MSG-048 initial demonstration, describe the lessons learned in the process of creating the demonstration, and summarize the way ahead for the work of MSG-048, including its support for validation of the products of SISO's C-BML Product Group.*

1. Introduction

This paper reports on the first, successful phase of a multinational project that is evaluating a capability for interoperation of Command and Control (C2) systems with Modeling and Simulation (M&S) systems for coalition operations. The system provides for rapid, effective information sharing among coalition organizations. The key enablers of this capability are an emerging standard language for military operations, the Battle Management Language (BML) a Web service repository based on the Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM). The Web service schema and Reference Implementation software which provided the basis for interoperation was developed under the Joint Battle Management Language (JBML) project [3, 4].

The need to interface C2 systems with simulation systems has long been established. However, while the simulation community has established general simulation-to-simulation standards (e.g., High Level Architecture - HLA), work to establish standards for C2-simulation interoperability has been limited. As a result, almost every simulation has a unique C2 interface. A notable exception is the BML initiative, which uses the Multinational Interoperability Program (MIP) data standard JC3IEDM as a system-independent community vocabulary for passing plans orders, and reports between C2 systems and simulations. BML seeks to manage complex interactions among Service, Joint and Coalition C2-simulation interoperation by providing a common means of exchanging information that all C2 and simulation systems can implement.

The remainder of this paper describes the technologies and development approach used in MSG-048's successful initial demonstration, held at the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) 2007 in Orlando FL. The following major sections first provide the background to understand the need for BML and how MSG-048 is working to meet it, then describe the BML representation, the Web services that were used, and technical contributions of the six nations that participated. The paper concludes with observations regarding the enablers for MSG-048's rapid development and a look at its future plans.

2. Background

This section provides background on BML and on the NATO MSG-048 Technical Activity in order to set the stage for understanding of the demonstration.

2.1 BML

BML began in work sponsored by the US Army's Simulation-to-C4I Interoperability Overarching Integrated Product Team (SIMCI OIPT). Carey *et al.* [5] describe the overall process used to show the feasibility of defining an unambiguous language, based on manuals capturing the doctrine of the US Army. This first BML project started by analyzing more than 70 doctrinal manuals related to tasking and reporting, beginning with general manuals, such as the Field Manual 3-0 on Operations and the US Joint Staff's Universal Joint Task List. The review included field manuals of Army elements such as Field Artillery, Air Defense Artillery, Engineers, Military Police, down to the platoon level. This work resulted in definition of an unambiguous Operational Order (OPORD) using the traditional "5 Ws" (who-what-when-where-why) to describe military tasks [1]. This first effort developed a prototype for battalion operations orders demonstrating 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 chartered to build on the US Army's initial work, with two main objectives: (1) using Service Oriented Architecture (SOA) technology for information exchange among the systems' interfaces and (2) using the MIP's Command and Control Information Exchange Data Model (C2IEDM, an earlier version of the JC3IEDM) as a basis to represent the information to be exchanged between the systems. JFCOM 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 to evaluate whether the concepts of BML are applicable to air forces as well as ground forces, using Theater Battle Management Control System (TBMCS) and Air Warfare Simulation (AWSIM) systems with positive results [6]. XBML also became the basis for an international experiment, driven by interest of the Exploratory Team which was formulating the proposal that led to MSG-048, as described in [7].

The latest progression in US work on BML is the JBML, which expanded BML into the Joint arena including ground, air and maritime domains and urban warfare and was successfully demonstrated in May 2007. JBML achieved considerable technical progress by creating a revised Web service schema, based on lexical grammar and designed to facilitate expansion into other military realms, which was implemented in the open source JBML Web Services as described below [3, 4]. In parallel with JBML, the US Army Topographic Engineering Center

(TEC) has been developing a geospatial BML (geoBML) which will bring a wealth of geospatial data to the C2-M&S environment [8].

2.2 MSG-048 Background

The need for C2-simulation interoperability in coalition operations is even greater than that of national Service and Joint operations. Coalitions must function despite greater complexity due to significant differences among doctrine and human language barriers; thus the agility to train and rehearse rapidly before the actual operation is highly important [9]. The NATO Modeling and Simulation Group (MSG), in recognition of this need, chartered Technical Activity MSG-048 to explore the promise of BML in coalitions combined with SOA technologies [10].

3. Demonstration Overview

This section describes two aspects of the MSG-048 November 2007 demonstration: the overall information technology-based system, and the military scenario use to evaluate and demonstrate that system.

3.1 C2 and Simulation System of Systems

Figure 1 shows the interoperating elements of the demonstration: three national C2 systems, the middleware C2 Lexical Graphical User Interface (GUI) and JBML Web Services, three national simulation systems, and a JC3IEDM visualizer that was used to provide a common operating picture of the overall situation. The individual systems and the way they interoperated are described in section 4 below.

