NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

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**RTO TECHNICAL REPORT** **TR-MSG-048**

# Coalition Battle Management Language (C-BML)

## (Langage de gestion du champ de bataille (C-BML))

NMSG-048 Final Report.

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- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

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# List of Acronyms

| | |
|---|---|
| AAR | After Action Review |
| ACO | Airspace Coordination Order |
| ADatP-3 | Allied Data Publication-3 |
| APLET | Aide à la Planification d'Engagement Tactique terrestre |
| ATO | Air Tasking Order |
| BML | Battle Management Language |
| C2 | Command and Control |
| C2IEDM | Command and Control Information Exchange Data Model |
| C2IS | Command and Control Information System |
| C2LG | Command and Control Lexical Grammar |
| C2PC | Command and Control Personal Computer |
| CAPES | Combined Arms Planning and Execution System |
| C-BML | Coalition Battle Management Language |
| COA | Course Of Action |
| COAA | Course Of Action Analysis |
| COI | Community Of Interest |
| CONOPS | Concept of Operations |
| COP | Common Operational Picture |
| CROP | Common Relevant Operational Picture |
| DIS | Distributed Interactive Simulation |
| DSS | Decision Support System |
| eCOA | enemy Course Of Action |
| FOM | Federation Object Model |
| FRAGO | Fragmentary Order |
| FTRT | Faster Than Real-Time |
| GCS | Ground Control Station |
| HLA | High Level Architecture |
| ICC | Integrated Command and Control |
| IEM | Information Exchange Mechanism |
| ISIS | Integrated Staff Information System |
| JADOCS | Joint Automated Deep Operations Coordination System |
| JAUS | Joint Architecture for Unmanned Systems |
| JBML | Joint Battle Management Language |
| JC3IEDM | Joint Consultation Command and Control Information Exchange Data Model |
| JSAF | Joint Semi-Automated Forces |
| MIP | Multinational Interoperability Programme |
| MOE | Measures Of Effectiveness |
| MOP | Measures Of Performance |
| MR | Mission Rehearsal |
| MSDL | Military Scenario Definition Language |

| | |
|---|---|
| NORTaC-C2IS | NORwegian TaCtical-C2IS |
| OneSAF | One Semi-Automated Forces simulation |
| OOB, ORBAT | Order Of Battle |
| OPGEN | General Operational Message |
| OPORD | Operations Order |
| OPSTAT | Operational Statistics |
| OPTASK | Operational Task |
| POW | Programme Of Work |
| RECCE | Reconnaissance |
| ROE | Rules Of Engagement |
| SA | Situational Awareness |
| SBML | Scripted Battle Management Language |
| SCIPIO | Simulation de Combat Interarmes pour la Préparation Interactive des Opérations |
| SICF | Système d'Information pour le Commandement des Forces |
| SIMBAD | Command Post Simulator from Battalion to Platoon |
| SISO | Simulation Interoperability Standards Organization |
| STANAG | Standardization Agreement |
| TA | Technical Activity |
| TAP | Technical Activity Proposal |
| TRL | Technical Readiness Level |
| TTP | Techniques, Tactics, Procedures |
| UAS | Unmanned Air System |
| UAV | Unmanned Aerial Vehicle |
| UVS | Unmanned Vehicle System |
| VV&A | Verification, Validation & Accreditation |
| WARNO | Warning Order |

