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Title: **Developing a Coalition Battle Management Language to facilitate Interoperability between Operation CIS and Simulations in support of Training and Mission Rehearsal**

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Developing a Coalition Battle Management Language to facilitate Interoperability between Operation CIS and Simulations in support of Training and Mission Rehearsal

ABSTRACT

The Battle Management Language (BML) initiative started by the US Army Modeling and Simulation Office (AMSO) published a standard in 1999. It organised doctrinal terms into “5W’s”; “Who, What, When. Where and Why”, to faciliate interoperability between command and control systems and simulations. BML is an unambiguous language used to command and control forces conducting operations and support situational awareness and a common operational picture. It is being developed as a standard representation of a “digitized commander’s intent” to be used by warfighter’s, simulated forces, and robots. A BML prototype was demonstrated in 2003.

This prototype was used to analyse the applicability of BML to UK doctrine. A French Army BML was also prototypically implemented within their research program, and there is a US-German initiative, Project SINCE, that added the “How” and “Which” to give a “W6H” construct. XML, the use of web services, and BML representation within the Command and Control Information Exchange Data Model (C2IEDM) has provided a common thread.

The paper provides descriptions of these development and insights into two initiatives that have started as a result of this work; the creation of a Simulation Interoperability Standards Organisation (SISO) Study Group and NATO Exploratory Team-016.

1. INTRODUCTION

As technologically advanced nations increasingly digitise their military forces and operations are no longer conducted by a single service but are now not only joint but more likely to involve either a coalition of willing countries or existing alliances such as NATO, there as been a growing awareness that the traditional exchange of information that have been limited to data exchange and the use of common message text formats such as Allied Data Publication Number 3 (ADatP-3) and data exchange links such as Tactical Digital Information Links (TADIL) may not be sufficient. In addition emerging developments are enabling deeper information sharing and the establishment of a Common Operational Picture (COP). The increasing use of commercially supported open standards pushes the information technology (IT) infrastructure from proprietary military solutions towards web-enabled Service-Oriented Architectures (SOA). Distributed operations will be supported based on a heterogeneous computer grid comprising resources and data from all participating partners in operations, and not limited to the military domain. Modeling and Simulation (M&S) will be integrated into this heterogeneous SOA. M&S functionality will be available in the form of operational M&S services. One possible way to migrate M&S into web-enabled infrastructures is described in Morse et al. [1].

These developments are tightly connected to the objectives defined in the NATO M&S Master Plan [2], in particular the operational requirements to enable not only embedded training, that means the use of tactical equipments such as Operational Command and Information Systems (OpCIS) to conduct the training instead of special training equipment (“train as you fight”), but also the support of real world operations. Although the use of M&S components is seldom explicitly mentioned in capstone documents defining net centric warfare, the use of M&S functionality is a common theme. Alberts and Hayes give a good overview on net centric operations and warfare in *“Power to the Edge, Command and Control in the Information Age”* [3]. One of the main ideas introduced is the quality chain of net centric warfare starting with data and going over information and knowledge to awareness. This quality chain was used in numerous articles and papers to cope with the benefits of recommended improvements for Command and Control (C2), among these the *NATO Code of Best Practise for Command and Control Assessment* [4] and many papers of the annual U.S. Command and

Control Research and Technology Symposium (CCRTS) and the International CCRTS (ICCRTS), which is conducted every two years, all available via the Command and Control Research Program (CCRP) [5]. The four quality categories are defined as follows:

- The value chain starts with *Data Quality* describing the information within the underlying C2 information systems.

- *Information Quality* tracks the completeness, correctness, currency, consistency and precision of the data items and information statements available.

- *Knowledge Quality* deals with procedural knowledge and information embedded in the command and control system such as templates for adversary forces, assumptions about entities such as ranges and weapons, and doctrinal assumptions, often coded as rules. In future systems, this agile component could be presented by M&S systems.

- Finally, *Awareness Quality* measures the degree of using the information and knowledge embedded within the C2 system. Awareness is explicitly placed in the cognitive domain.

In summary, the data describing the conducted and supported operations are of critical importance. When placed into context, data leads to information. Information applied in the form of agile models, offered as M&S services within a SOA, will even enable the support of knowledge within C2 information systems.

In order to be able to make use of these potentials, C2 processes must be integrated and aligned. The data of C2 must be integrated seamlessly into this environment. The various national Battle Management Language (BML) efforts are the basis to migrate C2 into the information age by digitising tasks, missions, operation plans and the commander's intent[1]. This paper gives a short summary on the underlying problem and the existing national efforts the authors are aware of. It will furthermore propose a roadmap on how to merge these efforts into the development of a Coalition BML to support current and future coalitions and alliances such as ABCA[2] and NATO, in order to meet existing and merging military requirements.

2 What is BML – A Definition of the Underlying Issues?

C2 in the Information Age is driven by the rapidly changing and agile battlefield and related events within the sphere of operation, producing legions of data. C2 must ensure that the commanders know precisely, in real-time, the location of all friendly and enemy forces. The appropriate use of new resources and the increased reliance on extended range engagement reflecting domains such as precision strikes, minimization of collateral effects, effect based operations, etc. must be supported.

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[1] Digitized Commander's intent in this sense goes beyond the paragraph defined in the tradition 5 paragraph operational order of armies. It describes everything that is needed to describe an executing system (OpCIS, Simulated System or Robotic Forces) to understand what a commander wants, which includes traditional orders. It is not envisaged that the paragraph that relates to Commander's intent in a traditional order would be replaced and would therefore remain as "free text".

[2] The ABCA program originated as a result of close cooperation between Allies during World War II and it was decided it should continue and by 1947 a "Plan to Effect Standardisation" was initiated between the Armies of the United States of America, Britain and Canada. In 1963 Australia joined the organisation hence ABCA (America, Britain, Canada, Australia). New Zealand was granted observer status under the sponsorship of Australia in 1965. Main focus of the program is on interoperability, defined as: "the ability of Alliance Forces, and when appropriate, forces of Partner and other Nations, to train, exercise and operate effectively together in the execution of assigned missions and tasks".

Furthermore, the increasing use of unmanned vehicles and future robotic forces must be integrated into new C2 concepts.