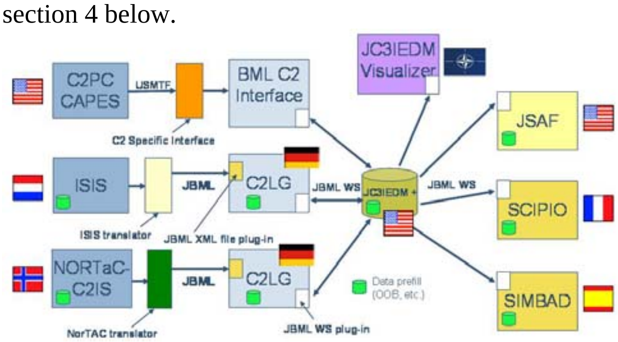

Figure 1. System Architecture

3.2 Military Scenario

The scenario used for the demonstration was based initially on a Netherlands analysis scenario. To enable later integration of geoBML, a switch to the U.S. Army Training and Doctrine Command (TRADOC) Common Teaching Scenario was made. This scenario is located in the Caspian Sea area and set in the 2025 timeframe. The entire region has a long history of fighting, factionalism and unrest. The fictional countries of Donovia, Minaria, Gorgas and Atropia are successor states to the Zloi Empire that collapsed in 1991. Ethnic tensions, economic difficulties, and weak and non-responsive governments have created instability in some states. Traditional and emerging secular and clerical states try to control the unrest of their populaces by emphasizing external enemies and increasing the size and prestige of their militaries. Western economic interests and investments are centered on increasing the oil and gas extraction for export. The major threat to international interests is the curtailment or loss of energy exports from the region. The Ariana government, supported by Donovian rebel forces, may try to occupy and claim the (oil rich) Arzak section of Atropia. Donovia may invoke a revolt by the Donovian majority in the Kazi Magomed valley of Atropia. Donovian rebels are expected to occupy the Karvi Magomed Airport to create a second front for the Atopian forces. Section or platoon sized motorized Donovian rebel resistance is expected (harassment and hasty defensive positions) between the Atropicana River and the Kazi Magomed Airport.

Figure 2. Caspian Sea Region

The Commander Joint Forces Land Component Commander (CJFLCC) has decided to commit the 43rd Multi-National Brigade (43 MNB - Figure 3) composed of three Battalion (Bn) Task Forces (TF) to secure the Kazi Magomed Airport. For this mission, the Commander 43 MNB requires the use of two of his three BN TFs. He has selected 1 (USA) TF, a US Combined Arms Battalion, and has to decide between 2 (NLD) TF (Netherlands) and 2 (NOR) TF (Norway) for his second TF. He has asked the commanders of NLD (Maneuver Battalion) and NOR (Telemark Battalion) both to plan for the same assignment. The outcome of the simulation-based COA-analysis will support the commander’s decision.

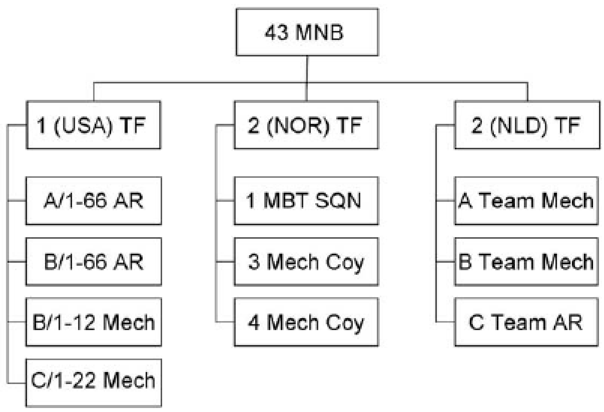

Figure 3. ORBAT 43 MNB

Figure 4 shows the overall plan. On 10 August 2025, the CJFLCC orders 43 MNB to seize and defend the Kazi Magomed Airport intact to deny the expected Donovian occupation of the airport and to deny interference by the Donovian rebels. Operation PERSEUS is planned to start at first light on 11 August. The key to success for 43 MNB is for 1 (USA) TF to seize the bridges intact and then conduct a passage of lines as the stationary force to support the onward movement of either the NLD or NOR Bn TF in order to secure the Airport. The assigned second TF will seize and defend the Airport in order to deny any Opposing Military Forces (OMF) or Donovian interference.

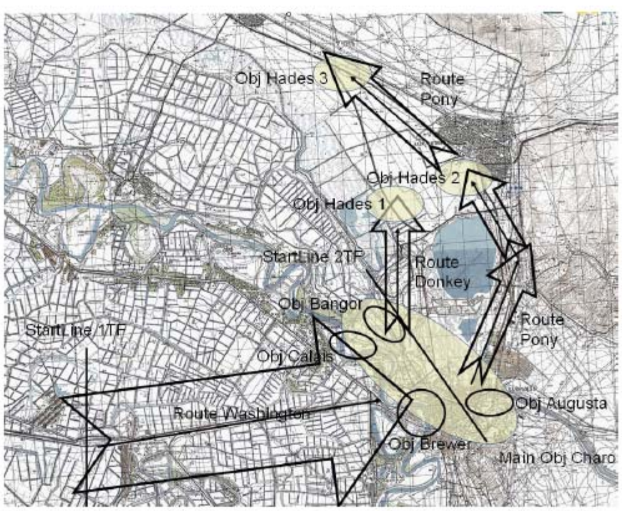

Figure 4. 43 MNB Plan

4. National Contributions

The six nations that participated in the demonstration each contributed significant a technical capability. These national contributions are described in this section. The core capability was the JBML Web Services, which will be described first, coupled with the C2LG GUI, which will be described next. Following this the various national contributions will be described (in alphabetic order).

4.1 JBML Web Services

The Web services were implemented as open source Java software by the JBML project. The intention was to provide a reference implementation serving both as basic infrastructure for the project, in support of the C-BML standards effort [13]. The implementation is based on Web service networking standards [14] and was originally reported in [15]. Figure 5 provides an overview of the JBML Web service Architecture. The service layers are:

- 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 of military orders (who, what where, when, why) and other constructs of interest. In Web services terminology, these implement "business rules."
- The lowest layer represents the information exchange of information elements. This layer is normally hidden from the user. In JBML, this is the Common Data Access Service (CDAS) which provides for access to the database.

