Adding Reports to Coalition Battle Management Language for NATO MSG-048

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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. Its initial work in defining and demonstrating a basic capability for this purpose has been reported in previous Euro-SIW papers. This paper addresses Phase 2 of the Technical Activity which expanded the BML paradigm by adding C2 Reports, enabling two-way flow of information between C2 and simulation systems. The new capability was demonstrated at the InterService/Industry Training, Simulation and Education Conference (I/ITSEC) 2008. The demonstration configuration combined three national C2 systems and three national simulations along with middleware from two other nations. The result was a generic C2-simulation linkage with no humans in the information exchange loop. This was achieved in only four months, using a network-enabled development approach with an Internet Reference Implementation combined with a powerful development environment based on a C2 Lexical Grammar graphical user interface for inspection of the exchanged information, plus a scripted approach for rapid development of expanded BML Web services. This paper provides a description of the BML Reports and the enhanced development methodology to support expansion of the BML concept in general and the work of the SISO C-BML Product Development Group in particular. We conclude with a projection of the work of MSG-048 in 2009, which focuses on operational validation of the C-BML concept.*

1. Introduction

This paper reports on the second, 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), and 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 SIMCI Combined Project 2008 [5].

The need to interface C2 systems with simulation systems is widely accepted. The BML initiative seeks to provide standards for this, working with the Multinational Interoperability Programme (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 predecessor to the work described here was reported in [6].

The remainder of this paper describes the technologies and development approach used in MSG-048's successful second demonstration, held at the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) 2008 in Orlando FL. The following major sections first summarize the background to understand the need for BML and how MSG-048 is working to meet it, then describe technical contributions of the six nations that participated. The paper concludes with a summary of the 2009 plans of MSG-048.

2. Background

This section provides brief background on BML and on the NATO MSG-048 Technical Activity in order to set the stage for understanding of the demonstration. More details are available in [1-16].

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.* [7] describe the overall process used to show the feasibility of defining an unambiguous language, based on manuals capturing the doctrine of the US Army. 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. XBML also became the basis for an international experiment, driven by interest of the Exploratory Team formulating the proposal that led to MSG-048 [9]. This was followed by 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. 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 [10].

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 [11]. The NATO RTO 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 [12]. The first major demonstration by MSG-048, in which BML supported only the exchange of orders, is described in [8]. The remainder of this paper describes the second major demonstration.

3. MSG-048 2008 Demonstration

The 2008 demonstration improved over previous work by adding Reports to the previous Orders. It also introduced Air C2 and simulation in addition to the Ground components previously included.

3.1 Purpose and Architecture

The architecture of the 2008 demonstration is shown in Figure 1. Its primary purpose was to evaluate the effectiveness of BML Reports in maintaining shared status in the C2 systems.

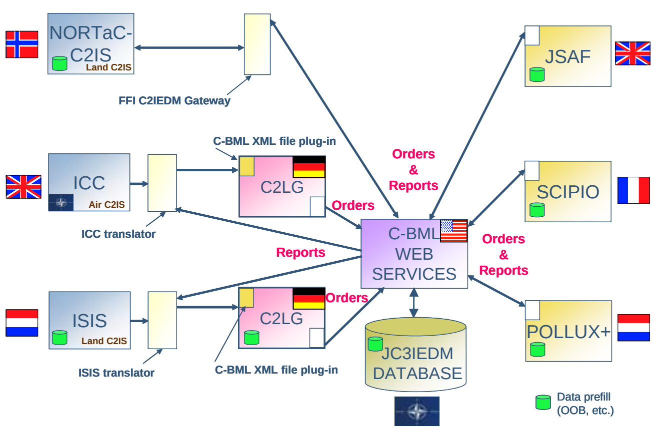

Figure 1. Demonstration Architecture 2008

3.2 Scenario

The 2008 demonstration scenario was a refinement of that used in 2007. This scenario, Operation Perseus, is located in the Caspian Sea area and set in the 2025 timeframe. Details are given in [6]. The geographic region used in shown in Figure 2.

Figure 2. Caspian Sea Region

3.3 Grammatical Foundation

The BML used in the demonstration is based on a grammar, the Command and Control Lexical Grammar (C2LG) [7, 13]. A grammar determines the lexicon of the language to be defined as well as the rules that describe how lexical elements can be concatenated to form expressions. In this subsection, we will present the grammatical bases for those types of reports that were exchanged among the systems participating in the demonstration. More details about the C2LG's report representation can be found in [19]. Additional details on the approach can be found in [20-23].