2.1 Command and Control Data in the Information Age

Currently, C2 is still supported by a human-to-human "battle management language" developed over centuries. An analysis of task orders and operational orders shows that the important parts are very often captured in free text sections of the messages. Although C2 is supported by IT, and the information systems use more or less standardized data models to capture the information exchange requirements, orders are still more prose than data with the only structure provided in orders in the 5-Paragraph template standard within NATO.

As stated, communication of C2 information for military forces is moving towards more digitized systems. As such, not only are humans consuming this information but also automated systems are required to do so. Therefore, the communication must become less interpersonal and more data oriented. However, the most critical C2 information, the commander's intent, encapsulated in orders and directives, does not currently flow as data. While the status quo may be suitable for interpersonal communication, it is considered inadequate for use with automated systems.

2.2 Definition, Principles and Scope of BML

BML is an essential component for addressing this problem; in other words: BML digitizes the commander's intent and makes it data. In summary, BML is the unambiguous language used to command and control forces and equipment conducting military operations and to provide for situational awareness, including a shared, common operational picture. In addition to this definition, four principles were established in presenting BML to the M&S community [6]:

- BML must be unambiguous.
- BML must not constrain the full expression of the commander's intent.
- BML must use the existing C2 information system's data representations, where possible.
- BML must allow all elements to communicate information pertaining to themselves, their mission, and their environment in order to create situational awareness and a shared, common operational picture.

Therefore BML must be rooted in doctrine and all terms used within BML must be captured in field manuals, keystone and/or capstone documents or other sources of operational use. Within NATO for example, the *NATO Glossary of Terms and Definitions* [7] provides an appropriate start and a good kernel for future extensions. Furthermore, BML must result in Executable Descriptions of Missions. Each mission may comprise several aligned and orchestrated tasks. It is worth mentioning that the definition of BML only speaks of "Command and Control of forces and equipment conducting military operations." There is no hint that it is limited to real forces or to human beings. In other words, BML is applicable to generate executable descriptions of a mission that can be used by human forces in real operations supported by OpCIS, by simulated forces in simulated operations, and by robotic forces in real operations. The following figure shows the scope of BML as defined to date.

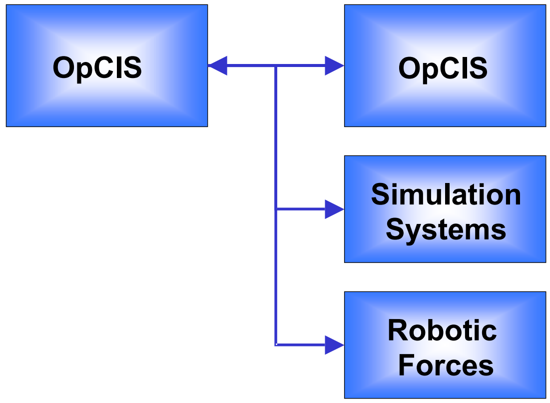

Figure 1: Scope of Battle Management Language (BML)

2.3 Applying the Command and Control Information Exchange Data Model

The two requirements are logically leading to the use of operational data models, as already mentioned in the third principle of BML. Although there are other candidates, the authors are currently favoring the Command and Control Information Exchange Data Model (C2IEDM). In order to understand the value of this data model, a short overview of the history is necessary.

In 1978, NATO's Long-Term Defence Plan (LTDP) Task Force on C2 recommended that an analysis be undertaken to determine if the future tactical Automatic Data Processing (ADP) requirements of the Nations (including that of interoperability) could be obtained at a significantly reduced cost when compared with previous approaches. In early 1980, the then Deputy Supreme Allied Commander Europe initiated a study to investigate the possibilities of implementing the Task Force's recommendations. This resulted in the establishment of the Army Tactical Command and Control Information System (ATCCIS) Permanent Working Group (APWG) to deal with the challenge of the future C4I systems of NATO. The ATCCIS approach was designed to be an overall concept for the future command and control systems of the participating nations. One constraint was that each nation could still build independent systems. To meet this requirement, ATCCIS defined a common kernel to facilitate common understanding of shared information. In 1999, ATCCIS became a NATO standard with the new name Land Command and Control Information Exchange Data Model (LC2IEDM). In parallel to this, the project managers of the Army Command and Control Information Systems (C2IS) of Canada, France, Germany, Italy, the United Kingdom and the United States of America established the Multilateral Interoperability Program (MIP) in April 1998. By 2002, the activities of LC2IEDM and MIP were very close, expertise was shared and specifications and technology were almost common. The merger of ATCCIS and MIP was a natural and positive step. LC2IEDM became the data model of MIP. In 2003 the name was changed to C2IEDM. In the future it is planned to change to become the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM).

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There are two application domains for the C2IEDM within NATO: Data Management and Information Exchange. The NATO Data Administration Group used the C2IEDM to map all information exchange requirements between the national command and control systems to it in order to ensure semantic ("What the data means?") and pragmatic ("What the data is used for?") interoperability between the systems. The MIP data managers will continue this task after the merger between MIP and C2IEDM is finished. MIP also uses the C2IEDM to exchange data between national C2 systems in order to foster sharing information and gain a common understanding on what is happening on the battlefield. To this end, the national systems establish data translation layers mapping their internal data presentation to the data elements of C2IEDM for information exchange with the other systems.