# Key Audiences

| | |
|---|---|
| **1) NATO Partners.** | ACT<br>NATO Consultation, Command and Control Agency (NC3A)<br>NATO Industrial Advisory Group (NIAG)<br>NATO Underwater Research Centre (NURC)<br>Allied Command Operations (ACO) |
| **2) National Representatives.** | Conference of National Armament Directors (CNAD)<br>Agile Mission Group (NRF)<br>NATO Military Committee<br>Nations (customers)<br>National Modelling and Simulation Coordination Offices |
| **3) NATO RTA bodies whose activities largely depend on M&S as a lead investment in various capabilities as well as Net-Enabled Capabilities.** | Applied Vehicle Technology (AVT) Panel<br>Human Factors and Medicine (HFM) Panel<br>Information Systems Technology (IST) Panel<br>NATO Modelling and Simulation Group (NMSG)<br>System Analysis and Studies (SAS) Panel<br>Systems Concepts and Integration (SCI) Panel<br>Sensors and Electronics Technology (SET) Panel |
| **4) The warfighters and national representatives associated with M&S of any NEC, from "start to finish".** | Warfighters at all levels, including planners, decision-makers, analysts/scientists, involved in the following:<br>CD&E<br>Acquisition, T&E, Logistics<br>Operations<br>Training and Exercises<br>Joint Multi-National and Inter-Agency Activities<br>Force Development, Force Generation, Force Employment |
| **5) International C2 and Simulation Interoperability Standards Organizations.** | MIP<br>SISO C-BML Product Development Group<br>SISO MSDL Product Development Group |

# Acknowledgements

The **"MSG-048 Technical Activity Final Report"** is the result of a complex and consultative process involving a large number of technical and operational Subject-Matter Experts (SME) from all MSG-048 participating Nations. In coming together to share data, information, knowledge, experiences and collective lessons learned gathered in executing common experimentations from 2006 to 2009, the contributors have strengthened the international understanding of the benefits, possible uses and required improvements for a Coalition Battle Management Language to support NATO M&S interoperability primarily with C2 and robotic systems.

Sincere gratitude for this support, consultation, and guidance is extended to all members of the MSG-048 technical activity. We came together as individual national SMEs, but we came out as one, providing what we believe will likely spark a revolutionary change in the way military operations are planned, rehearsed and conducted. We are also coming out of this effort with warm professional relationships and friendships that surely will grow under the auspice of MSG-085 that will ensure the coherence of a C-BML enabled approach in the future.

It would be improper not to further extend my gratitude to Mark Pullen from the George Mason University and Kevin Heffner from PEGASUS SIMULATION who both strongly promoted the works achieved in leading conference papers, organizing C-BML workshop and being active at the SISO body for the elaboration of the standard.

Finally, I must acknowledge not only the support of the NATO Modelling and Simulation Coordination Office (MSCO) but in particular the Head of MSCO at NATO RTA in Neuilly-sur-Seine, Dr. Juan J. Ruiz. Without his strong support and influence, we would not have been so productive and effective and we are grateful.

Many thanks to all (see Official Members) for the tremendous effort and for what we accomplished together in this technical activity.

This "**MSG-048 Technical Activity Final Report"** should be read not only like a conclusion about the termination of the activity. Lessons learned and recommendations are inputs for MSG-085 activity to develop a C-BML mature capability that is consistent with an operational deployment.

**Lionel Khimeche**
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**MSG-048**

# Coalition Battle Management Language (C-BML)

## (RTO-TR-MSG-048)

# Executive Summary


The NATO Modelling & Simulation Group 048 (MSG-048) conducted a Technical Activity (TA) from 2006 to 2009 that involved an assessment of the concept of Coalition Battle Management Language (C-BML). C-BML is proposed as an interoperability-enabling technology that will promote the standardized exchange of information across Command & Control (C2) simulation and robotic systems. The assessment focused on evaluating C-BML as an enabler to increase effectiveness of various activities in support of coalition operations – including training, planning and mission execution.

The MSG-048 Technical Activity was mainly comprised of experimentation in a coalition context and focused on sharing of digitized military information among coalition member Command & Control (C2) and simulation systems. The MSG-048 TA included participation from Canada, Denmark, France, Germany, Great Britain, NC3A, Netherlands, Norway, Spain, Turkey and the United States.