In principle, the C2LG differentiates between three types of reports: task reports, event reports and status reports. In task reports, the sender reports about an ongoing military action, e.g., the attack of a hostile force against his position. In event reports, the sender reports about an event, an action that does not have an active animate entity that voluntary had initiated the action, like a flood, or an action of which this initiating entity is unknown to the sender. By status reports, the sender conveys status information or information about a position. Besides position reports, there are different kind of status reports: e.g., reports about the operational status of a unit, reports about the status of an ongoing task (e.g., started, completed to 40% or completed), reports about personnel status (two soldiers wounded), and reports about materiel status (three BMP immobilized). In the following, we will focus on position reports and reports about the operational status.

In C2LG, position reports follow rule

(1) RB → Hostility ***position*** Who Where When Certainty Label

In (1) "RB" means basic report. In a basic report exactly one fact is reported. In principle, a sender can combine multiple basic reports under one header in order to send this complex report to the addressee as one package. "position" is a key word. It indicates that the basic report in question is about position. "Hostility" indicates whether this basic position report is about the position of the sender (Hostility = own), about the position of an allied unit (friend), of an enemy unit (hostile) or of some others (neutral, suspect, …). "Who" denotes whose position is reported. "Where" denotes the position itself, e.g., by coordinates. "When" denotes the point of time when the position was valid (that may differ from the point in time the report is sent). "Certainty" is about the likelihood that the report is true. Its values are fact, plausible, uncertain, and indeterminate. "Label" is a unique identifier by which this basic report can be referred to. An example basic position report is given in (2) in which the second company reports that they are at control point 3 (at CP3) at the time the report is sent (at now).

(2) **Status-Report:** ***own position*** Coy2 **at** CP3 **at** now fact label-rp-289;

In the demonstration, position reports have been sent from simulated units to the C2 systems in order to update their own position. Besides, whenever a simulated unit spotted an enemy unit (according to the reconnaissance automatons programmed into the simulation) it sent a position report of spotted enemy unit.

The grammatical representation of reports about the operational status is quite similar to position reports. Operational status reports follow rule

(3) RB → Hostility ***status-general*** Who Status-Value Where When Certainty Label

(3) differs from (1) with respect to the key word. The key word in (3) is "status-general" to indicate that the report is about the operational status of a unit. Again, "Who" denotes the unit whose operational status is reported. "Status-Values" denotes the operational status. Allowed values are OPR (operational), SOPS (substantially operational), MOPS (marginally operational), TNOPS (temporarily not operational), and NOP (not operational). The values are provided by the JC3IED, table "organization-status-operational-status-code". An example basic operational status report is given in (4) in which the second company reports that they are operational at the time the report is sent.

(4) **Status-Report:** ***own status-general*** Coy2 OPR **at** CP3 **at** now fact label-rp-293;

In the demonstration, operational status reports have been sent from simulated units to the C2 systems in order to update their operational status in combat situations.

4.0 National Technical Contributions

The demonstration was assembled from C2, Simulation, Web Service, and GUI contributions of France, Germany, Netherlands, Norway, the United Kingdom, and the United States. The contribution from Germany was the C2LG GUI, previously described in [6]. The other national technical contributions are described in this section.

4,1 France Simulation: SCIPIO/SWORD

In the line of the NMSG-048 demonstration performed on ITSEC 2007 [6], the French contribution for the NMSG-048 phase 2 demonstration has been implemented on the SWORD simulation platform elaborated by MASA group. It allows preparation, play and control of the simulation through a custom application framework on a single workstation. The SWORD Training simulation uses the same simulation core as SCIPIO and provides also a "agent of agents" capability (play of agent at Battalion level controlling itself agents at company then platoon levels). Specific extensions for the 2008 demonstration were based on a specific BML plug-in application developed and integrated into SWORD. This plug-in component was aimed at connecting the simulation to C2S in order to:

- Pull the orders issued from C2S side according to the BML grammar and run the simulation. This development focused particularly on an automatic Pull order – Push report process.
- Push reports generated by the simulation to the C2S. Two kinds of reports were implemented: Spot report for the localization of Company units and General Operational Status reports.

The visualization and the management of the simulation was achieved by an operator through the SWORD Training "Gaming" GUI shown in Figure 3.