It would be possible to implement these three layers as cascading Web services, where the Web service at one layer invokes a Web service at a lower layer. While the layers are in fact configurable to be exposed as Web services, the design in Figure 5 avoids that because it would compound the already low performance of Web services. Since the three layers are present in the same computer, we access the lower layers through a software API rather than the Web service wrapper. The JBML Web Service deployment is described further in [16].

The BBS services are not accessed by the user of JBML, who uses the DCS. However, in order to support continued research in expanded BML, the JBML software has an option to expose the BBS as a Web service. In either form of access, the BBS provides a way to deal with the fact that the various *who/what/when/where/why* transactions may require multiple database table updates under the JC3IEDM (in the case of *what*, up to 25 tables). As a result, it is important that any such transaction be treated atomically so that two of them do not have interleaved access when updating the database, as that could leave the database in an inconsistent state.

A key to the rapid integration achieved among the six national technical groups in the MSG-048 demonstration was the practice of distributed development. This was based on availability via the Internet of an instance of the JBML Web Services, serving as a reference implementation that was available as open source software to all participants.

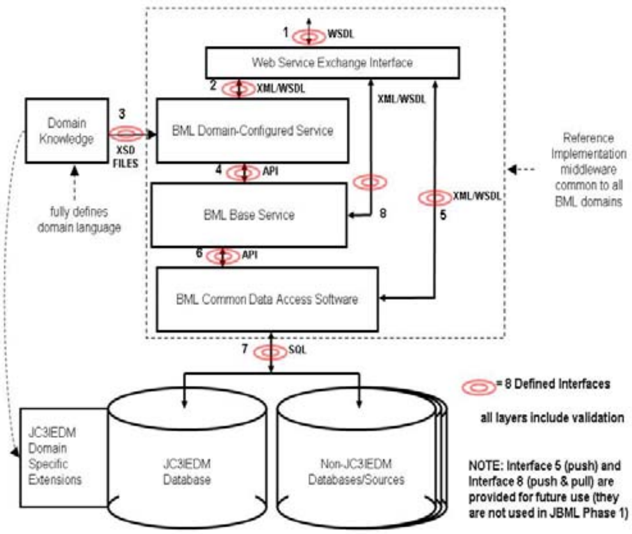

Figure 5. Layered Service Architecture

4.2 Command and Control Lexical Grammar (C2LG) and GUI

This section describes the contribution from Germany which provided the rationale for the JBML Web Services schema and also provided support to the NORTaC and ISIS C2 systems. Since the JBML schema was based on the C2LG, it was possible to transform JBML-formatted orders automatically into C2LG format. To ensure that the orders can be processed automatically, C2LG defines how orders are to be expressed in a BML that is a formal and unambiguous language. A formal language is generated by a grammar: Command and Control Lexical Grammar (C2LG) [11]. This section describes the C2LG as well as the GUI that can be used to formulate orders that respect the constraints set by the C2LG.

The C2LG can be used to formulate reports as well as orders [17]. However, in this paper, we consider the scope needed for the MS-048 demonstration, i.e. only those rules that are needed for tasking units. These rules form the subset of the C2LG rules known as "Tasking Grammar". In the tasking grammar, a single task is assigned to a unit by a basic order expression. These expressions have the form

(1) OB → Verb Tasker Taskee (Affected|Action) Where Start-When (End-When) Why Label (Mod)*

Representing the task the values for Verb have been taken from JC3IEDM's table "action-task-category-code". Tasker represents the unit or individual that assigns the task, and Taskee is the unit that has to execute it. Start-When and End-When express when the task has to start and has to be finished, respectively. End-When is optional as indicated by the brackets. Why denotes a reason for the assignment. Label is a unique identifier for the task. It is introduced such that the task can be referred to in other expressions. Mod (modifier) is a wild card. It has been used for describing formation or for denoting the manner in which the task has to be executed, e.g. as fast as possible or cautiously and without any risks. Affected and Action are only used in some basic order rules. Affected is used if the task directly affects someone or something, e.g. the enemy in the case of ***ambush***. Action is used in a similar way, namely if the assigned task affects another action, e.g. in the case of ***assist***. As different task verbs demand (and allow) different constituents like Affected or Action, there is one basic order rule for each task verb in the tasking grammar. (This is one of the reasons the grammar is a "lexical" grammar.) The type of the Where also depends on the tasking verb. Some tasks demand a Route-Where – to denote a route – whereas others demand an At-Where – to denote a location. In order to show how C2LG's basic order rules look like, (2) lists four of them (there are 65).

(2a) OB → ***advance*** Tasker Taskee Route-Where Start-When (End-When) Why Label (Mod)*

(2b) OB → ***ambush*** Tasker Taskee Affected At-Where Start-When (End-When)Why Label (Mod)*

(2c) OB → ***assist*** Tasker Taskee Action At-Where Start-When (End-When)Why Label (Mod)*

(2d) OB → ***rest*** Tasker Taskee At-Where Start-When End-When Why Label (Mod)*

Here is an example of an actual order using the grammar:

(3) ***pursue*** BtlC CavB En **towards** Z **at** now **in order to** destroy En label_3_15;

To use such orders in the experiment's simulation systems, they are processed in two steps. First, for each basic order expression, its constituents are identified. Second, the constituents are mapped into JBML. Because JBML's schema is based on the C2LG, the XML tags of the JBML schema correspond to the non-terminal symbols (Tasker, Taskee, Affected, etc.) used by the C2LG to represent the constituents formally. For example, in (3) CavB is the Taskee constituent. It is tagged <TaskeeWho> in JBML.