In summary, C2IEDM is derived through consensus and has active configuration management. It is a coherent, highly normalized data model, which leverages object type and sub typing hierarchy structures to simplify complexity. Its applicability to C2 as well as to M&S issues has been documented in "*Moving towards a Lingua Franca for M&S and C3I – Developments concerning the C2IEDM*" [8]. The C2IEDM is much more than just "another data model" for tactical data exchange and storage. The C2IEDM comprises of common vocabulary consisting of 176 information categories that include over 1500 content elements related to all domains of military operations, such as manoeuvre, fire support, air defence, engineering, civil military operations, anti terror special operations, etc. All data and relations are well documented and publicly available [9]. However, the most important point is that all participating MIP nations agreed that the information exchange captured in C2IEDM is operationally relevant and sufficient for allied operations. NATO is currently adopting the C2IEDM into a Standards Agreement (STANAG) 5523

Finally, communications protocols are needed to bring the executable mission description to the user. Starting with the ideas of net-centric operations and setting up a system of systems, the commercial world, as well as the military world, is moving from system components delivering the operationally required functionality, towards SOA. Within the commercial world, distributed computing environments operate as a uniform service, which looks after resource management and security independently of individual technology choices. Grid computing is a means of network computing that harnesses the unused processing cycles of numerous computers to solve intensive problems that are often too large for a single computer to handle. In other words, grid computing enables the virtualisation of distributed computing and data resources such as processing, network bandwidth, and storage capacity, to create a single system image which grants users and applications seamless access to vast IT capabilities. Just as an Internet user views a unified instance of content via the Web, a grid user essentially sees a single, large virtual computer. In order to access the functionality, services are defined based on common open standards and bridge the gap between the heterogeneous worlds of different languages, middleware solutions, and hardware. The authors perceive web services to be currently the strongest candidate for a technical solution to instantiate a SOA.

2.4 The Three Views of BML

The "state of the art" of BML can be summarized by three necessary views coping with all BML challenges documented so far. Figure 2 depicts the necessary views:

- BML Doctrine: Every term used within BML must be unambiguously defined and must be rooted in military doctrine. In other words the doctrinal view must be a glossary that comprises each term and its unambiguous definition. Nor should it implement a single service doctrine but allow different doctrinal viewpoints of services or nations to be defined [10].

- BML Representation: The representation structures and relates the terms defined in the doctrine in a way that they result in the description of executable missions and tasks. A mission is herby defined by a sequence of tasks, that must by executed in an orchestrated manner. Although the current recommendation is to use extensions and enhancements of the C2IEDM other alternatives must not be discounted as there are experts who question the applicability of data models to cope with ontological challenges. Artificial Intelligence (AI) approaches to support the structuring process by (semi-) automatic tools and linguistic approaches used for knowledge sharing between intelligent software agents seem to be valuable [10].

- BML Protocols: In order to communicate the necessary initialisation data into BML and the resulting executable missions and tasks from the BML to the executing system, communication protocols are needed. The protocol view standardizes the way the description of the executable tasks and assigned executing military means is transported from the BML implementation to the target system, which may be another OpCIS, a simulation system or robot. Web standards and grid standards are currently the most promising candidates. In particular the use of XML to describe the information exchange requirements is considered to be fundamental because it is the only standard for data description accepted by the C2, simulation and robotic community [10].

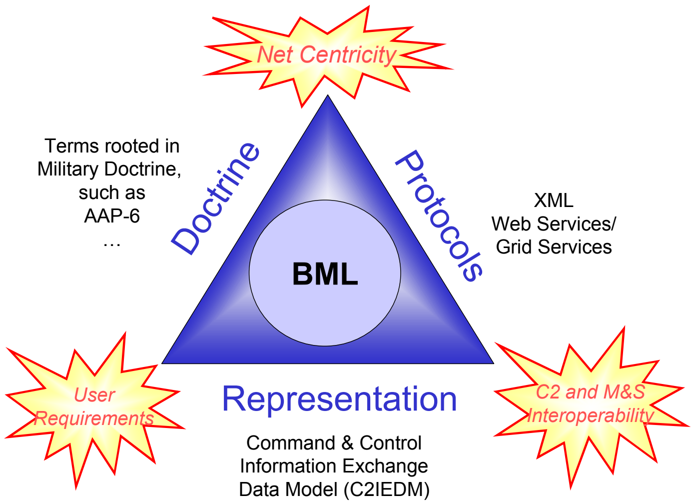

Figure 2: BML Views

The following section will deal with the various national efforts leading into this direction. This enumeration is neither exclusive nor complete. Everybody interested in these efforts is encouraged to join international standardization groups, in particular the actual study group as described [11] as well as in a later section of this paper.

3 EXISTING NATIONAL EFFORTS

The ideas described in general so far already have been evaluated by several NATO nations, namely the United States, United Kingdom and France. The prototypes proved the feasibility; the studies established the method underlying BML as it is currently applied. While the United Kingdom efforts were sparked by the United States activities, the French efforts were conducted independently and only after both prototypes were presented were the similarities identified during common symposia. In this section, the diverse national efforts are presented and prototypes are referenced.

3.1 United States Activities

In the United States, the Simulation to C4I Interoperability Overarching Integrated Product Team (SIMCI OIPT) of the U.S. Army initiated identified BML as a key requirement for C2 to Simulation Interoperability. The SIMCI vision is to provide recommendations on army-level policy for improving interoperability between the M&S and Command, Control, Communications, Computers and Intelligence (C4I) Domains. The SIMCI objectives are

- Seamless interoperability between M&S and C4I systems,
- Alignment of M&S and C4I standards, architectures, and common C4I components and
- Identification of requirements for simulations and C4I to support interoperability.

The BML prototype of the U.S. Army became the basis for a project sponsored by the U.S. Defence M&S Office (DMSO) to prove the feasibility to apply international data standards - namely the C2IEDM as well as the web-service ideas of the Extensible Modelling and Simulation Framework (XMSF). The U.S. Air Force and the U.S. Joint Forces Command use this new prototype for their BML feasibility studies and development efforts. The U.S. Army prototype was furthermore used by the United Kingdom to evaluate the value of BML and contributed to the formulation of UK research activity concerning BML. Independently from - but well aware of - the US prototype, France developed the BML prototype known by the acronym APLET ("Aide à la PLanification d'Engagement Tactique").

This section can only give a rough overview on these prototypes and developments. For the interested reader, the section includes references to other publications dealing in the necessary detail with the various approaches.

3.1.1. United States Army

The first prototype has been described in several symposia and workshops [6, 12]. For detailed information, please refer to these papers. Nonetheless, a short overview will be given in this section.

The US Army BML proof of principle comprises the following elements as shown in Figure 3:

- To generate orders, the Combined Arms Planning and Execution System (CAPES) was used. This is a prototype US Army Planning System. This C2 component creates operational orders (OPORD) that are exchanged using a proprietary tagged XML document.