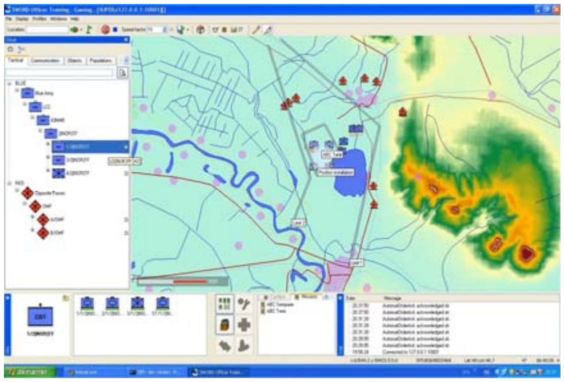

Figure 3 . SCIPIO/SWORD Gaming GUI

The C2 systems connected with SCIPIO/SWORD were ISIS (NLD) and NORTaC (NOR) as shown in Figure 4. details of these systems are provided in other subsections below.

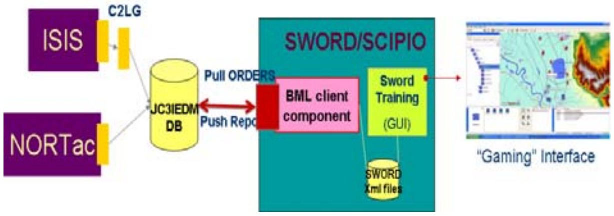

Figure 4. Connection architecture of BML Plug-In for SCIPIO/SWORD

Adapting the simulation for decision support

When dedicated to training, the SCIPIO simulation is actually used via a low controller animation performed by an operator. Usually, orders are transmitted by HQ staff to the appropriate level of control that executes them through the simulation. Symmetrically, reports generated by the simulation are transmitted by a human operator to HQ via the C2 system. In order to use the simulation in a decision support context, the connection requires automatic exchanges as far as possible and for this purpose, a specific software layer was implemented into the SCIPIO/SWORD BML client component, enabling time management, tasks scheduling and automatic reporting into the exchange database.

Managing PullOrder / PullReport requests

The parameter used to identify BML Order in the exchange database was by convention the Order ID and predefined IDs were set into a configuration file when pushing orders and reports into the database. Preconfigured ID intervals were used by the simulation and C2 system respectively to pull orders and reports. Extracting order and reports by multiple criteria requests is one of main extensions to deal with in future demonstrations. This is particularly important in operational planning context for which multiple-run of a Course of Action must be performed to draw the right analysis and make the good choice. At the same time, in case of two or more C2 systems connected to several simulations, extracting the right range of information from the database could be a critical issue. Solutions as Publish / Subscribe mechanism could be at least a solution to be implemented, allowing each C2S-Simulation couple to identify the right information to be exchanged.

Managing performance

A large number of spot reports generated by the simulation have to be processed by the Web service, both for the Simulation Push-Flow and for the C2S Pull-Flow. There was a potential for Web service queue overflow to occur, a critical issue for the demonstration. This issue was analyzed regarding the need for simulation to C2 system message exchange in terms of frequency and resolution. Data aggregation was performed by SCIPIO/SWORD to limit the number of reports (aggregation of several spot reports from platoon to Company level). Also it was necessary to limit simulation report production to a period of minutes rather than its customary scale of seconds, match the temporal resolution managed by the C2 system. These issues could become critical in larger operational scenarios and also in simulations implemented at a finer resolution.

4.2 Netherlands C2: ISIS

The Royal Netherlands Army C2 Support Centre (C2SC) 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. The C2FW is a configurable application platform and information system that provides generic functionality to support the C2 process.

The C2FW supports the users in building and maintaining a Common Operational Picture (COP) that provides Situational Awareness. The C2FW 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 ...) and dismounted domain (dismounted commanders, soldiers).

Figure 5 below shows how 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), Order Of Battle and Overlay displaying the commander’s plan graphically. The OPLAN is in accordance with the five paragraph NATO standard.

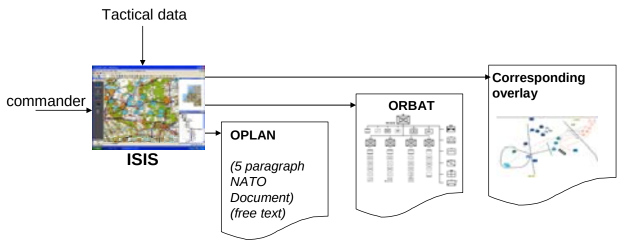

Figure 5. ISIS Input/Ouput

ISIS is a MIP enabled system, meaning that the data on this system can be aligned with other MIP enabled C2 systems using a MIP gateway. However, the free text used in the OPLAN and the ISIS overlay do not contain enough information to unambiguously and automatically generate BML statements by non-humans. In other words, the information is there, but cannot be extracted automatically. This was the reason why the ISIS system had to be BML-enabled.

