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Battle Management Language Transformations

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OVERVIEW

A critically needed element of transformation is to enable interoperation of alliance and coalition Command and Control (C2) and Modelling and Simulation (M&S) systems. Battlefield Management Language (BML) is being developed as a common representation of military mission suitable for automated processing. Within NATO the task group MSG-048 "Coalition BML" is defining a BML using the Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM) as a lexicon. BML addresses the capability to initialize Simulations with Operational orders and taskings that has been recognized as a key future capability for both training and experimentation.

We describe a limited demonstration where both French and US C2 planning systems were used to prepare a Course of Action (COA) to conduct a coalition coordinated operation which supported approval of the new Technology Assessment Program MSG-048. BML is being explored in US Army, US Joint and Coalition Contexts. With MSG-048, continued research in many dimensions is continuing to broaden the BML concept.

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Better integration of reasoning within a Coalition C2 process can be facilitated by specific BMLs. An example is geoBML. Such reasoning capabilities are fundamental to enabling transformation through C2-Simulation interoperation and also to providing capabilities for future experimentation. We describe how geoBML will be implemented through extensions of C2IEDM, expanding and further transforming coalition capabilities.

1.0 INTRODUCTION

A Battle Management Language (BML) is defined as an unambiguous language intended to provide for (1) command and control of simulated and live forces conducting military operations and (2) situational awareness and a shared, common operational picture. In October of 2004 France and the US presented demonstrations to the North Atlantic Treaty Organization (NATO) M&S Working Group showing how Coalition (C-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 C-BML. As a part of ET-016 it was decided that a limited demonstration of the exploratory team work would be developed to show that the concept of a C-BML was feasible. The limited demonstration was developed starting with components from earlier demonstrations in the US and had the objective to add a French C2 planning system that also had a simulation capability. It was agreed that the C2IEDM (with the extensions made to incorporate C-BML) would be used as the common data exchange model. In this paper we describe a limited demonstration where both French and US C2 planning systems were used to prepare a Course of Action (COA) to conduct a coalition coordinated operation which supported approval of the new Technology Assessment Program MSG-048 in October 2005.

With MSG-048, continued research in many dimensions is broadening the BML concept. Better integration of reasoning within a Coalition C2 process can be facilitated by specific BMLs. An example is geoBML, which will be implemented through extensions of C2IEDM and illustrated through operational vignettes leveraging the US Army's Battlespace Terrain Reasoning and Awareness (BTRA) capabilities and thus will expand and further transform coalition capabilities developed in NATO MSG-048. Terrain and weather effects represent a fundamental, enabling piece of battlefield information supporting situation awareness and the decision-making processes for C2. These effects can both enhance or constrain force tactics and behaviours, platform performance (ground and air), system performance (*e.g.* sensors) and soldiers. The Army Technology Objective for BTRA has developed baseline capabilities to capture and computationally represent elements of key terrain positions. The Topographic Engineering Center is developing a specific BML to address terrain effects called geoBML.

Studies leading to BML have been ongoing in various academic/technical organizations since 2002, as reported in references [1–14]. This paper draws heavily on publications by its authors in other forums, particularly references [11] and [14], in order to present the work of MSG ET-016 to the larger NATO MSG community.

2.0 COALITION BML

Coalition BML (C-BML) is a project of the Simulation Interoperability Standards Organization (SISO). It is aimed at creating a standard representation of digitized command and control information such as orders and plans that will be understandable by military personnel, by simulated forces, and by future robotic forces. In addition, C-BML must provide for situational awareness and a shared, common operational picture through digitized reports and returns. As such, C-BML is particularly relevant for enabling mutual understanding in the network-centric environment being developed by the US and its military allies, where multinational distributed/integrated capabilities are essential.

C-BML is a way of capturing doctrine, not a way of standardizing doctrine. Its vocabulary must be well defined in the context of both C2 and simulation domains in order to generate unambiguously executable tasks at the end of the process. To achieve this, C-BML uses an extended version of the Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM), as described below. C-BML also must specify the underlying protocols for transferring this information. The US Extensible Battle Management Language (XBML) project described in [4] demonstrated that Web Services provide an effective way to do this.

2.1 JC3IEDM in BML

The JC3IEDM (formerly C2IEDM) is a robust representation with two decades of development history. It is maintained by the Multilateral Interoperability Programme (MIP), a voluntary and independent organization that represents more than two dozen countries and headquarters organizations, as described at http://www.mip-site.org/. MIP is concerned with deriving a common data architecture and data model for multi-national C2 interoperability.

The JC3IEDM is derived through consensus and has active configuration management. It includes common vocabulary related to all domains of military operations, such as maneuver, fire support, air defense, engineering, civil military operations, and anti-terror special operations, based on five standard battlefield entities: organization, materiel, features, facilities and persons. All data and relationships are well documented and publicly available. Because its design is based on the information exchange requirements for battlefield C2 systems, the JC3IEDM deals naturally with orders, missions, tasks, situational awareness data, etc., that underlie BML.