FGAN-FKIE has developed a GUI (Figure 6) to allow and to facilitate the formulation of orders (and reports) according to C2LG's rules. The GUI includes plug-ins that allow it to be connected to other systems. In Figure 1 these are JBML plug-ins. In this way, C2LG is connected to the C2 systems ISIS and NORTaC. Using JBML output plug-ins, the C2LG is connected to the JBML Web Services which provide input to the simulation systems.

To formulate an order, the data flows as follows. The order is pre-formulated within the C2 systems (ISIS or NORTaC, respectively). The pre-formulated order then is loaded into the GUI via the input plug-in. The GUI checks the pre-formulated order and enforces the addition of missing information pieces. As can be seen in figure 6, the GUI uses drop-down menus and a map. In the map, units, facilities, features and locations can be selected (by mouse click) to speed up formulation, especially formulation of the Where elements. When a BML order is completed, it is processed in two steps as described above. The processing is executed by the output plug-in. After the calculation of the constituents, they are mapped into the JBML schema. As such, the output can be delivered to the simulation systems by the JBML web services.

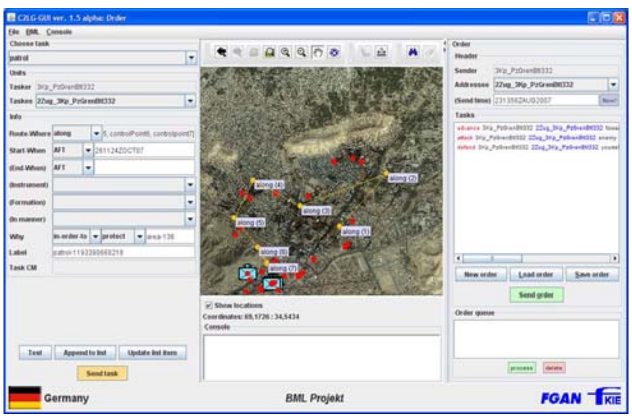

Figure 6. C2LG GUI

4.3 France Contribution: SCIPIO

SCIPIO is a full command post training system built for the French Army training center for training brigade and division HQs. SCIPIO provides the training center with three major key capabilities. The first is an Automated Simulation Control based on command agents. The second is a C4I integration providing the capability to send formatted reports to HQ C4I systems as well as to receive and make use of orders transmitted to the command agents under controllers checking. The last includes modern Warfare Modeling with high level automation where higher level entities are able to command and control their assigned subordinates. The SCIPIO training environment is shown in figure 7. It includes:

- Preparation tools allowing users to set up an entire exercise and including export functions to upload initial data (e.g. order of battle) in C4Is and devices for a rapid technical configuration of the training center;
- Exercise conducting tools equipping 35 battalion level cells, directorate staff and exercise analysts;
- After Action Review tools including visual replay of the battle, statistics analyses tools and a set of "on the map" visual indicators.

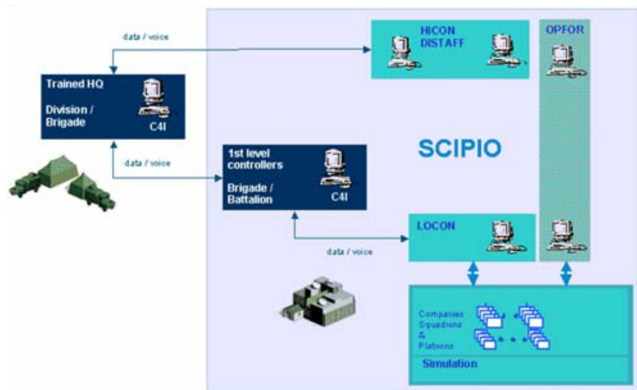

Figure 7. Training organization with SCIPIO

For the demonstration, SCIPIO was used with ISIS and NORTaC C2 systems which are described below. The orders elaborated for the different courses of action of the scenario through the command systems were manually or automatically extracted from the JBML repository database and simulated in SCIPIO. The simulated situation was displayed through the SCIPIO Supervision interface. The connection was performed through a BML plug-in application developed and integrated into SCPIO specifically for the demonstration. This plug-in aimed to connect SCIPIO to the data repository, to pull the orders and data according to the JBML grammar and to run the simulation. The visualization and control of the simulation was achieved by an operator through the SCIPIO Low Controller and Supervision Interface.

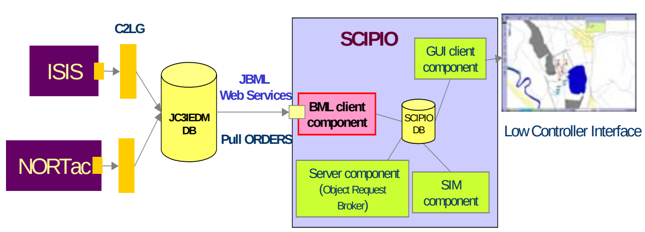

Figure 8. Connection architecture of SCIPIO

Adaptation of the scenario and doctrine

The SCIPIO simulation implements agents and behaviors according to French force structure, organization and doctrine. Thus, on the basis of existing units and agents, specific models and Command Agents have been created to fit Netherlands and Norwegian order of battle, especially in terms of equipment and capabilities in order to make simulation rendering and agent behaviors as "realistic" as possible. Similarly, the SCIPIO simulation implements French doctrine and in order to fit the Perseus scenario, a specific adaptation effort with MSG-048 military experts was performed to map tasks and all associated parameters implemented in SCIPIO with BML tasks defined in the scenario. For example, the "March" order is not implemented "as is" in SCIPIO. A mapping implements the effect defined in the scenario by a sequence of SCIPIO tasks.

Training or decision support ?