The tactical data is input to ISIS as shown in the figure above. ISIS has also been enabled to visualise tactical data in BML format. The result of this for the I/ITSEC-08 demonstration is displayed in Figure 6 below.

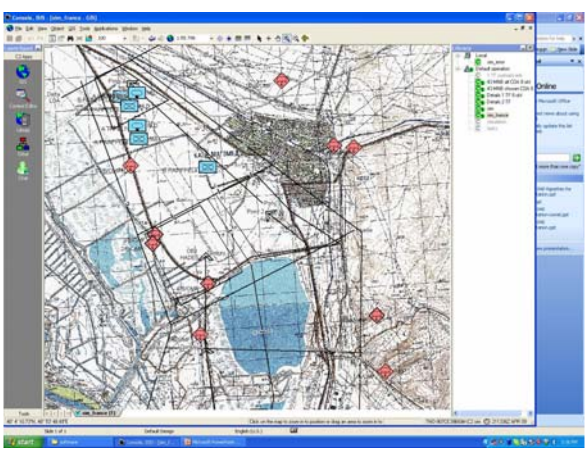

Figure 6. ISIS display of situation reports

4.3 Netherlands Simulation: Pollux

The NLD simulator that was used in the I/ITSEC-08 demonstration is the Pollux Command Staff Trainer that responds to BML orders and outputs situation reports in BML format. The simulator itself is a platoon level simulator that has been enabled to respond to Company level orders by making use of Command Agents transforming Company level orders to Platoon level orders. Figure 7 below is taken from Pollux, showing the simulator state in the demonstration.

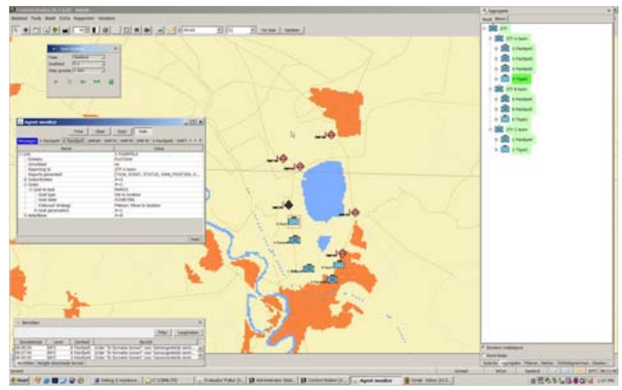

Figure 7: Pollux display of simulator state

4.4 Norway C2: NORTaC-C2IS

The NORTaC-C2IS is the Norwegian C2 system for tactical army operations, developed by Kongsberg Defence & Aerospace (KDA). At the MSG-048 demonstration at I/ITSEC 2007 [6] the NORTaC-C2IS was used to present the plan for the Norwegian task force to the user. For the 2008 demonstration, NORTaC-C2IS was extended to support creation of plans. From earlier NORTaC-C2IS supported definition of basic information elements, e.g. units, control measures and task graphics. The extension made by KDA for this year's demonstration provided a user interface to associate tasks to units (Taskee, Tasker, AffectedWho), objectives, resources and control measures. The new user interface also enabled users to define parameters (start- and end-time) for tasks. Figure 8 shows a screenshot of NORTaC-C2IS.

The extension enabled users of NORTaC-C2IS to create tasks, control measures and units, and the relations between these. Plans created in NORTaC-C2IS are stored in an unmodified C2IEDM database. The mappings used are based on the JBML mappings [4].

To extract the plan from the C2IEDM database, the FFI C2IEDM Gateway developed by the Norwegian Defence Research Establishment (FFI) was used. This application translated the order expressed in C2IEDM to an IBML order. In contrast to the gateway application made for I/ITSEC 2007 [6], this gateway allowed for orders to be sent directly to the IBML server. In other words, combined with the FFI C2IEDM Gateway it became possible to develop and send a basic plan from the C2 system.