3.0 LIMITED DEMONSTRATION COMPONENTS AND ARCHITECTURE

The experiment undertaken by France and the US provided a limited demonstration of interoperation between C2 and simulation systems of the two nations. The US and French components described in this section provided the C2 and simulation capabilities. The systems were coupled via a BML Web Services component developed using the approach described in [2]. They were used to represent a BML Course of Action (COA), which was held in a relational database with a schema defined by a tagset derived from the C2IEDM. The experimental architecture is shown in Figure 1; the components are described in the remainder of this section.

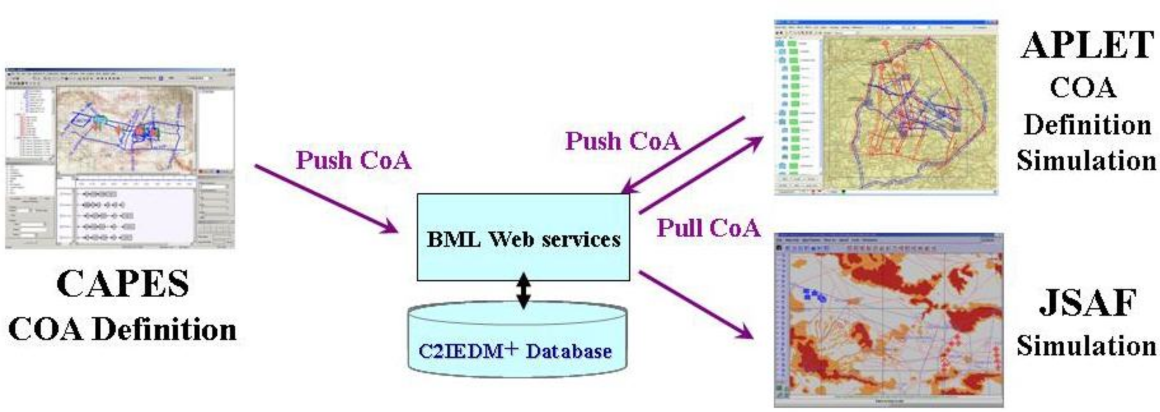

Figure 1: Limited demonstration architecture

3.1 CAPES

The Combined Arms Planning and Execution monitoring System (CAPES) is a prototype US Army command and control planning system. Its purpose is to develop a COA and generate a corresponding military plan. CAPES creates military operation orders that are exchanged using an Extensible Markup Language (XML) document with a tagset that is unique to CAPES. An XML-encoded scenario file also is generated.

The BML interface to CAPES was implemented by parsing the CAPES scenario file and translating its contents into BML objects. These objects are passed via the Web Services Definition Language (WSDL) interface to the BML web service, where they are inserted into the C2IEDM database. Thus, CAPES provides the COA data as common data tables and elements for the US plan to be exchanged with the simulation systems and the French planning system. This is possible because BML adds the necessary context to remove ambiguity in the understanding of orders to be exchanged and coordinated.

3.2 JSAF

The Joint Semi-Automated Forces (JSAF) simulation used by the US for this experiment is a computer generated forces (CGF) system. It is maintained by the US Joint Forces Command and used by them for joint experimentation. It also is used by the US Navy for Fleet Battle Experiments and by the Air Force Research Lab in support of the Distributed Mission Training program. JSAF provides entity-level simulation of ground, air, and naval forces. It has been used to simulate up to 40,000 entities within a single distributed simulation. JSAF is descended from the Modular Semi-Automated Forces (ModSAF) simulation and was developed by the Defense Advanced Research Projects Agency as part of its Synthetic Theater of War program.

The XBML project [7,8] created a BML interface for JSAF via Web Services. This interface was used to load both the COA generated by CAPES and the COA generated by APLET (see below) into JSAF, where the entire coalition plan could be simulated.

3.3 APLET

The *Aide a la Planification d'Engagement Tactique* (APLET) is a French Ministry of Defense Research and Technology program which aims to analyze simulation concepts to facilitate and improve Course of Action Analysis performed at Brigade or Division Headquarters fitted with the French C2 System *Système d'Information pour le Commandement des Forces* (SICF). APLET also addresses technical issues of C2 – simulation interoperation [9,10]. APLET's main objectives are:

- Automate the Military Decision-Making Process for Course of Action Analysis (COAA);
- Foresee capabilities and added value given by simulation in case of close integration with C4I systems and as an example with SICF;
- Explore and solve C4I-simulation inter-operability issues and propose recommendations to bridge the gap between those systems;
- Define the most suitable simulation granularity allowing COAA in a tight period;
- Propose mechanisms to automatically produce Operation Orders from a selected COA.