This issue relates to the question of the operational field addressed by the demonstration. The script of the demonstration dealt with a planning decision making process showing how different courses of action elaborated from a C2 system could be supported by simulation in order to enable the operational planning officer to make a decision. SCIPIO actually is a training simulation based on low controller animation performed by operator. Usually, orders are transmitted by HQ staff to the appropriate level of control that executes them through the simulation. To use this capability for decision support, a specific software layer was implemented in a SCIPIO BML plug-in to support management of time and scheduled tasks contained in the JBML ORDER. The execution of task was automatically performed from the JBML exchange database flow, with a manual option.

FRAGO Management

SCIPIO needs a low level controller to assemble detailed actions into a task. These internal actions are achieved by using Fragmentary Orders and generally depend on the reception of operational reports from the simulation. For instance, arriving on a "line of departure" triggers a report from the simulation to the low controller who then will issue a Departure FRAGO at the suitable moment. To fit to the demonstration scenario, some operational reports returned by the simulation have been specifically configured in order to display them on GUI or to associate them to the execution of a FRAGO. An analysis by military experts defined which FRAGO to write according to the information reported by the simulation.

Extension to the BML status

The demonstration revealed some needs and extensions to be considered in the future. Two major points have been identified from the simulation side.

Reporting from Simulation to C2 System. In an operational context, the demonstration aimed to show how information can flow from the C2 system to the simulation as well as from the simulation to the C2 system. The capability to report from the simulations to the C2 Systems has not yet been implemented. Thus the SCIPIO low controller GUI is the only way to display the execution of orders and to control that they have been correctly received and accomplished. The implementation of BML Reports is planned as the next step to have a real interaction between C2 systems and simulation systems.

Management of pullOrder requests. The parameter used to identify the correct BML Order in the exchange database had been by convention the Order ID. This parameter was predefined or orally transmitted by the creator of the BML Order (C2 System part) when pushing the order into the Database. The ID then was used by the simulation to pull the order out of the database. These technical issues – how to automatically fire the pull order requests and which parameters are necessary to identify the order in the database – need to be studied as BML is extended for future application. For example, orders could be aggregated into a specific context such as a course of action or a plan; this is supported by the JBML schema but was not used in the demonstration.

4.4 Netherlands Contribution: ISIS

The Royal Netherlands Army C2 Support Centre is developing a generic, configurable and distributed Command and Control information system. This system, known as C2 Framework (C2FW), 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 the foundation for a family of C2 Information Systems. The Integrated Staff Information System (ISIS) is aimed at the static domain (compound, command post). It is developed and used within the Royal Netherlands Army as a main C2 application for issuing orders and delivering a COP throughout the mission. Other systems, based on the framework are OSIRIS and XANTHOS which are used in the mobile (command vehicles, tanks, etc.) and dismounted domain (dismounted commanders, soldiers).

Figure 9 shows that ISIS enables the commander to view tactical data in the form of a COP and assemble plans to be sent out to the users. The plans are in the form: Operation Plan (OPLAN) (5 paragraph NATO standard), Order Of Battle and Overlay displaying the commander's plan graphically. ISIS is a MIP enabled system meaning that the data on this system can be aligned with other MIP enabled C2 systems using the MIP gateway.

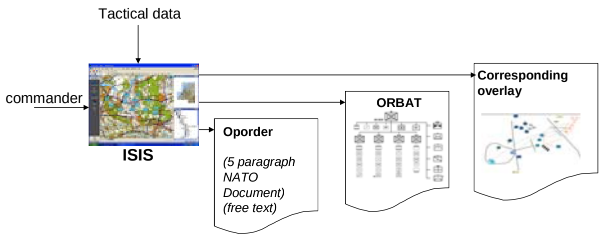

Figure 9. ISIS Input/Ouput

The problem with the output of ISIS in the context of the MSG-048 BML experiments is that neither the free text used in the OPORD nor the overlay contains enough information to unambiguously and automatically generate BML statements by non humans. In other words, the information is there but cannot be extracted. For this reason, in the MSG-048 experiments the ISIS system had to be enabled to generate BML. The architecture in figure 10 has been used for this purpose. More details are provided in [19].

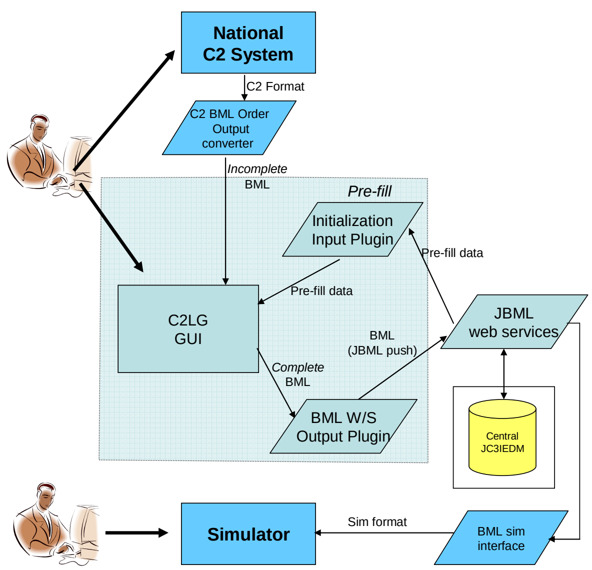

Figure 10: Architecture for enabling non BML capable C2 systems to generate BML using the C2LG GUI

4.5 Norway Contribution: NORTaC

The Norwegian contribution in the demonstration was to BML-enable the NORTaC-C2IS. The NORTaC-C2IS is the Norwegian C2IS for tactical army operations and is developed by Kongsberg Defence & Aerospace. A plan stored in the C2IS can be sent to the C2LG as a JBML XML document. Control measures created by the C2IS can be used a starting point for creating plans or fragmentary orders using the C2LG.