- A Multi Source Data Base (MSDB) based on the U.S. Army Standard data model of the Joint Common Data Base (JCDB), which had been extended by the BML development team by introducing over 100 new tables and relations. It is accessed via standardized database manipulation statements based on ODBC or JCDB. It is implemented in open source software of the Linux environment.

- A BML Demonstrator specific XML-BML Parser reads the information from the XML document and generates data manipulation statements. The XML-BML Parser reads the XML document, maps the information to data elements of the MSDB and inserts the information contained in the document into the MSDB.

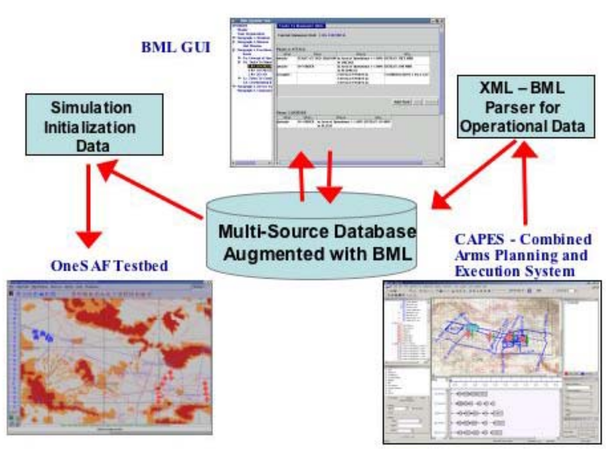

Figure 3: Components of the BML US Army Prototype

A BML Graphical User Interface (BML-GUI) allows data manipulation of the content of the MSDB under consideration of the semantic and syntactic constraints of the BML. The input of CAPES can be used as a basis to create more detailed operational orders for the subordinated units (which are simulated using the OTB simulation system). The paradigm here is who-what-when-where-why, also called "the 5Ws".

The MSDB information is based on the U.S. Army doctrinal language. In order to execute such orders, this information has to be mapped from doctrinal terms to OTB interpretable terms. This is done by the C4I Simulation Interface (C4ISI), which reads the MSDB and generates order files for OTB.

Finally, the M&S component OneSAF Test Bed (OTB) system is used to simulate the effect of the generated orders. It reads the order generated by C4ISI and executes them respectively.

The Army prototype demonstration focused on a real-world Army scenario – an actual National Training Center (NTC) Brigade OPORD. The demonstration showed how a Battalion OPORD could be built in BML and then sent to a simulation (OTB) to be executed.

3.1.2 XBML

The U.S. Army BML Prototype proved the general feasibility of the approach. Extensible Battle Management Language (XBML) was launched to raise the prototype to the new level of joint and combined operations; in other words, make it applicable to other services than the Army (joint) and other nations than the U.S. (combined). Furthermore, the integration of BML into the real future operational environment was targeted.

XBML was designed to be gradually developed and improved in phases:

- Phase 1 comprised two tasks: (1) a study on the applicability of joint tactical/operational data models for the MSDB, and (2) a prototypical implementation of the XMSF ideas to distribute the components of BML (CAPES, MSDB, BML/GUI, and OTB) and execute them over the Web.

- Phase 2 to implement and populate a C2IEDM version of the MSDB.

The next phases are to bring additional systems in and currently, the integration of the Joint Semi-Automated Forces (JSAF) simulation system in addition to the OTB system has taken place.

Phase 1 has been successfully conducted and was finalized in late spring 2004. Phase 2 is in the final stage; the experiences with the mapping of JCDB/BML to C2IEDM are topic of a separate report [13]. Furthermore, the use of JSAF is under preparation. The following gives a short overview on XBML. More details are given in [14] and [15].

XBML is supported by DMSO as part of the XMSF project. XMSF is evaluating the applicability of a set of web-based, open standards, developed by existing standards bodies, and methodologies focusing on – but not limited to – web-based distributed modelling and simulation. Because it is based on web standards, it has the ability to provide simulation services to a wide class of live systems. XMSF uses open standards and open sources to increase the efficiency of development and applicability of simulation systems. Many software systems composably scale to worldwide scope by utilizing Internet and web technologies. XMSF, by applying these web-based technologies, is an advance toward composable simulation systems. It furthermore bears the potential to migrate legacy and future M&S into web-centric components to be used in net-centric C4ISR environments, such as the Global Information Grid (GIG). These ideas are motivated and described in more detail in [16].

Various XMSF projects demonstrated the advantage of using web standards in SOAs. One of the major advantages is that the services can more easily adapt to utilize distributed applications in heterogeneous infrastructures. Nothing in particular has to be done programmatically to the service, except to enable it to receive requests and transfer results using web based messaging and transportation standards. In many cases, web services are straightforward and existing software can easily be adapted to create new web services usable within an SOA. Examples for M&S applications are given in [17]. The main steps to be conducted for this purpose are:

- Defining the information exchanged requirements using XML,

- Exchanging the information based on XML using the Simple Object Access Protocol (SOAP),

- Describing the procedures, access points, ports, and data involved using the Web Service Description Language (WSDL),

- Posting the WSDL schema to a universal description, discovery and integration (UDDI) registry.

The use of WSDL and UDDI is only necessary if it is important that other services, applications, and users can search and identify the web service. Within the XBML prototype, this was not the case, as the objective was to show that BML could be web-enabled, not to establish it within a SOA (although this step is trivial after the feasibility of web-based information exchange based on XML and SOAP is demonstrated). Therefore, the first step was to cut the U.S. Army prototype into components, defined the information exchange between these components using XML, to distribute the components in the web, and connect them via SOAP calls.

Figure 4 shows a diagram of the XBML prototype: The CAPES planning system became one component, for which the already existing XML interface could be re-used. The OneSAF Testbed simulation system became the second component. The results of the C4ISI interface was used to define the XML interface, resulting in an XML interface for OTB. The BML-GUI interface to the MSDB was the last interface. Standard tools, such as XML-Spy, creating tag sets based on the database scheme, could directly define the XML data.