The final experimentation, conducted in November 2009, captured a combined cumulative experience and experimentation capability that was acquired and developed over the course of the two previous years' experimentation. This event was conducted in collaboration with active and retired military personnel from several of the participating (NATO) Nations. Several of them played an active role in the exercises that comprised the experimentation event.

Consistent with the overall feedback from the operational SMEs that participated in the final experimentation event, the MSG-048 work has confirmed the usefulness and applicability of using a standardized, digitized form (i.e. C-BML) for the exchange of military orders and reports among C2 and simulation systems to increase the efficiency and effectiveness of coalition forces during training exercises, planning activities and coalition operations. The conclusions of the MSG-048 Technical Activity are presented in this report. Also presented are recommendations concerning the steps that are required to bring C-BML technology to a Technical Readiness Level (TRL) that is consistent with an operational deployment.

# Langage de gestion du champ de bataille (C-BML)

## (RTO-TR-MSG-048)

# Synthèse


Le groupe modélisation et simulation de l'OTAN 048 (MSG-048) a été chargé de conduire une activité technique (TA) de 2006 à 2009 concernant l'évaluation du concept de *Coalition Battle Management Language* (C-BML). C-BML est une technologie à même de faciliter l'interopérabilité pour l'échange normalisé d'information entre les systèmes de type Command & Control (C2), les simulations et les systèmes robotiques. L'évaluation a permis d'apprécier l'efficacité de la technologie C-BML pour améliorer différentes activités relatives aux opérations en coalition comme notamment l'entraînement, l'aide à la planification et à la conduite de mission.

L'activité technique MSG-048 a porté principalement sur la conduite d'une série d'expérimentations au sein d'un environnement représentatif de celui d'une coalition internationale et plus particulièrement sur le partage d'information opérationnelle numérisée entre les systèmes C2 et les simulations des membres de la coalition. Les nations suivantes ont participé activement à l'activité technique MSG-048 : le Canada, le Danemark, la France, l'Allemagne, la Grande-Bretagne, les Pays-Bas, la Norvège, l'Espagne, la Turquie, les Etats-Unis d'Amérique et la NC3A.

L'expérimentation finale qui s'est déroulée en novembre 2009 a permis aux membres du groupe de se forger une expérience sans précédent et de disposer de moyens d'expérimentation développés et mis en œuvre au cours d'expérimentations conduites les deux années précédentes. Cet événement majeur s'est déroulé avec le concours de personnels militaires d'active et en retraite de la plupart des nations participantes. Ils ont joué un rôle déterminant lors des exercices regroupés au sein de l'expérimentation finale.

En accord avec l'ensemble des appréciations formulées par les experts opérationnels qui ont participé à l'expérimentation finale, les travaux du MSG-048 ont confirmé l'utilité et l'emploi d'un standard sous une forme numérique (i.e. C-BML) pour l'échange des ordres et des comptes rendus opérationnels entre les systèmes C2 et les simulations afin d'améliorer l'efficacité et le bon déroulement des forces opérant en coalition lors des exercices d'entraînement, des travaux de planification et au cours de la conduite des opérations. Les conclusions de l'activité MSG-048 sont présentées dans ce document. Il propose également des recommandations concernant les étapes devant conduire à atteindre le niveau maturité technologique (*Technical Readiness Level*, TRL) cohérent avec un déploiement opérationnel.

# Chapter 1 – INTRODUCTION

The need to interface C2 systems with simulation systems has long been established [1]. The simulation community has developed simulation-to-simulation standards such as Distributed Interactive Simulation (DIS) and High Level Architecture (HLA) through standards bodies such as the *Simulation Interoperability Standards Organization* (SISO), while the *Multi-national Interoperability Programme* (MIP) has elaborated the Joint Consultation Command and Control Information Exchange Data Model (JC3IEDM) for the exchange of military information across C2 systems. However, the work to establish standards for C2-simulation interoperability has been limited. As a result, many simulations have a unique C2 interface.