An operation plan (OPLAN) was developed for the 2(NOR)TF by the Norwegian Army Combat Manoeuvre Training Centre (NACMTC). The OPLAN was developed in accordance with STANAG 2014 [reference] and the national army planning framework. This plan consists of three phases, each basically securing one of three defined objective areas. The plan was formulated at the company level, that is, the tasks are assigned to companies and squadrons.

The plan developed was successfully translated into the JBML framework by the use of the JBML XML Schemas. Challenges were however discovered, both with respect to capturing all elements of the plan and to simulate it. Some challenges were:

- The plan required a high level of flexibility in execution, for example "on order be prepared to support unit x."
- The order of battle might change during execution by attachment and detachment of units.
- The sequencing of tasks and defining task dependencies. (BML does not yet have a mechanism for the simulation to report when a task has been completed.)
- Control measures such as fire coordination lines might be activated and deactivated during the operation.

The plan was entered into NORTaC-C2IS through its existing C2IEDM database. This allowed for NORTaC-C2IS to graphically present certain elements of the plan (see Figure 11). This also enabled a complete or partial JBML formatted order to be sent from NORTaC-C2IS to the C2LG. A NORTaC JBML Translator was developed for this purpose. The translator extracts a complete or partial order from a C2IEDM database (in this case of NORTaC-C2IS) and outputs it as a JBML XML document. The XML document is sent to C2LG using Web protocols.

The main function of the NORTaC JBML Translator is to map between a C2IEDM relational database and a JBML XML document. The implementation task was greatly simplified by the use of open source projects and data generation tools (Hibernate, Eclipse Hibernate Tools and JAXB). The main work was thus to define the mapping between the applicable parts of the C2IEDM and the JBML XML Schema. A more detailed description of the translator can be found in [19].

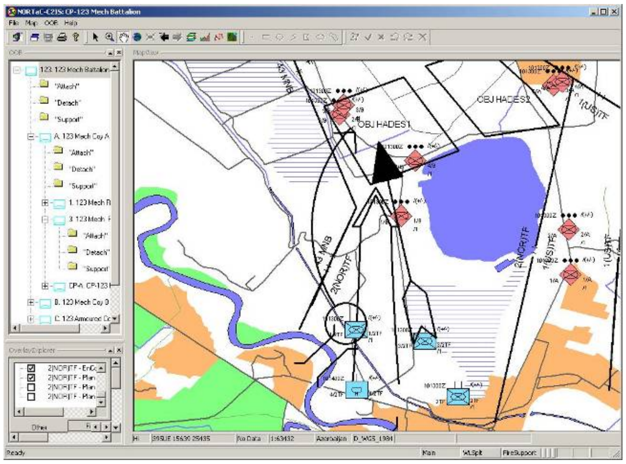

Figure 11: Phase 1 of the Norwegian plan

4.6 Spain Contribution: SIMBAD

The Spanish constructive simulator SIMBAD was designed to train battalion-level task force command posts in course of action and logistic support. Military units are typically represented in SIMBAD at the level of aggregation of platoons. The object model used within SIMBAD is based on C2IEDM structures. Some of the main features of SIMBAD are:

- Predefined rules of engagement (ROE)s, engagement tables and algorithms, and a set of configurable parameters.
- A Tactical Event Manager, which also deals with time management issues.
- A GIS-based GUI, which can represent both geographical and tactical layers.
- An HLA interface (using a proprietary, C2IEDM-inspired FOM).

SIMBAD was the last system to be identified by the group as a candidate for the MSG-048 demonstration at I/ITSEC'07, just three months prior to the event. This addition was made because having an extra system on the simulation side would allow more BML use cases to be tested. In particular, the demonstration showed that military plans can be expressed using BML, independent of the system that needs to interpret them afterwards. The late inclusion of SIMBAD in the demonstration was considered to be low risk since SIMBAD had participated in previous BML-related NATO experiments and the core of the simulator is already C2IEDM oriented. The demonstration's system architecture proved to be flexible, allowing the unplanned late inclusion of a new system with no impact on the rest.

Due to the way in which this SIMBAD is used to train commanders it offers almost no automation to the user, who is responsible for initiating and controlling the execution of elementary actions such as "move" or "engage" in order to undertake operational tasks. For this demonstration, a JC3IEDM-SIMBAD gateway was developed to allow the transformation of operational tasks into elementary actions that could be understood by SIMBAD. This gateway consists of two applications that communicate using shared memory: one of them pulls orders from the JC3IEDM database through Web service calls and transforms the JBML tasks included in the orders into elementary actions that SIMBAD can undertake. The second application sends these elementary actions to SIMBAD using its communications library, which is called Geminis.

For example, the process required to transform a "SEIZE" task into elementary actions is described as follow:

- The first application pulls a JBML order from the database. This order includes a "SEIZE" task having the properties TaskeeWho = B/2(NLD)TF and Where = AreaOfInterest Hades1.
- Then, the application proceeds to calculate the route that B/2(NLD)TF needs to follow in order to reach Hades1. For every enemy unit located within a given range from the shortest route to the destination, a new point is added to the route, as well as a "direct fire" action so that B/2(NLD)TF engages these enemy units prior to reaching Hades1.
- Finally, the first application stores the elementary actions in shared storage and calls the second application so that the task is sent to SIMBAD for execution.