A major goal of APLET development was to create a demonstrator for Brigade COAA to highlight the usability and the effectiveness of selected technologies for C2 – simulation interoperation. This demonstrator was tested operationally during a Brigade exercise in November 2004. The overall program is intended to produce specifications for an operational system embedded into SICF. For the purpose of the NATO BML limited demonstration, a BML interface was developed for APLET, taking the place of the SICF XML interface.

A simulation capability for COA Analysis is embedded in the APLET planning system. Figure 2 shows an overall view of the APLET system architecture:

- SICF-APLET interchange mechanisms based on SICF XML format;
- APLET system consisting of :
  - Operator workstation: for exchanges with SICF, COA definition, COA comparison and operations order drafting;
  - APLET XML database, implementing APLET's data model;
  - APLET simulation, with "simulation initialization data" (COA) loaded from APLET XML database;
  - HLA connection used during simulation for cartographic display of simulated units.

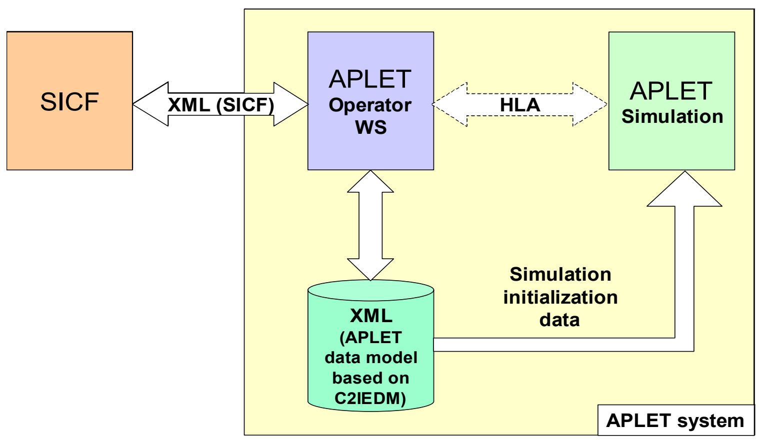

Figure 2: APLET architecture

3.4 BML Database Represented in C2IEDM using Web Services

As part of the earlier US XBML project, BML was implemented in the C2IEDM, identifying which C2IEDM tables would be used to represent the "who, what, when, where, why" (5W) of the military operations order. To do this using C2IEDM required an association between activities and a plan, where each activity is represented by the associated tables for its 5W BML representation. The associations and relationships provide the context to the specific tasks and missions to eliminate any ambiguity. Representation in the 5W format and the C2IEDM contextual associations and relationships are the keys to removing ambiguity of terms to resolve the free text problem associated with traditional operations orders.

One of the major contributions of the XBML project was demonstrating the effectiveness of Web Services technology as a way to rapidly implement interoperation of C2 and simulation systems. The limited demonstration could have been achieved by simply sharing a C2IEDM database via Structured Query Language (SQL) exchanges of data. However, this approach would require all developers to have very detailed knowledge of the C2IEDM and its structure in order to properly form queries to retrieve even the most basic pieces of information. Further, direct database access does not represent a practical path for multinational C2-simulation interoperation, because it requires adoption of a specific database system rather than an open communication standard. These problems were overcome by making the shared database accessible via Web Services so that distributed C2 and simulation systems can communicate in a platform and language independent manner using proven standards from various aspects of the World Wide Web. The basic approach used is described in [2].

Two Web Services were implemented, each using Web Service Description Language (WSDL) schema definition with communication over the Simple Object Access Protocol (SOAP) and the HyperText Transport Protocol (HTTP). Use of Web Services in the experiment allowed extremely rapid integration of disparate systems even though the components would not be tested directly with each other until shortly before the actual demonstration. The two services are:

- The BML Web Service, which provides a BML-oriented view of the C2IEDM. Its WSDL interface allows information retrieval structured as an operation order in 5W format. This provides a natural and understandable structure for military users, who are familiar with the five-paragraph operations order structure.
- C2IEDM-oriented Web Services for retrieval and insertion, which give access to the data as it appears in the C2IEDM without additional structuring. These services retain the detailed C2IEDM structure but increase ease of use by providing methods to allow the user to retrieve associated data without having to go directly through all of the intermediary tables. As an example, a single call allows retrieval of the current position of a unit, taking the place of four tables that contain the data elements needed to derive the same information.

4.0 DEMONSTRATION EXECUTION

4.1 Initial Scenario

An operational scenario was constructed to demonstrate a combined US and French force maneuvering against a common Opposing Force (OPFOR). Boundaries and Phase Lines were created to delineate the operational areas of interest for each of the coalition forces. The composition of forces using in developing the demonstration scenario were as follows:

- A US Mechanized Infantry Battalion comprised of 3 Mechanized Companies, 1 Armoured Squadron and 1 Recon Platoon.
- A French Armoured Battalion comprised of 3 Armoured Squadrons, 1 Mechanized Company and 1 Recon Platoon.
- The initial laydown of opposing forces were comprised of 2 Mechanized Companies and 1 Recon Platoon.