Early Battle Management Language (BML[1]) work on defining interfaces for information exchange between C2 and simulation systems utilized the Command and Control Information Exchange Data Model (C2IEDM) – predecessor of the JC3IEDM – as a basis for a system-independent community vocabulary for passing plans orders, and reports [3][4]. 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.

## 1.1 COALITION BATTLE MANAGEMENT LANGUAGE BACKGROUND

In September 2004, SISO formed the Coalition Battle Management Language (C-BML) Study Group (SG) which ultimately led to the formation of the C-BML Product Development Group (PDG) in Spring 2006 [2]. Reference [2] relates some of the earlier work that influenced and contributed to the C-BML effort. One of the main recommendations of the SISO C-BML SG was utilizing the C2IEDM as the underlying reference model upon which C-BML should be based. Also, the applicability of a BML approach to interoperability with robotic systems was identified clearly in this work. In parallel with the SISO C-BML standard development activity, SISO has also developed a related standard in the Military Scenario Definition Language (MSDL) [21]. MSDL and C-BML are considered to be closely related specifications that likely both will be used in developing C-BML compliant applications. MSDL addresses the issue of providing the necessary information required for initializing simulations.

## 1.2 C-BML RELATIONSHIP TO BML

In the course of the past decade, there have been many BML efforts that will not be mentioned here. Although, the focus of the MSG-048 mandate was on C-BML, the activities that are reported on in this document utilized elements from other BML initiatives.

For the purposes of this document, Battle Management Language (BML) refers to the general approach of utilizing a digitized form of military information in support of the unambiguous exchange across C2, simulation and robotic systems. C-BML refers to the branch of BML that specifically addresses needs associated with coalition operations. The term “SISO C-BML” is used in this document to refer to the SISO C-BML standards effort.

[1] This report deals primarily with C-BML, which for the purpose of this document represents a standardized version of BML in support of (NATO) coalition operations – even though during the execution of the MSG-048 Technical Activity no such standard was available. The term “BML” is used in a more general sense to denote the family of Battle Management Languages that share the same constructs and often much of the same foundational research. Note that many of the C-BML benefits, requirements, lessons learned and recommendations cited in this report go beyond the strict needs of the coalition and apply, in many instances, to the needs of national forces (operating independently) and also to the broader BML family as well.

## 1.3 NATO MSG-048 OVERVIEW

The need for C2-simulation interoperability in coalition operations arguably 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 ability to train and rehearse rapidly before the actual operation is of significant importance [4].

### 1.3.1 NATO MSG-048 Technical Activity Proposal

In parallel with the SISO C-BML efforts and in order to promote the standardization of C-BML, the NATO RTO approved the Technical Activity Proposal (TAP) [7] for MSG-048 "Coalition BML" (C-BML) in spring 2006. The MSG-048 TAP expressed the following need:

> *"An open framework is needed to establish coherence between Command and Control (C2) and Modelling and Simulation (MandS) type systems in order to provide automatic and rapid unambiguous initialisation and control of one by the other. To accomplish this, C2 and MandS concepts must be linked in an effective and open manner defining new, system-independent, community standards and protocols. The MSG-048 intends to explore the emerging concept of "Battle Management Language" as a component of an open framework to link C2 systems and MandS or robotic systems in the NATO context."*

The primary objective of this TAP is stated as:

> *"...to provide a NATO C-BML specification by analysing and adapting the available specifications and implementations from SISO or Nations..."*

Because the SISO C-BML specification was not available for evaluation and experimentation purposes[2] at the onset of MSG-048, the MSG-048 technical activity based its work on input from participating Nations. However, throughout the technical activity, MSG-048 has maintained close ties with the SISO C-BML PDG and has communicated MSG-048 findings and recommendations that have served and continue to serve as valuable inputs for the SISO C-BML PDG Drafting Group (DG).