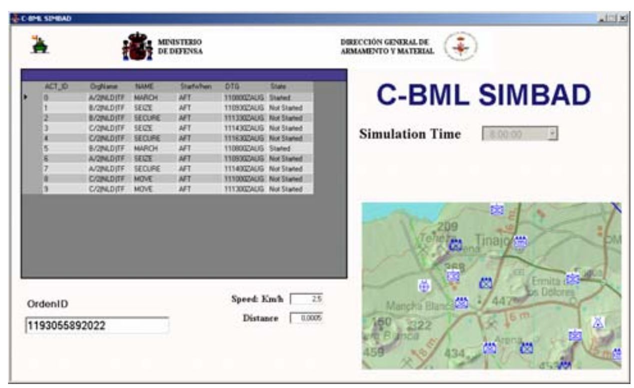

Figure 12. JC3IEDM-SIMBAD gateway screenshot

The transformation process described above is illustrated in figure 13. The Task "B/2(NLD)TF SEIZE AreaOfInterest HADES 1 AFT 110930ZAUG2025" is decomposed in three elementary SIMBAD actions:

- Action 1: B/2(NLD)TF has to move along "Path 1" at 09:30 on August 11.

- Action 2: B/2(NLD)TF has to engage OMF3 after Action 1.

- Action 3: B/2(NLD)TF has to move along "Path 2" after Action 2.

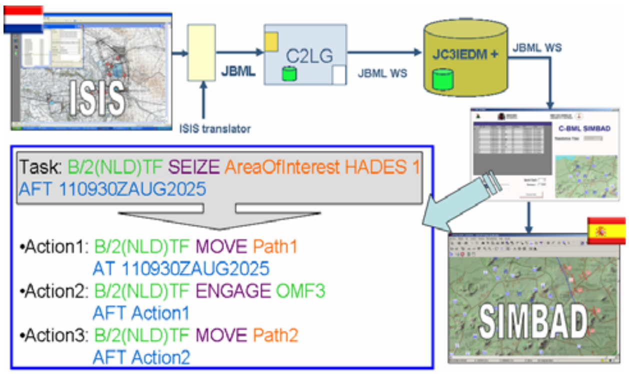

Figure 13. Transforming JBML task into elementary SIMBAD actions

4.7 USA Contribution: C2PC, JSAF and Visualizer

C2PC/CAPES 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 injector for C2PC. Following the injector architecture, a BML module also could be added such that C2PC would generate BML as a native language; at present it is interfaced to the BML Web service by a software module. C2PC also has the advantage that it is available in an unclassified form for US participation in experiments.

JSAF is a constructive simulation that represents objects down to individual platforms and combatants. It was developed and is maintained for training and experimentation by the US Joint Forces Command (JFCOM), which makes it available to US forces and 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 an interface between JSAF and the XML schema associated with the JBML Web Services.

The JC3IEDM visualizer was provided by the Virginia Modeling, Analysis and Simulation Center (VMASC) under NATO funding. It consists of an open source software map viewer that is capable of displaying all units in the JC3IEDM database, in order to provide a common operating picture for all participants.

5. Conclusion

The MSG-048 November 2007 demonstration provides very strong evidence in favor of the techniques employed as a basis for an SOA approach to using simulations with C2 systems. First and foremost, the approach based in formal linguistics (using the C2LG-inspired schema) and associated Web Services, with strong semantics (using the JC3IEDM-derived vocabulary), provided an extremely effective medium of expression for communication among the various systems. Perhaps equally important, the network-centric development methodology proved highly effective, especially when employed by national development teams with a highly cooperative spirit, including technical developers and military subject matter experts.

The project described in this paper is only the beginning of MSG-048's development of a BML/SOA-based environment for evaluation of the potential of these techniques for coalition C2/simulation interoperation. The plan for 2008 calls for evaluation of multiple additional experimental coalition configurations and language extensions/improvements. After that, if the technology and associated development methodology proves as successful as indicated by this first step, MSG-048 will seek its application in a NATO exercise or experiment.

6. References

[1] Sudnikovich, W., J. Pullen, M. Kleiner, and S. Carey, "Extensible Battle Management Language as a Transformation Enabler," in *SIMULATION*, 80:669-680, 2004

[2] Tolk, A. and J. Pullen, "Using Web services and Data Mediation/Storage Services to Enable Command and Control to Simulation Interoperability," 9th IEEE International Symposium on Distributed Simulation and Real Time Applications (DS-RT 2005), Montreal, Canada, 2005

[3] Pullen, J., M. Hieb, S. Levine, A. Tolk, and C. Blais, "Joint Battle Management Language (JBML) - US Contribution to the C-BML PDG and NATO MSG-048 TA," IEEE European Simulation Interoperability Workshop, June 2007

[4] Levine, S., M. Pullen, M. Hieb, C. Pandolfo, C. Blais, J. Roberts and J. Kearly, "Joint Battle Management Language (JBML) Phase 1 Development and Demonstration Results," IEEE Fall Simulation Interoperability Workshop, Orlando, FL, 2007

[5] Carey, S., M. Kleiner, M. Hieb, and R. Brown, "Standardizing Battle Management Language – A Vital Move Towards the Army Transformation,"