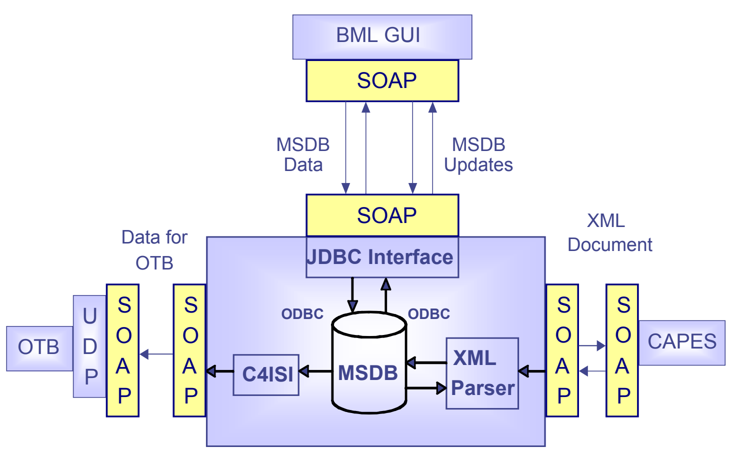

Figure 4: XBML Prototype

3.1.3 Air Operations Battle Management Language

The first prototype of BML was focused on the U.S. Army ground operations, specifically the OPORD. However, none of the characteristics of BML cited above requires limiting BML to one service. Quite the opposite – from the beginning, other services and nations were part of the BML concepts. To support the United States Joint Forces Command (JFCOM), the BML team was tasked to prove the feasibility of multi-service operations within the common framework of BML. To this end, air operations were added to existing ground operations within BML using a common representation. An initial prototype was demonstrated at the Interservice/Industry Training, Simulation & Education Conference (I/ITSEC) in December 2004. For further details see Perme et al [18].

3.1.4 Future Work

A first proposal has been written for the development of Naval BML in strong alignment with the Ground and Air Operations BML.

3.2 United Kingdom Activities

Although the Research and Development (R&D) community in the UK have long recognized the need for C4I to simulation interoperability particularly in the training domain it is now recognized that if real benefits are to be reaped from initiatives such as Digitization, the US Network Centric Warfare (NCW) initiative and the UK equivalent of Network Enabled Capability (NEC), the burden of manually translating between different data protocols will need to be overcome. If not this will be the 'Achilles heel' of these initiatives because the inefficiency in communicating C2 information between the operational systems, people involved, and simulations will fundamentally limit the benefit.

What is needed is the adoption of a common language across these functions that lend itself to both human and machine interpretation. To fulfil this need the concept of a universal BML has been introduced in the USA.

3.2.1 NEC and Digitization

From the UK perspective NEC is a vehicle to guide the coherent integration of sensor, weapon, decision-maker, and support capabilities. NEC aims to improve operational effectiveness by enabling more efficient sharing and exploitation of information within the British Armed Forces and our coalition partners. NEC is therefore key to interoperability with other nations. In particular, policy requires that the UK is able to act as an effective and capable member of future US-led coalition operations. Interoperability with the US is therefore a priority and alignment with the US Transformation process is considered essential. NEC will help the UK achieve this.

Achieving this integration and interoperability through NEC is a fundamental driver of the need for a BML. Meeting the full potential of NEC aspirations will require the co-evolution of all the Lines of Development (LoD) (in the UK Lines of Development equate to US DTLOMS). Therefore in developing a BML due account must be taken of its need to support interoperability across all relevant LoDs and with allies.

For the UK, the cost of replacing or updating military capability to meet the aspirations of NEC in a single jump is prohibitive. Military capability will have to evolve as a series of prioritized capabilities and a BML must similarly cope with evolution in both operational and training systems.

There is ongoing work to determine requirements for the operational employment of simulations, for example in planning and Course of Action Analysis (CoAA) and BML will potentially play a role in supporting these requirements.

3.2.2 UK Research

During the Synthetic Theatre of War (STOW) 97 program, the UK R&D community built up considerable knowledge based on the use of CCSIL. However, subsequently there was very little development in this area until the Adapted Middleware (AMID) concept was established. The AMID concept was developed independently of knowledge about the U. S. Army BML initiative.

More recent UK MoD Research into the impact of NEC on collective training has identified that the single most critical shortfall for current and future training is the inability to achieve flexible, adaptable interoperability with operational systems, such as future C4I and Intelligence, Surveillance, Acquisition and Reconnaissance (ISTAR) systems. Research under the Software Agents as Facilitators of Interoperability in Collective Training (SAFICT) programme identified a number of emerging technologies that could provide viable interoperability solutions. The AMID concept seeks to support a run-time plug and play approach to system and organisation integration. The interoperability approach proposed by this study will significantly ease and reduce the cost of integration of future systems, enhance the flexibility of training establishments and enable the delivery of deployed collective training and mission rehearsal.

The basic concept of this work is to develop an AMID solution that supports flexible plug-and-play style interoperability between Synthetic Environments (SEs) and C4I and ISTAR systems in the collective training environment. In contrast to conventional approaches to interoperability, which often focus primarily on data translation and exchange, the proposed work assumes that flexible system interactions can only be achieved if the middleware is viewed as a system in its own right. Its primary purpose is to support the definition and management of relationships between other systems. This approach ensures that the interoperability infrastructure is explicitly visible and manageable, and does not become a set of independent and unwieldy point-to-point inter-system connections that themselves form a significant barrier to subsequent technical change.

The proposed solution recognises that the AMID must be designed to be extensible from the outset, so that a new external system can be accommodated with little or no impact on any existing combination of systems managed by the AMID solution. It is also intended to support use by staff with little or no technical training. In particular, it is designed to support re-configuration within and between exercises, so that the exercise staff can provide an overall training system precisely tailored to the C4I/ISTAR training needs of different training audiences.

The work will employ a set of technologies that are entering mainstream commercial use, and which taken together offer a powerful new approach to the training interoperability problem. They provide a set of complementary mechanisms that are grounded in conventional software engineering techniques (e.g. they are based on robust mainstream programming languages), but which provide significant leverage in some key technical areas that are very relevant from an interoperability perspective.

Able to support external systems (C4I, ISTAR and SEs) that exhibit a wide range of different approaches to technical interoperability, and which cannot themselves be easily modified (either because they are legacy or proprietary, or both).