The laydown of initial conditions (boundary lines, phase lines and enemy positions) is shown on the display of the CAPES system Figure 3.

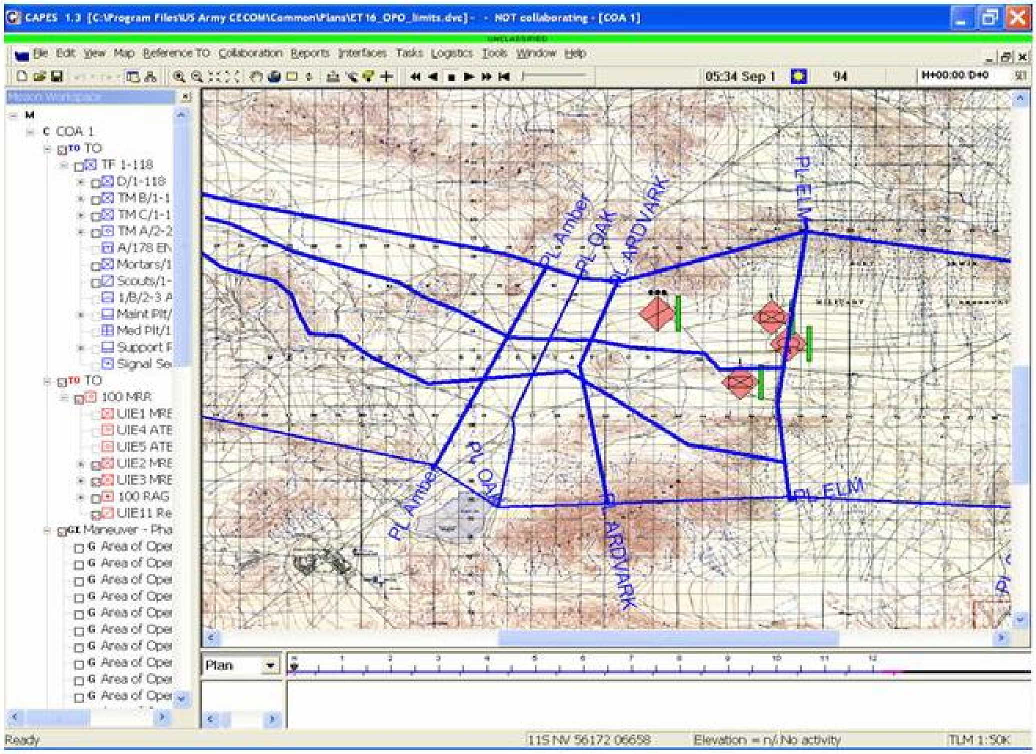

Figure 3: Initial Conditions displayed on CAPES

4.2 Execution of Scenario Using C-BML

In this section we step through the execution of the scenario within the demonstration environment. Screen shots from the systems used are shown collectively after the textual description. The following description of the information flow assumes that a coalition task force Brigade level operations order has been created and disseminated to the respective coalition Battalion level planners. Given that starting point, a high level overview of the steps conducted in the information flow of the demonstration is as follows.

1. Coalition HQ initiates a Context Overlay consisting of boundary lines, phase lines and initial enemy positions. This information is displayed on the CAPES system (Figure 3) and pushed from CAPES into the C2IEDM enhanced database using the BML web service interface.

2. APLET pulls the Context Overlay from the database using the BML web service interface and displays it as shown in Figure 4.

3. After review, the French Battalion planners request a change in boundary line position.

4. The boundary lines between coalition forces are edited on the CAPES system and pushed to the database to be updated as shown in Figure 5.

5. The French Battalion planners pull this information into the APLET system to display and validate as shown in Figure 6.

6. The US Battalion planners develop a course of action on the CAPES system and push the information into the C2IEDM enhanced data base using the BML web service as shown in Figure 7.

7. The French Battalion planners develop a course of action on the APLET system and push the information into the C2IEDM enhanced data base using the BML web service as shown in Figure 8.
8. The French Battalion planners pull the combined force COA out of the database and load the APLET simulation capability as shown in Figure 9.
9. The US planners pull the combined force COA out of the database and load the JSAF simulation system.
10. JSAF is demonstrated as having automatically been initialized with all boundaries, phase lines, initial enemy positions, both US and French forces and locations, and also all planned tasks developed by each of the coalition planners ready to execute in the simulation to evaluate the COA.