### 1.3.2 NATO MSG-048 Experimentation Programme

The assessment of C-BML for use in support of coalition operations was performed based on a series of experiments conducted collectively by the MSG-048 Member Nations in 2007, 2008 and 2009. The following paragraph highlights this 3-year experimentation programme and is further described in Chapter 4.

In 2007, the MSG-048 planned and performed an experiment utilizing C-BML that involved the execution of orders sent from a C2 system by a simulation system [8][9][10]. The 2008 experimentation added the capability of the simulations to send reports back to the C2 systems. Also this experiment introduced Air C2 and simulation elements in addition to the Ground components previously included. The final 2009 experimentation built upon the previous experiment. It involved a significant number of C-BML-enabled systems (five simulation systems and six C2 systems) communicating over a C-BML communication infrastructure and involved active and retired military personnel in training and planning exercises. These events, described in more detail in Chapter 4, advanced the state of knowledge of C-BML considerably. They have been reported on in various publications (see Chapter 4) and the lessons learned that are presented in this document draw upon this experimentation and also form the basis for the recommendations made in Chapter 6 (Recommendations).

[2] The SISO C-BML PDG published its initial C-BML draft specification in September 2007.

### 1.3.3 NATO MSG-079 C-BML Workshop

In addition to the experimentation programme and this final report, the MSG-048 TA Programme of Work (POW) planned for MSG-048 to organize a symposium or workshop to report back the lessons learned from the experimentation programme [46].

1) *The technical activity MSG-048 will conclude with a symposium on NATO C-BML.*
2) *The symposium will provide information and education on NATO C-BML and give a summary of the studies conducted by MSG-048.*
3) *Lessons learned and way ahead will be presented.*

MSG-048 organized a workshop dedicated to C-BML that took place in Farnborough UK from February 24 – 25 2010. The highlights of this event are discussed in Chapter 5 on lessons learned.

## 1.4 MIP AND C-BML

The relationship between the NATO MSG-048 C-BML activities and the MIP has been a topic of much discussion. Certainly SISO C-BML is linked closely to the MIP-JC3IEDM, as it is the reference data model. However, it is not always immediately obvious to all how the two standards complement each other and more specifically: What is the added-value of developing a new standard such as SISO C-BML with respect to the alternative of simply using a well-established standard such as the JC3IEDM. Annex B – summarizes how these two standardization activities differ and how they are complementary.

## 1.5 DOCUMENT OVERVIEW

This is the final report of the MSG-048 Technical Activity. Its intended audience is the NATO technical community, in particular, those in the domains of C2 and Modelling and Simulation.

This report is structured in eight chapters, Introduction (Chapter 1), Description of C-BML (Chapter 2), Requirements for C-BML (Chapter 3), MSG-048 Experimentation Programme (Chapter 4), Lessons Learned (Chapter 5), Recommendations (Chapter 6), Summary and Conclusions (Chapter 7) and References (Chapter 8).

# Chapter 2 – C-BML DESCRIPTION

In this chapter a brief description of C-BML is provided. For more details, Annex A – provides a historical perspective of some major BML activities, related to the MSG-048 Technical Activity.

## 2.1 COALITION BATTLE MANAGEMENT LANGUAGE (C-BML)

C-BML defines a digitized form of C2 information such as orders, plans, reports, and requests. In a digitized format, this C2 information can be processed readily by C2 systems, simulation systems or interfaces to automated forces (i.e. robotic systems) – as depicted in Figure 2-1. SISO is developing C-BML as a standardized representation for joint, combined and coalition operations, consistent with C2 and simulation system requirements and based on an operations-centric common reference model (i.e. the MIP-JC3IEDM).