The flexible adaptivity of the proposed middleware derives from two key design principles:

- Management of the data and rules that control interaction between the external elements is viewed as the primary function of the AM system;

- Encoding the data exchange rules and functions in a manner that facilitates their visualisation and manipulation, for example in a relatively high level vocabulary (or ontology) that can itself be edited using tools provided by the system.

This contrasts with traditional non-adaptive data exchange solutions where the system is hard-wired around dedicated translation functions, and where the behaviour of the system is encoded in low-level representations that cannot be easily inspected or modified except by skilled software engineers. Although such traditional solutions can exchange data perfectly well in closed and static environments, they constitute a significant barrier to the introduction of new external systems, especially those that exhibit novel interoperability requirements (such as emerging C4I/ISTAR systems).

To achieve flexible interoperability, such as that which is the aim of adaptive middleware, there will need to be at its logical heart some form of what might be called a reference meta-language through which 'non-standard' dialects can be mapped and made interoperable.

The meta-language within middleware will need to deal with more than operational communications such as control and data capture for analysis but otherwise there is the potential for alignment between this and the goals of BML if not BML itself.

The more that C2 and systems move towards common syntax and semantics (e.g. through a BML) the simpler the task of middleware becomes. Indeed both approaches seek to support rich interoperability.

In the UK work is now programmed to assess the US efforts on BML to see if it meets the UK requirements for C4I to simulation interoperability. In addition the UK plans to support the Coalition BML initiative sponsored by the Simulation Interoperability Standards Organization (SISO). A more detailed discussion of the UK perspective is given in [19].

3.3 French Activities

The French efforts in this domain have been presented in various papers during the recent workshops, APLET is a French Ministry of Defence (MoD) R&T program, which aims to investigate the capabilities offered by M&S for its integration into an existing Brigade level C4I system for CoAA purposes. In addition, this program is dedicated to exploring the technical issues of C4I-M&S coupling and to providing recommendations for M&S interfaces, models and data models to overcome the gap between current M&S and legacy C4I. A series of demonstrators is developed to prove the feasibility and demonstrate the technical approaches studied and recommended for future use.

APLET main objectives are:

- Automate the Military Decision-Making Process for 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 interoperability issues and propose recommendations to bridge the gap between those systems;
- Define the most suitable simulation granularity allowing CoAA in a tight period and experiment new algorithms like RDE (Reaction Diffusion Equation);
- Propose mechanisms to automatically produce OPORD from a selected CoA.

The APLET program is divided into three phases. The first one, called “preliminary study”, was aimed to address the gathering of operational requirements and the analysis of different technologies for C4I and simulation coupling. This phase ended with a mock-up illustrating the military requirements collected during interviews. The results were presented in [20].

The second phase goal is the development of a demonstrator for Brigade CoAA that highlights the usability and the effectiveness of the technical recommendations proposed during the preliminary study phase. This demonstrator was tested in real situation during a Brigade exercise in November 2004. The work is summarized in [21]

The third and final phase objective is the implementation of a second version of the demonstrator, taking into account the lessons learned during experiments. Finally, the overall program will end in 2006 with the specifications for an operational system.

This program is a part of different works on C4I-M&S interoperability led by the French MoD. A short-term objective is to obtain an operational interoperability between legacy C4I and simulation systems that meets the major Military requirements. Thus, alignment of C4I and simulation data models based on C2IEDM is seen as mandatory. A mid-term objective is to share common components between C4I and M&S in order to improve interoperability and then to extend military use of simulation on the battlefield. The long-term objective is to reach the alignment of architectures, for embedding simulation into C4I thus covering the full spectrum of operational requirements.

3.4 Other International Interests in BML

The BML activities were presented during diverse international conferences and symposia in the M&S and C2 domain, in particular:

- The Simulation Interoperability Workshops (SIWs) and European SIW sponsored by SISO;
- The CCRTS and International CCRTS sponsored by the CCRP;
- I/ITSEC held annually in Orlando, Florida.

The international response was generally very positive and not limited to NATO or Partnership for Peace nations. Among the nations having expressed interest in BML are – besides France, United Kingdom and United States – Australia, Canada, Czech Republic, Germany, Italy, Singapore, Spain, Sweden and Turkey. However, no funded common international effort has been established so far.

4 INTERNATIONAL ACTIVIES USING THE BML APPROACH

Within the research underlying this paper, four international activities using the BML approach or having potential to use the BML due to their operational requirements have been identified. As before, this enumeration is neither complete nor exclusive and every hint to additional activities is welcome. The four activities are:

- Project SINCE a US-German initiative;
- The Coalition BML Study Group sponsored by the SISO;
- The Research and Technology Organization (RTO) Modelling and Simulation Group (MSG) activity Exploratory Team-016
- The NATO RTO MSG activity MSG-027 “Pathfinder.”

4.1 Project SINCE

The focus of Project SINCE experimentation activities is:

- The conduct of collaborative mission planning and execution management that are needed to support coalition force operations at brigade, battalion and echelons below;
- To demonstrate a common international information exchange interoperability interface that supports the connection of OpCIS and simulations;
- To integrate and use M&S technologies to support mission planning and management of complex joint and combined/coalition missions and operations.

The project is a bilateral undertaking by the US and German Armies. The types of information exchanged between the two armies C4I are through MIP C2IEDM ADat-P3 messages or C2IEDM database to database replication mechanisms. The M&S systems information exchanges are defined in the structure of a High Level Architecture (HLA) Federate Object Model (FOM) and actually exchanged using HLA Run-Time Infrastructure (RTI) mechanisms. Real-time tactical information required for planning is defined as XML based text and graphics constructs that are exchanged primarily via a Web-based collaboration portal and mapped into extended C2IEDM/JDBM. The claim is that it allows real-time visualisation and planning concept information exchanges by implementing a common agreed set of terms, tactical phrases and BML concepts to ensure consistent execution of coalition operations. To date it appears that the US has demonstrated MIP ADat-P3 messages converted to XML constructs and they have been mapped into C2IEDM. [22]

Unlike the SIMCI-OIPT BML effort described above that uses a "5W" format Project SINCE is developing what it describes as a W6H formatted operational order. They are planning to parse a natural language operational order text and graphics in terms of the W6H reference model. They still are using CAPES and the CAPES/XML constructs and the simulation model is also OTB. The 6th 'W' is "Which" and the 'H' is "How". The "W6H" Natural Language Parsing Model is shown at Figure 5. This paper does not examine the merits of using a "5W" or "W6H" model but interestingly the US members of Project SINCE although clearly advocating their own models and methodology have stated that the project will move forward using which ever of the two constructs are acceptable to the user community.