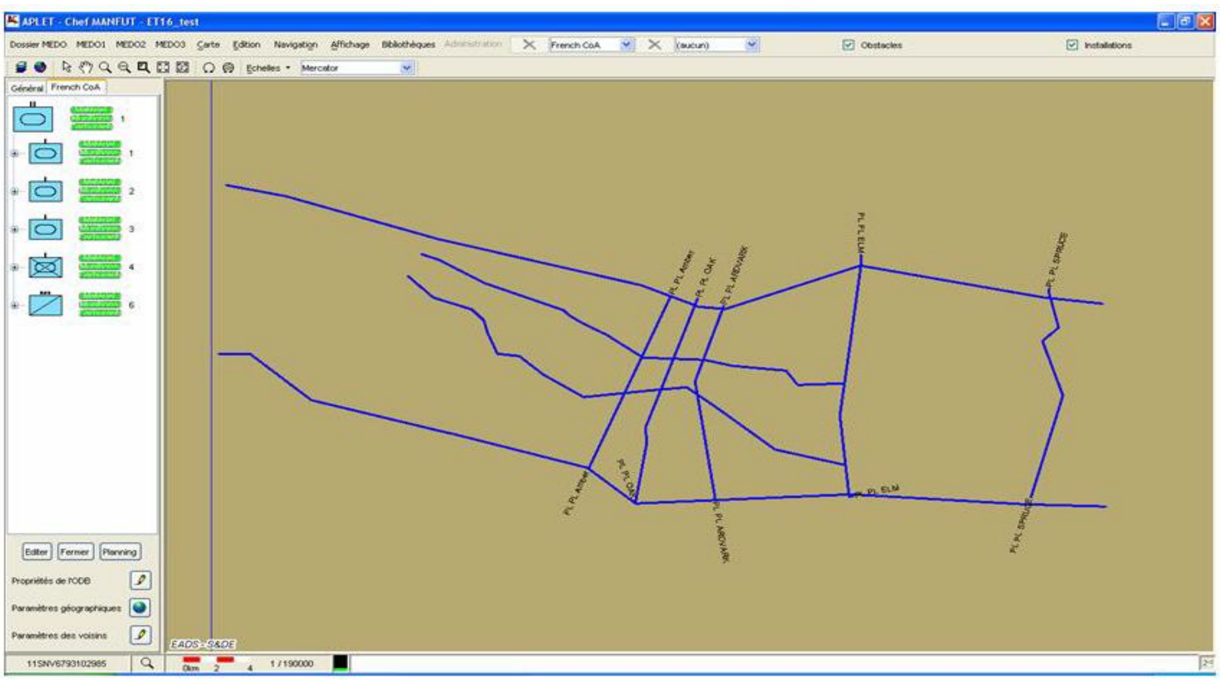

Figure 4: Initial Conditions as displayed on APLET

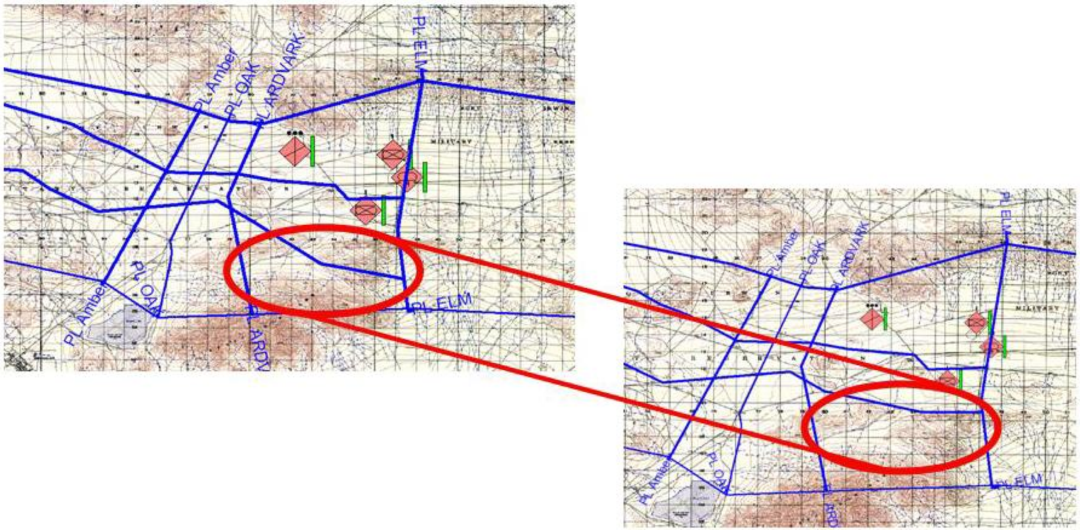

Figure 5: Boundary line adjustment on CAPES

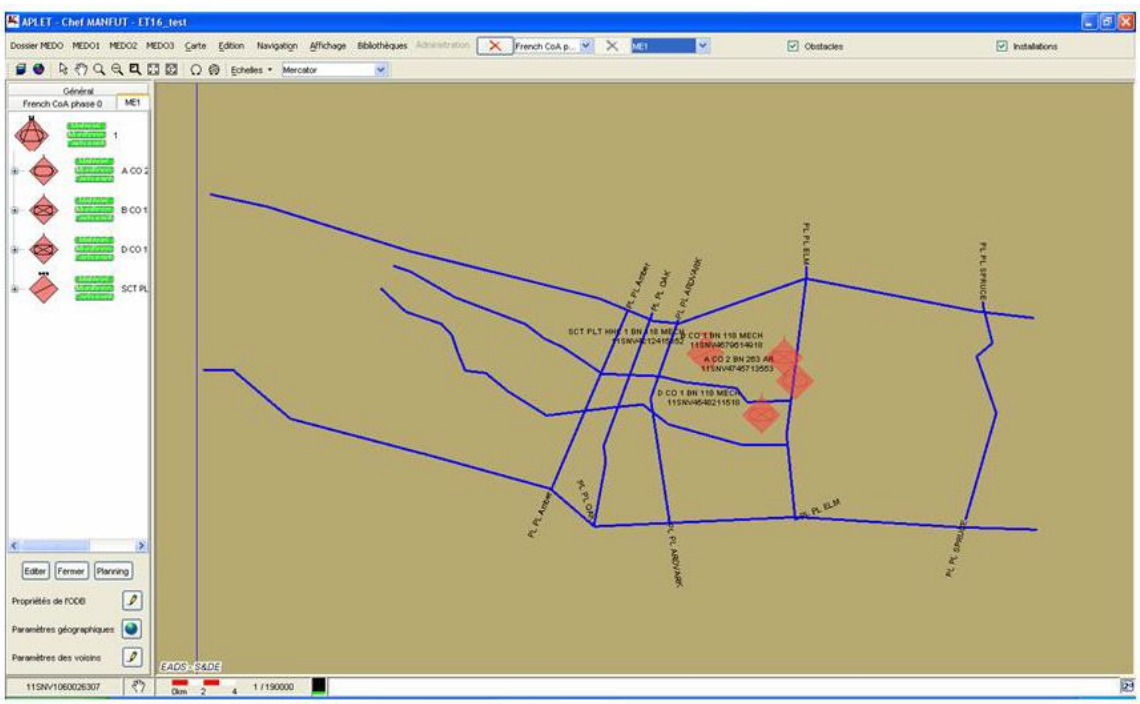

Figure 6: Boundary line update as displayed on APLET

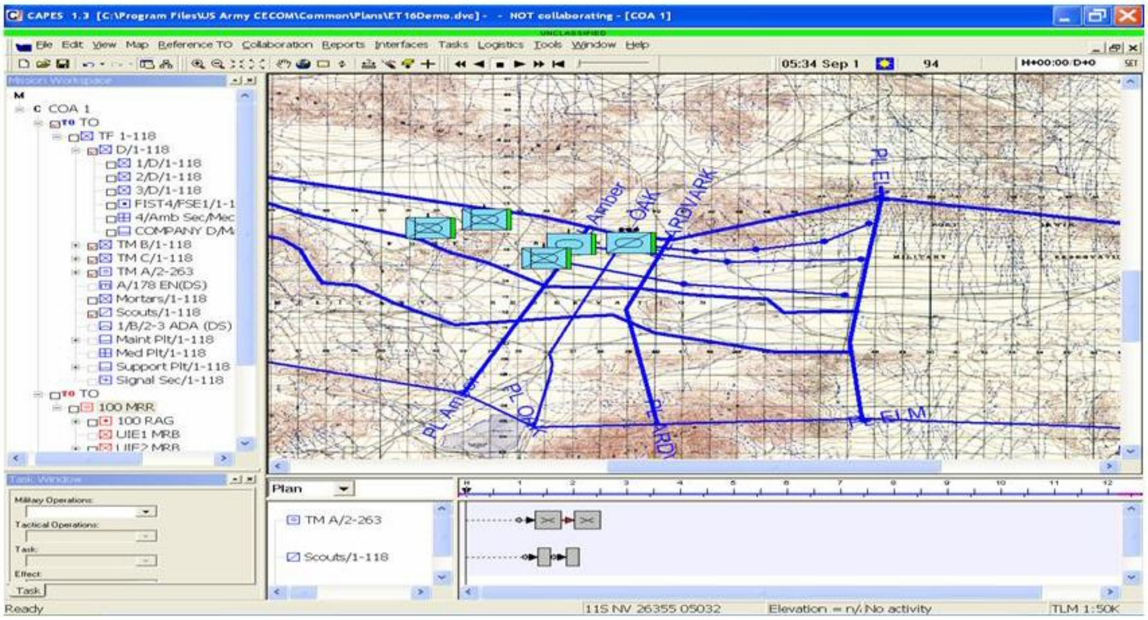

Figure 7: US COA development on CAPES