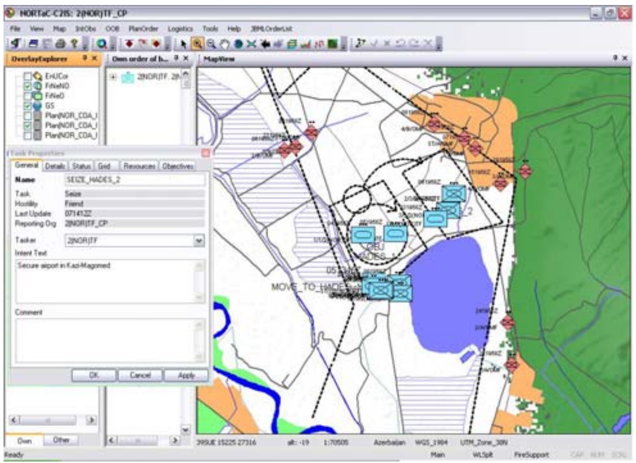

Figure 8. NORTaC-C2IS plan and position reports

To support presentation of simulated reports, the C2IEDM Gateway was designed to pull position reports from the IBML server, before translating and inserting them into a C2IEDM database. C2IEDM database events caused NORTaC-C2IS to present the reported data to the user.

4.5 UK Air Scenario Reporting

The UK C-BML system produced as part of the NATO MSG-048 demonstration provided air mission planning, report display and simulation capability for an air scenario which could be integrated with the ground-based components supplied by the other member nations. The air scenario was planned with a mixture of air units, role assignments and air missions able to support the coalition ground units.

Figure 9 indicates the units and reporting flows represented in the UK C-BML air scenario. Each aircraft reports its own position to the airborne command and control aircraft (MAGIC 01). MAGIC 01 relays these positions, combined into a Recognized Air Picture (RAP), to the 3 ATF CAOC and to the 43 MN BDE HQ. In addition, each aircraft should send In-Flight Reports (IFREPs), the contents of which depend on aircraft role as shown in Table 1.

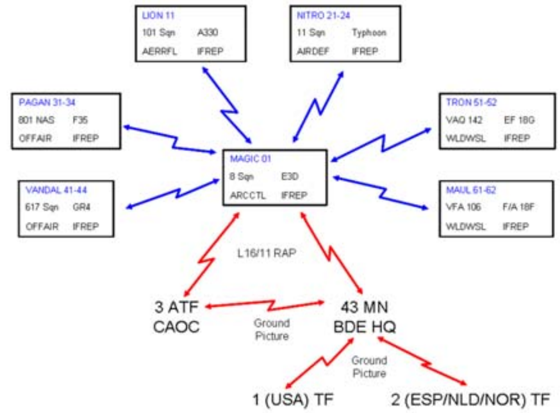

Figure 9. Air units and reporting flows

Aircraft call sign	Role	IFREP contents
MAGIC01	ARCCTL	Time on/off station
LION11	AERRFL	Time on/off station
NITRO21-24	AIRDEF	Time on/off station, any air defence activity
PAGAN31-34	OFFAIR	Time on/off station, targets attacked, target damage status
VANDAL41-43	OFFAIR	Time on/off station, targets attacked, target damage status
TRON51-52	WLDWSL	Time on/off station, any EW activity
MAUL61-62	WLDWSL	Time on/off station, any EW activity

Table 1. Aircraft In-Flight Reports

The UK C-BML configuration consists of:

- C2 system – NATO ICC, an air mission planning tool which is also able to entabulate and plot live (OTH Gold) feeds using the NIRIS interface;
- M&S – JSAF (Joint Semi-Automated Forces), a constructive simulation developed in the US by JFCOM;
- Enabling middleware – GMU web services to process C-BML and access an enhanced JC3IEDM data-base; and
- C-BML translator modules developed in the UK for ICC/NIRIS and JSAF.

Not shown at I/ITSEC, but also integrated with the UK C-BML system is JADOCS (Joint Automated Deep Operations Coordination System) which can also be used to display position reports and tracks.

In C-BML, the reports are generated by the simulations and are sent to a central JC3IEDM data-base from where they may be accessed by any user. Of primary interest are C-BML position status reports. Things which need considering, and may only be possible to determine after suitable experimentation, are the message contents and update rates. In reality MAGIC 01 will receive position (+ velocity) updates from coalition aircraft every 1 second via Link 16 (or possibly less accurately via IFF transponders). The C-BML report schema now permits an optional velocity vector (defined as speed in KPH & bearing (degrees from North in range 0-360, +ve clockwise) to be appended to any JBML AtWhere object. The RAP will be forwarded to the CAOC and Bde HQ at a lower frequency, say once per minute. In the UK C-BML environment ICC is able to display reported locations using the NIRIS interface.