W6H Natural Language Parsing Model

Who /whom/whose:	**unit, resource, asset, individual**
What (do):	**action, plan, operation, task, mission, results, status, outcome**
Which (object/product):	**platform, equipment, supply, system, package(messages, images, cargo, ordnance)**
Where (at):	**place, vicinity, coordinates, region, location, position**
When (on):	**datetime, event, before, after, during, parallel, sequential, o/o**
Why (to):	**purpose, goal, objective**
How (by):	**organization, formation (arrangements of forces for specific purposes), command relationship (degree of control responsibility), timing**

Figure 5: W6H Natural Language Parsing Model

Project SINCE is also utilising MIP. The aim of the MIP is to achieve international interoperability of Command and Control Information Systems (C2IS) at all levels from corps to battalion, or lowest appropriate level, in order to support multinational, combined and joint operations and the advancement of digitization in the international arena including NATO.

4.2 Study Group on Coalition Battle Management Language

SISO conducts three SIW annually: the Spring SIW and the Fall SIW within the United States, and a European SIW during summer in Europe. The scope of the Workshop encompasses a broad range of simulation issues and communities, including military applications as well as other government and non-government applications. Workshop participants include simulation developers, simulation users and operations analysts, from various government, industry, and academic communities. The Workshop focuses on issues involving distributed interoperable and composable simulations, reusable components, and on the development of a common process model for designing, composing, executing, and analysing the results of simulations, as articulated in the High Level Architecture (HLA) for Modelling and Simulation. While HLA is definitely a cornerstone of SISO and SIW activities, the actual scope is broadening and new technologies supporting concepts of advanced distributed simulation are evaluated increasingly. The SIW includes tutorials, papers on state-of-the-art experiences, identification and discussion of interoperability issues, and presentation of proposed solutions. As these solutions are prototyped and demonstrated, they become candidates for possible standards within relevant simulation communities. Various workshop forums provide opportunities for user and technical communities to meet, share ideas and experiences, identify ways to make distributed simulation more effective and efficient, and support the development of appropriate interoperability standards. This is done in Study Groups (SG) and Product Development Groups (PDG). The process is well defined and documented by the Standards Activity Committee (SAC) of SISO. The general process is that a SG evaluates the feasibility and usefulness of a new standard first and then, after successfully finished this stage, emerges into a PDG establishing a new standard.

Following several presentations of the national activities on BML, during the spring SIW 2004 the idea was presented to establish a SG on Coalition BML. The SAC accepted the Statement of Work (SOW) and Terms of References in the summer of 2004 and a paper [11] was written as a summary on Coalition BML ideas relevant for the SG. The SOW for the Coalition BML study group identified the following tasks:

- Task 1 - The SG shall conduct a Paper Survey comprising as many as possible international contributions applicable to the Coalition BML effort.

- Task 2 - The SG shall develop a Plan how these various efforts identified in Task 1 can contribute to a common Coalition BML standard/standard framework.

- Task 3 - The SG shall formulate a set of Recommendations on how to proceed toward a Coalition BML PDG.

The products resulting from the establishment and execution of these tasks shall include, but is not limited to a literature survey summarizing the results of task one, and a final report, to be delivered during the SIW Fall 2005. The SG is expected to collaborate, as needed, with other organizations with potential interest in this work, in particular NATO and CCRTS groups interested in this topic. From the SISO side, the collaboration with the NATO M&S Group (NMSG) is already is in place.

The Coalition BML SG formally began its work at the 2004 Fall SIW. It will submit an interim report at the 2005 Spring SIW, and will complete its work and submit a final report to the Executive Committee (EXCOM), SAC and Conference Committee by the 2005 Fall SIW. In addition to electronic collaboration facilitated by use of the SISO web site, a number of interim meetings are scheduled to be held in conjunction with other M&S-related conferences during the period of the study. The first of these additional meetings took place at I/ITSEC 2004 in Orlando, Florida and more recently a Face-to-Face Workshop was held in Norfolk, Virginia.

4.3 NATO Exploratory Team - 016

The NMSG Conference "Command, Control, Communications and Intelligence (C3) and Modelling & Simulation (M&S) Interoperability" was conducted in Antalya, Turkey from 9 to 10 October 2003. During this conference, the results of work conducted by SISO on C2 and simulation systems were presented. This demonstrated the applicability of SISO products to the NATO community. Therefore, one of the recommendations was a closer relationship between the NMSG and the SISO. As SISO is dedicated to facilitating simulation interoperability across a wide spectrum and provides forums, educates the M&S community on implementation, and supports standards development for M&S. Only recently, the SAC of SISO merged with the IEEE counterpart (SISC) so that SISO now is the M&S standard development agency. Observation, and where appropriate, active participation in Study Groups and PDGs, were perceived to be likely to support the NMSG. A formal liaison would ensure that the NMSG is aware of the latest developments of the simulation standardisation world and can influence the new standards by bringing in the NMSG requirements as early as possible, i.e., before the standards are established. This recommendation of last year's conference directly leads to the actual recommendation to actively participate in the only recently established SG on Coalition BML.

The prior text and references demonstrate the feasibility of the Coalition BML ideas and the applicability to both NATO's relevant issues, in particular dealing with the seamless integration of C2 data into C2 information systems and simulation systems. To implement BML most efficiently into the NATO processes, two recommendations were given to facilitate this, namely:

- The alignment with the already established MIP responsible for the C2IEDM development, extension and enhancements;

- The establishment of a technical area dealing with issues of a NATO BML under sponsorship of the Research & Technology Organization (RTO) under participation of the NMSG as well as the Information System Technology (IST) system.