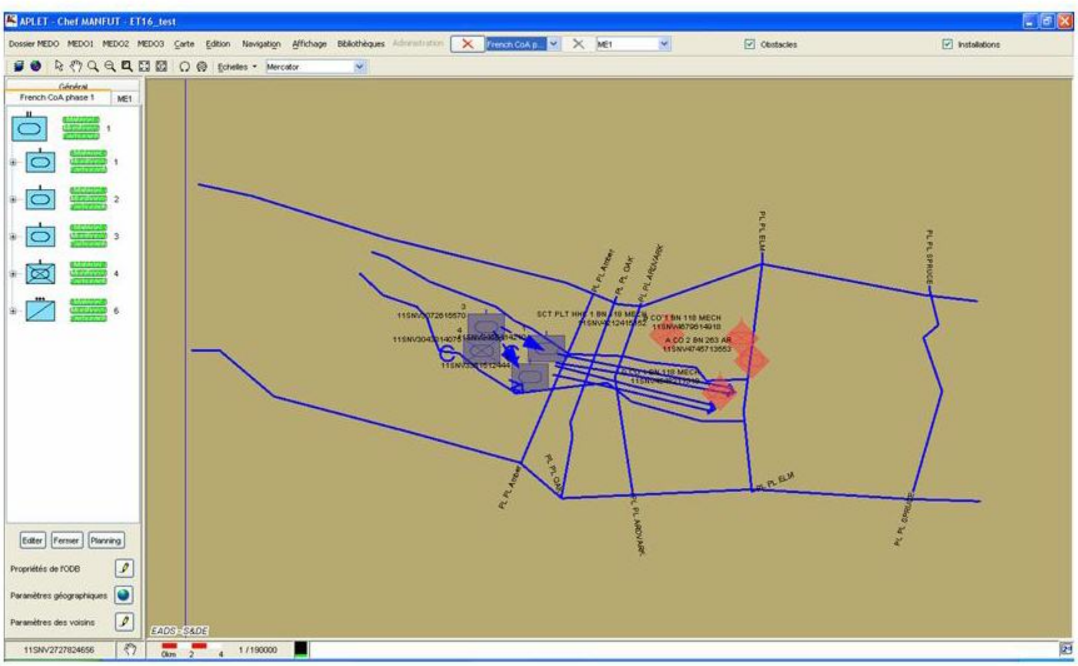

Figure 8: French COA development on APLET

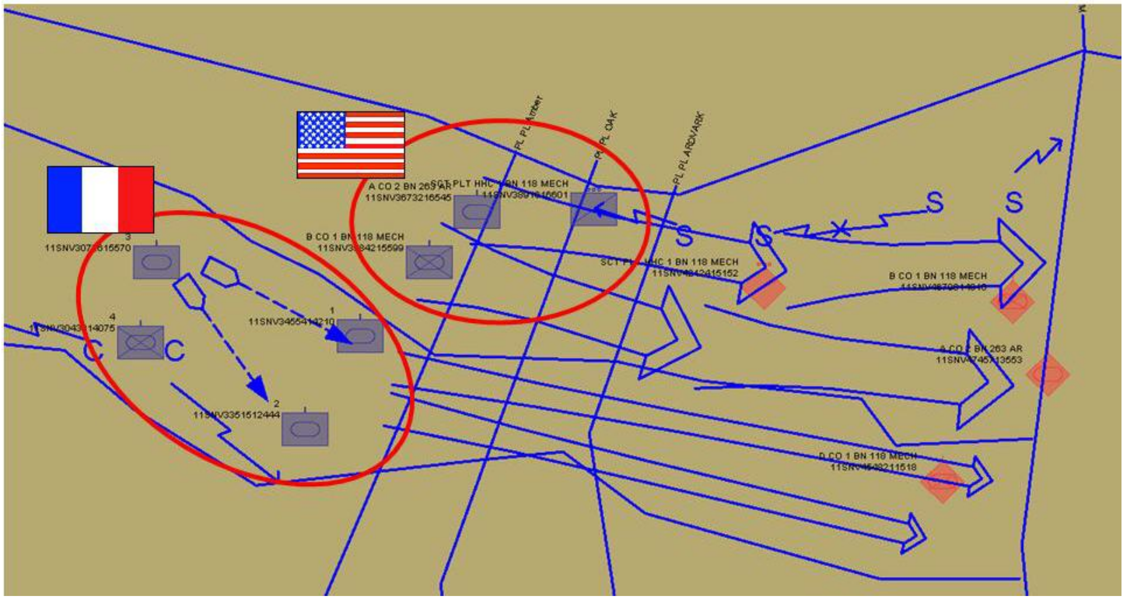

Figure 9: Combined plan as displayed on APLET

5.0 FUTURE WORK

Based on the plan that emerged from the Exploratory Team and the successful demonstration described above, NATO Modelling and Simulation Group Technical Activity 048 was approved in March 2006. It will build on the C-BML standard to conduct a series of C2-simulation interoperation experiments among the participating nations. In addition, the outlines of two new aspects for BML have begun to emerge: a formal BML grammar, and extension of BML to geospatial/environmental information (geoBML).