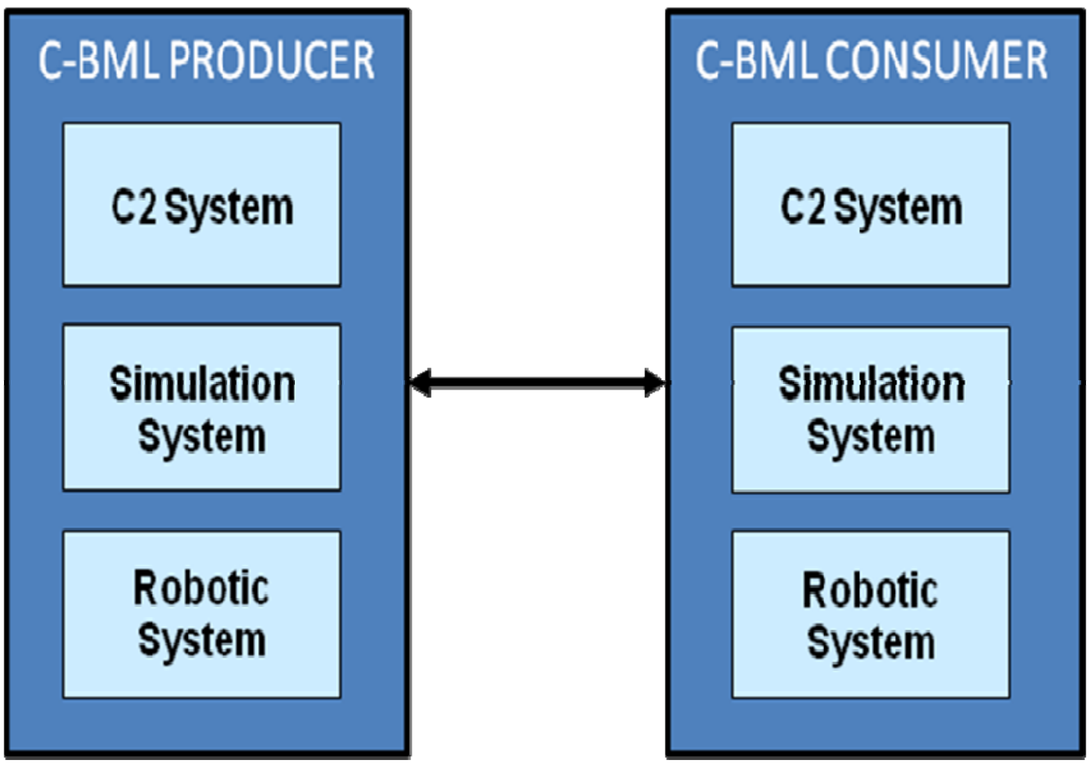


**Figure 2-1: C-BML Producers/Consumers [58].**

Based on the set of possible C-BML producer/consumer relationships, Figure 2-2 presents a view of the various areas of interoperability that were considered during the MSG-048 Technical Activity.