IEEE Fall Simulation Interoperability Workshop, Orlando, FL, 2001
[6] Perme, D., M. Hieb, J. Pullen, W. Sudnikovich, and A. Tolk, “Integrating Air and Ground Operations within a Common Battle Management Language,” IEEE Fall Simulation Interoperability Workshop, Orlando FL, 2005
[7] Sudnikovich, W., A. Ritchie, P. de Champs, M. Hieb, and J. Pullen, “NATO Exploratory Team – 016 Integration Lessons Learned for C2IEDM and C-BML,” IEEE Spring Simulation Interoperability Workshop, San Diego CA, 2006
[8] Hieb, M., S. Mackay, M. Powers, M. Kleiner, and J. Pullen, “The Environment in Network Centric Operations: A Framework for Command and Control,” 12th International Command and Control Research and Technology Symposium, Newport, RI, 2007
[9] Tolk, A, M. Hieb, K. Galvin, L. Khimeche, and J. Pullen, “Developing a Coalition Battle Management Language to facilitate Interoperability between Operation CIS and Simulations in support of Training and Mission Rehearsal”, 10th Command and Control Research and Technology Symposium, McLean, VA, 2005
[10] Galvin, K., W. Sudnikovich, P. deChamps, M. Hieb, J. Pullen, and L. Khimeche, “Delivering C2 to M&S Interoperability for NATO - Demonstrating Coalition Battle Management Language (C-BML) and the Way Ahead,” IEEE Fall Simulation Interoperability Workshop, September 2006
[11] Schade, U. and M. Hieb, “Development of Formal Grammars to Support Coalition Command and Control: A Battle Management Language for Orders, Requests, and Reports, 11th International Command and Control Research and Technology Symposium, Cambridge, UK, 2006
[12] Hieb, M. and U. Schade, “Formalizing Command Intent Through Development of a Command and Control Grammar,” 12th International Command and Control Research and Technology Symposium, Newport, RI, 2007
[13] Blais, C., K. Galvin and M. Hieb, “Coalition Battle Management Language (C-BML) Study Group Report,” Paper presented at IEEE Fall Simulation Interoperability Workshop, Orlando FL, 2005
[14] Tolk, A., S. Diallo, C. Turnitsa, and L. Winters, “Composable M&S Web services for Net-centric Applications,” in *Journal of Defense Modeling and* Simulation 3:27-44, 2006
[15] Pullen, J., K. Makineni, and P. McAndrews. “A Grammar-Based Web Service Enabling Multi-domain Distributed Interoperation of Command/Control and Simulation Systems, 11th IEEE International Symposium on Distributed Simulation and Real Time Applications (DS-RT 2007), Chania, Greece, October 2007
[16] Pullen, J., M. Hieb, and S. Levine, “Using Web Service-based Command and Control to Support Coalition Collaboration in C2 and Simulation,” 13th International Command and Control Research and Technology Symposium, Bellevue, WA, 2008
[17] Schade, U., and M. Hieb. “Battle Management Language: A Grammar for Specifying Reports,” IEEE Spring Simulation Interoperability Workshop, 2007, Norfolk, VA
[18] NATO STANAG 2014, Formats for orders and designation of timings, locations and boundaries, 17 October 2000
[19] de Reus, N., R. de Krom, O. Mevassvik, A. Alstad, U. Schade and M. Frey, “BML-enabling national C2 systems for coupling to Simulation,”, IEEE Spring Simulation Interoperability Workshop, 2008, Newport, RI

Author Biographies

SCOTT CAREY is a research associate at George Mason University's C4I Center. He is a retired US Army Lieutenant Colonel with special interest in BML and command and control in simulations.

NICOLAS CORDONNIER is an information engineer with Thales Communications. He supports the French SCIPIO system in the MSG-048 configuration.

SERGIO GALAN CUBERO is a system engineer, assigned to the M&S office in the R&T organization of the Spanish MoD, leading and supervising projects related to M&S interoperability. His domains of expertise include middleware, software architecture and development process.

MAJOR KEVIN GALVIN is a serving Infantry officer with over 33 years of service in the British Army. In the last 10 years, he has been actively involved in the UK Digitization programme as an Operational Architect looking at Command and Control processes and information flows.

LIEUTENANT SABAS GONZÁLEZ GODOY is a serving Polytechnic Engineering officer with 17 years of service in the Spanish Army. Since 2000, he has been working in the procurement and development of simulation systems for training as well as in technical multinational M&S activities.

LIONEL KHIMECHE is an R&T program manager in the field of M&S for planning and forces readiness at the DGA (Delegation Generale pour l'Armement) / Center for Defense Analysis. His main topic of research deals with

C4I-Simulation Interoperability. He co-chairs the NATO Technical Activity on C-BML and he leads several international projects for cooperation.

NANNE P. LEGRAND is a former Colonel of the Royal Netherlands Army. During his 36-year career he was deeply involved in military domains including Command, Training, Plans and Policy-making, and Leadership. Today he is and advisor to TNO Defence & Security in domains of C4I, M&S, Training, Technology Assessment and Future Concepts and Doctrine, where he is very much involved in scenario development.

OLE MARTIN MEVASSIK is a Principal Scientist at the Norwegian Defence Research Establishment (FFI). He holds a M.Sc. degree in Engineering Cybernetics from the Norwegian Institute of Technology (NTH). He has been involved in research activities within command and control with picture production, data fusion techniques and systems engineering in general. His current research interest is within the area of modeling and simulation, with application to training and experimentation. He is the Norwegian representative in the NATO MSG-048 Coalition Battle Management Language activity.

MICHAEL POWERS is a Director of Research at the US Army Topographic Engineering Center. He has special interests in Terrain Reasoning and Battle Management. He co-chairs the NATO Technical Activity on C-BML

DR. J. MARK PULLEN is 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 has served as Principal Investigator of the XBML and JBML projects.

NICO DE REUS is a member of the scientific staff in the M&S department at TNO Defense, Security and Safety in the Netherlands. Nico has a professional background in Applied Mathematics in the area of weapon systems simulations. His current work focuses on Simulation in general, specifically on C2-Simulation interoperability.

DR. ULRICH SCHADE is a senior research scientist with FGAN. He is an expert in computational linguistics and has contributed greatly to the understanding of how formal grammar can improve BML.