5.1 Tasking Grammar for C-BML

In [12] it is argued persuasively that in addition to a supporting vocabulary defined by the C2IEDM, a complete BML requires a formal grammar. For example, a basic rule for the BML Grammar is:

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

Development of the BML grammar will need to proceed in parallel with definition of C2IEDM representations and extensions in order to provide a complete language.

5.2 geoBML

[13] defines a major new area of investigation, geoBML, which builds upon the BML work described above. A key goal of geoBML is to make available actionable geo-information products to the C2 processes in the same conceptual framework and BML. Currently, geospatial products are created using varying techniques and procedures resulting in fundamentally different representations and processes than are used in the C2 planning process for forces and equipment. As a result, the context for command and control processes lacks uniformity, so that results may not be consistent. Here again, an unambiguous representation is needed.

However, the currently available BML does not include an *explicit* geospatial, terrain, weather or other environmental data component.

To provide for effective communication among components participating in C2 and simulation processes, the activity described in [13] seeks to expand upon the BML concept to remedy this situation and thus enable the network-centric future sought by US and coalition military. As argued by Devlin [15], the effectiveness of any interaction is dependent on degree and quality of a shared context among the participants. This is an especially significant condition for geo-environmental information. Knowledge of terrain and weather is, in and of itself, a context applied in a multitude of military decisions regarding tactics and tasks. Thus, tight coupling of geo-environmental information with doctrine, missions and defines geoBML.

Mission planning is dependent upon terrain. However, terrain data is not often shared between different systems. But in order to have consistent analysis between systems, the critical effects of terrain should be represented in such a way that they can be exchanged as well. One approach to improving interoperability is to have all C2 and simulation systems use the same representation for their data and information. However, this has not worked in practice. Instead, interface services and layers have been devised to share data and information that needs to be exchanged.

Independent of their nation or the doctrine they employ, military commanders regularly utilize information, knowledge and understanding of terrain, atmosphere and weather impacts on military operations. Geo-environmental information provides a base context for military decision making. Additionally, geo-environmental information has a ubiquitous quality in many aspects of C2 decision making within both planning and execution phases of a mission. Consequently, this information represents a commodity that will be exchanged and employed widely in acquiring a shared, common awareness, a unity of action and a synchronization of effects.

Focus on information for decision-making is central to the approach being followed to develop geoBML. In the domain of C2 operations there are many specialty functions engaged in data processing, analysis or reasoning, and/or decision making (C2). Each specialty area has its own terms, references and processes codified in doctrine. For the purposes of this geoBML discussion and the central role of the C2IEDM in C2 interoperability, the geoBML focuses on the role of information for decision making. This information is tailored (abstracted) for individuals with a greater training and context in C2 and operations as opposed to data processing and lower level fact analysis. Further, the ability to incorporate information and knowledge facilitates predictive awareness within the context of the original mission planning phase while maintaining responsiveness to dynamic changes in battle execution. A necessary condition for the abstractions of geo-information and geo-knowledge products is that they be “dynamic” and “smart,” *i.e.*, responsive to changing situation and mission as contained in other reports and messages defined under the MIP and JC3IEDM.

The complete set of information objects, evolved from accepted doctrine: 1) provide a meaningful structure for relationship to the JC3IEDM, 2) provide a complex set of interrelated use cases for evolving a language addressing both planning and execution and 3) provide a unified representational foundation capable of supporting cognitive and automated processes. These functions apply not only to the current C2-Simulation role, but also to support communication among C2 systems. Our work in C-BML indicates that this principle applies also to coalition C2 systems, where communication generally is stressed and the ability to simulate a plan to validate its effectiveness can enable more effective operations [5]. Expanding BML to incorporate geoBML only increases the validity of this principle in that the C2 planning process and its evaluation via simulation become much more effective where the effects of terrain can be incorporated with high accuracy. This is the promise and challenge inherent in transforming C-BML by incorporation of geoBML.

6.0 CONCLUSIONS

This paper has described a successful experiment in interoperation of command and control systems with simulation systems, conducted by the US and France in support of the work of a NATO Modelling and Simulation Working Group Exploratory Team. Using Web Services combined with the C2IEDM data model, the experiment very rapidly achieved interoperation among the systems of the two nations. The experience gained, and recent insights regarding the need for a BML grammar and a geoBML, provide strong support for the work of a NATO Technical Activity that was approved after success of the experiment. These techniques provide a promising path to distributed software interoperation involving a variety of simulation and other components.

BML has been explored in US Army, US Joint and Coalition Contexts. Under MSG-048, continued research in many dimensions is continuing to broaden the BML concept. Better integration of reasoning within a Coalition C2 process can be facilitated by specific BMLs. An example is geoBML. Such reasoning capabilities are fundamental to enabling transformation through C2-Simulation interoperation and also to providing capabilities for future experimentation.

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