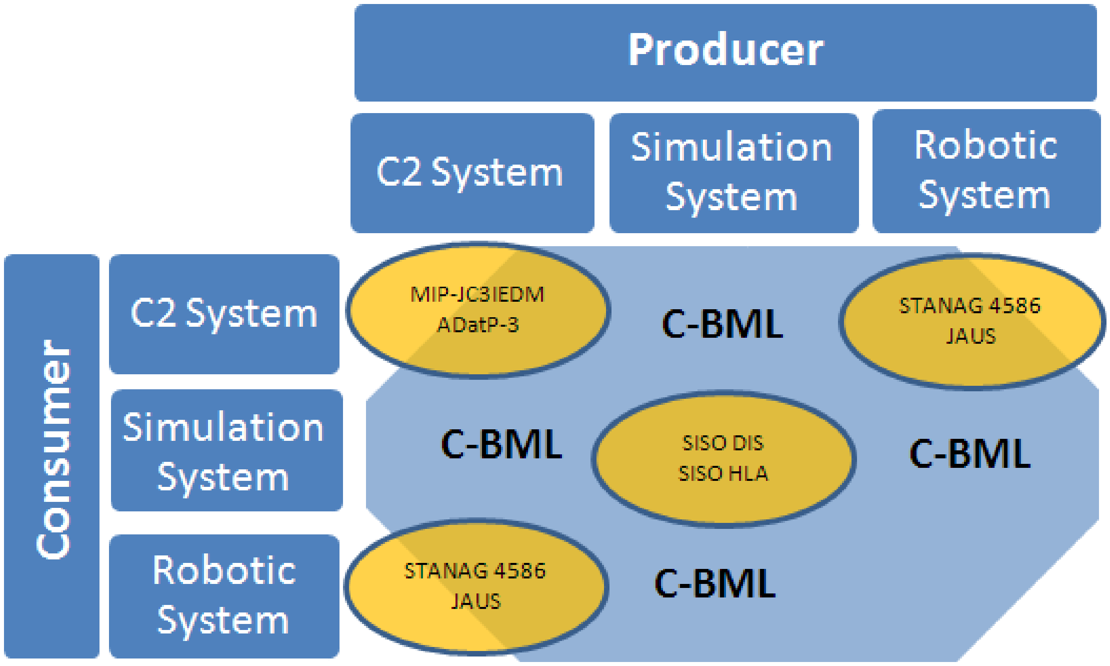


**Figure 2-2: C-BML Producer/Consumer Matrix [58].**

### 2.1.1 C-BML versus BML

C-BML has its source in the modelling and simulation domain. Although the concept is far from new, the terms C-BML and BML have only been in existence for about nine years. The recent focus of SISO is on exchanges between simulation and other systems, as illustrated. However, there is growing interest in exploiting C-BML for tasking and reporting between C2 and robotic systems and also between simulation and robotic systems.

### 2.1.2 C2-Simulation Interoperability

The main focus of C-BML has been in this area. The primary goal of C-BML is to allow C2 systems to be able to task constructive simulations *directly* through a well-defined standard interface and to allow for simulation systems to report back to C2 systems through the same interface. This topic is discussed in greater detail in the following sections.

### 2.1.3 C2-C2 Interoperability

Coalition C2-to-C2 interoperability (upper left in Figure 2-2) is addressed by the MIP in the form of the JC3IEDM standard. The Allied Data Publication-3 (ADatP-3) also addresses C2-C2 interoperability by specifying a set of formatted tactical messages standardized by NATO under STANAG 5500 [54]. ADatP-3 messages formed the basis for some of the C-BML expressions constructed during the MSG-048 2009 Experimentation Event (see Section 4.3).

During the course of MSG-048 experimentation programme, there was some indication that C-BML also had the potential of improving the way orders and reports are created and represented and exchanged among

C2 systems. This is discussed further in subsequent chapters of this report and forms the basis of one of the main recommendations of this report (see Chapter 6 – Recommendations).

Nonetheless, this report focuses on the results and findings of the experiments conducted as part of the MSG-048 Technical Activity and thus the discussion has been limited mainly to the exchange of information between C2 and simulation systems in support of coalition operations.

### 2.1.4 C2-Robotic System Interoperability

Interoperability between C2 and robotic systems is addressed in standards such as STANAG 4586 [53] and the Joint Architecture for Unmanned System[1] (JAUS) specification currently under development by the SAE International. STANAG 4586 specifies the interface between UAV Ground Control Stations (UAV GCS) and C2 systems.

Interoperability involving robotic systems was touched upon during the MSG-048 Technical Activity and will be discussed in this report as it represents an important part of the future use of C-BML in support of coalition operations.

### 2.1.5 Simulation-Simulation System Interoperability

At the center of Figure 2-2, simulation-to-simulation interoperability is clearly addressed by SISO's standards for High-Level Architecture (HLA) and Distributed Interactive Simulation (DIS). Although C-BML mainly addresses interoperability needs involving simulation and other types of systems (e.g. robotic or C2), C-BML messages and expressions could be shared across simulation systems, including the use of agent-based approaches.