4.3.1 Alignment with the Multilateral Interoperability Programme

As pointed out in detail, the three views describing BML are doctrine, representation and protocols. The recommendation of the authors as well as other BML experts is the use of the C2IEDM to cope with the BML representation view. As described in detail in section 2.3, the MIP is responsible for the further development, extension and enhancement of the C2IEDM.

It is without question that BML will lead to further information exchange requirements not yet part of the actual generic hub of C2IEDM. As BML copes with C2 data describing the commander's intent in C2 data, it is more than likely that extensions and enhancements of BML developments will facilitate the future enhancement of C2IEDM and beneficial to the MIP. The other direction is valuable as well: findings of MIP are without doubt of interest and value for BML.

It is therefore perceived to be essential to establish a vivid mutual relationship between BML and MIP. As NATO is the sponsor of MIP, it is the natural home for these related efforts to couple BML and MIP efforts as well. BML must be driven by the same degree of consensus and must have the same active configuration management as already in place for the C2IEDM via MIP. Establishing BML efforts without alignment with MIP would unavoidable lead to double efforts and unnecessary interface definitions of potentially stovepipe solutions in later phases.

4.3.2 The Establishment of a Technical Area on NATO BML

Despite the necessary alignment with MIP, BML is an activity with its own value and therefore to subsume it under MIP would not be objective driven. As pointed out before, the use of the C2IEDM is only one of the three views coping with BML. The other views, BML doctrine and BML protocols, are as important as the BML representation.

All three views have in common that they are tightly connected to the M&S community as well as the C2 information systems community. Within the NATO RTO, two groups are dealing mainly with these topics: the NMSG and the Information System Technology (IST) panel. The Studies, Analysis and Simulation (SAS) panel is connected as well, but more from the user and requirement side. It was therefore recommended to align BML activities within the NMSG as well as the IST under consideration of relevant SAS issues, in particular C2 related studies, such as the C2 Assessment studies described in [4].

A demonstration of the U.S. Army Prototype and a paper [23] recommended at the NMSG Conference in October 2004 in Koblenz, Germany that it was the best RTO group to become a home for BML activities. During the activities of establishing the NATO M&S Master Plan, similar arguments such as those applicable in the context of BML were discussed before: The implementation of the M&S Master Plan as defined in [2] was partly covered by several of the NATO RTO bodies. Nearly every panel either applied simulation systems, defined their use or is connected with the use of military IT. The result was the establishment of the MSG to combine all these activities. As the same was true for BML – and the MSG already is established to cope with issues concerning C2 information and simulation systems, such as the common integration framework of the Pathfinder project, – it seemed to be the logical recommendation to establish a technical area dealing with NATO BML issues under the aegis of the NMSG with tight relations to IST and SAS activities under sponsorship of the NATO RTO. As a result it was agreed to establish NATO ET-016 under the leadership of France. An initial meeting took place in Paris in February 2005 and seven countries were represented; Denmark, France, Germany, Holland, Norway, UK and the USA. It is scheduled to report to the NMSG at its conference in Warsaw, Poland in October 2005.

4.4 Applicability in the NATO Pathfinder Project

The fourth project of interest is the NATO RTO MSG activity MSG-027 "Pathfinder", as initiated by the NATO M&S Master Plan [2]. The Pathfinder concept will enable the provision of different purpose federations composed of simulations and tools of NATO agencies and the nations and the interaction of these simulations and tools with C2 information systems of NATO and the nations for applications in support of military commanders and their staffs. To this end, Pathfinder supports the application of simulation in education, training, exercise, execution support of defence planning, operational planning, and conducting operations at the strategic, operational, tactical level for different kinds of missions for different staffs involved.

The targeted common integration framework for building future distributed simulation applications will integrate various existing national and NATO capabilities utilizing existing standards to accomplish this task. Among the identified issues to be solved are in particular multi-resolution modeling issues, concepts for linking simulations and C2 systems, the identification and description of support systems, the description of interface requirements at the application side, and the design of the integration framework.

The ideas of BML identified and described in the first sections of this paper are directly applicable to most of these areas: the standards supported and required by BML solutions are within the scope of Pathfinder standards. Although BML does not solve the multi-resolution problem, it helps to identify areas where due to multi-resolution additional challenges may surface within a project. The application in both communities, C2 and M&S, is one of the roots of BML and therefore the applicability of BML in the context of linking simulations and C2 systems seems to be obvious. BML therefore has a great potential in supporting Pathfinder and should be evaluated as a potential key component of the Pathfinder integration framework.

5 SUMMARY

NATO and other technologically advanced nations are rapidly moving to net centric operations and warfare. Net centric warfare is data centric. Data in context leads to information. Agile and dynamic information becomes knowledge. Applied knowledge finally supports awareness. Current C2 is not even data centric. Battle management is mostly limited to humans and doesn't support automated systems to the extent needed to enable future warfare. BML closes this gap by migrating the commander's intent into C2 data. BML results in executable descriptions of missions and tasks. The resulting three views are BML doctrine, BML representation and BML protocols.

The feasibility has been proven in various national prototypes. Furthermore, the operational pressure to develop a common BML can be seen by the independent developments in the same direction in different NATO countries and other nations and the adaptation of these ideas in others. There is a strong international interest in these activities and the SISO has initiated the first step in the standardization effort for Coalition BML by the establishment of the SG. The CCRP in the United States is well aware of these activities and is supportive. DMSO and the Defence Information Systems Agency (DISA) support BML activities. The JFCOM sponsors BML developments for training and experimentation.

BML uses open and international standards of C2 and the M&S community, such as web and grid services for communication protocols, NATO doctrine documents and the C2IEDM. BML is already connected to MIP; the applicability within Pathfinder is obvious.

In summary, SISO needs to move from its Coalition BML SG activity into a PDG and the NATO ET-016 on completion of its initial remit should develop into a Technical Activity Program as soon as feasible and as already been allocated the reference number MSG-040 in anticipation that the it will gain approval to proceed after the meeting in Warsaw. If the work achieved in the last 5 years is not to be wasted it will be necessary for Nations to provide funding so that the goal of a universal BML for coalition operations can be achieved.

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