Two main options exist regarding the use of the ICC tactical display:

- To treat the ICC as an AWACS terminal and display the higher frequency locations of the aircraft – this is similar to monitoring the simulation and will show little latency.

- To generate the RAP as a C-BML report broadcast, say every one minute and treat the ICC as a CAOC or Bde capability showing RAP and coalition ground positions. This is the preferred option.

Other C-BML report types not yet implemented in the UK system are: general status, task, event and US army. Two factors relate:

- Which of these can be generated by the simulation systems and expressed in C-BML (particularly JSAF 2007). JSAF is already capable of generating a variety of reports including take off/landing and weapon/fuel status; this capability is readily extended to represent other report types.

- How can they be displayed on the C2 system. A simple message table listing non-position reports would suffice.

Position status reports are generated at a fixed time interval for each of the air units and these are pushed into the JC3IEDM database using the GMU web services. Reading reports is a two stage process. The database is polled on a regular basis to identify new reports which are then extracted and translated into OTH Gold format for consumption by NIRIS/ICC. This report extraction process relies on the assignment of blocks of report IDs to particular units and scenarios. Agreed use was made of the report ID, header time-stamp and body time-stamp to ensure the correct reports were selected.

Using the web services it was possible to process reports which originated from the other partners' simulation systems. This can be useful where isolated units occur and the simulations cannot be federated, e.g. if they run at different simulation speeds. It is also possible to use these reports to populate the simulation, the UK did this to generate an initial OPFOR. Once the database has been populated it is then possible to replay the scenario at any speed in the C2 system.

Report management will benefit from developments to the web services to permit applications to subscribe to newly posted reports. It is also felt that more JC3IEDM data-base monitoring and control applications would be beneficial, e.g. to understand the contents of the data-base by indicating which reports (and orders) relate to which country, units, time period and scenario or providing capability to remove obsolete reports selectively. The use of the GMU scripted web services should help develop such applications.

4.6 US Scripted BML Web Service

The US technical contribution for the MSG-048 I/ITSEC 2008 demonstration was an open source Web Service that was redesigned from the one use in 2007 (Figure 10) [17, 18]. The new service, reported in [5] and [24], has the properties that:

- Scripts can be created or revised with much less time and effort than previous services coded in Java
- The scripting language offers only a minimal set of features, so that opportunities for error are reduced
- The script representation defined the mapping used concisely

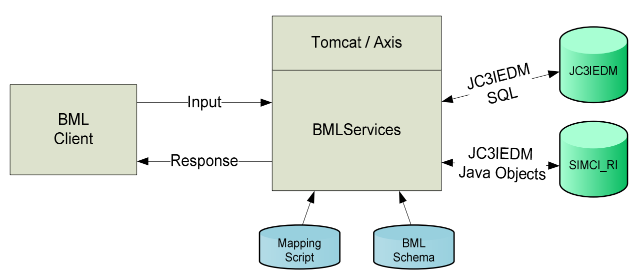

Figure 10. Scripted BML Web Service

4.7 Configurations

The demonstration was presented in four different configurations, combining the various national contributions. The power and flexibility of the BML approach was clearly indicated in the ability to "mix and match" system components at will. The configurations demonstrated were:

- ISIS/C2LG – Pollux
- NORTaC C2 – SCIPIO
- ICC/C2LG – JSAF
- ISIS/C2LG – SCIPIO
- NORTaC – Pollux

5. Conclusions

We conclude once again that BML is a powerful, general approach to interoperability of coalition C2 and simulation. We were able to extend BML to reports in a few months of work. As before, the availability of a Reference Implementation on the Internet (in the form of the Scripted BML Web Service) was an essential feature in this rapid development, as was a large measure of good will on the part of all developers and SMEs. The primary concern identified was that simulations running faster than real time may produce message rates that overwhelm both Web services and C2 systems. This requires care in configuring the simulations.

MSG-048 has entered its fourth and final year. Its plan for 2009 is to expand from experiments with interoperation technology into experiments with operational use of BML. Thus we plan a week of testing with and enhanced configuration: that of 2008 plus a UAV to be provided by Canada. Two sets of military SMEs will be engaged in the experimentation; in addition to the supporting SMEs who have worked with MSG-048 to create the capability, there will be a new, unbiased group of SMEs to evaluate the utility of BML in the coalition context, thus fulfilling MSG-048's charter to validate the utility of BML for NATO.

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