## 2.2 C-BML CHARACTERISTICS

This section describes the characteristics that allow C-BML to act as an enabler for operational capabilities – as described in Section 2.6 which enumerates some of the potential benefits associated with a C-BML-enabled approach to information sharing during coalition operations.

Figure 2-3 presents a simplified view of how the SISO C-BML standard is expected to be used to enable information exchange between systems. The characteristics and capabilities described in the following paragraphs deal with structure and content as well as the services aspects.

[1] http://www.openjaus.com/understanding-sae-jaus.

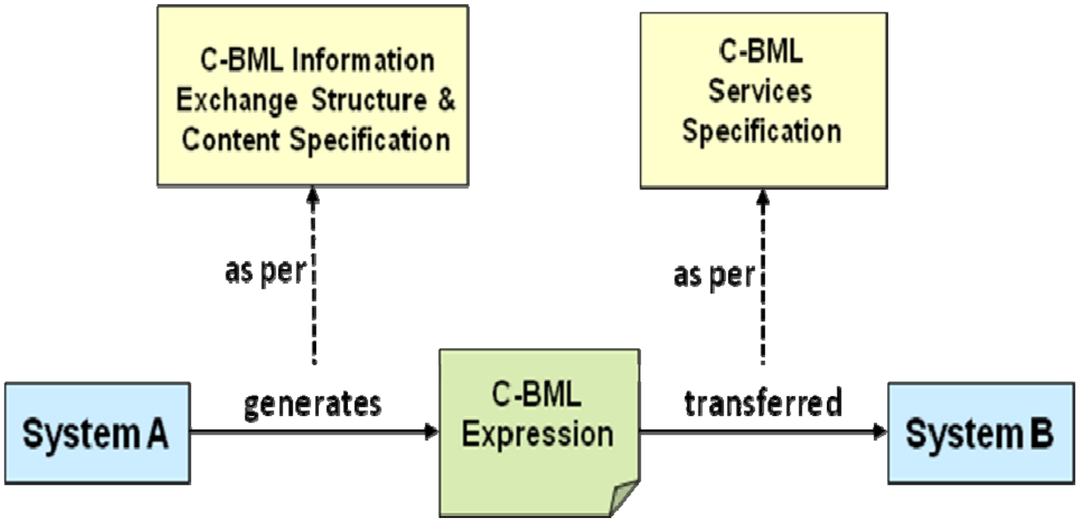


**Figure 2-3: SISO C-BML Specification Overview [57].**

### 2.2.1 A Set of Unambiguous Valid Expressions

The use of unambiguous expressions is a mandatory requirement for C-BML when interfacing a C2 system with a simulation or robotic system. In the case of the simulation, the messages are interpreted by a computer that is not generally capable of interpreting free text information. The SISO C-BML specification defines the set of valid C-BML expressions that can be generated.

### 2.2.2 A Set of Services for the Exchange of C-BML Messages

C-BML messages are composed of valid C-BML expressions. In addition to defining the valid set of expressions, the SISO C-BML standard prescribes the specification for the set of services that can be used to exchange C-BML messages.

## 2.3 SISO C-BML AND SISO MSDL

Virtually all use-cases and scenarios involving the use of C-BML as the basis for information exchange among simulation and other systems require a means for providing a static or pseudo-static description of the battlespace at a given point in time. For example, initializing simulation systems requires organizational structure (e.g. Order of Battle); friendly and opposing force deployment and operational status, environmental elements such as weather conditions, etc. In SISO, MSDL has been developed for this purpose and is presented as a complementary specification to C-BML. As stated in the MSDL specification [21]:

> *"...The Military Scenario Definition Language (MSDL) is an XML-based language designed to support military scenario development that provides the modelling and simulation community with:*
>
> *A common mechanism for verifying and loading military scenarios.*
>
> *The ability to create a military scenario that can be shared between simulations and C4I devices.*
>
> *A way to improve scenario consistency between federated simulations.*

*The ability to reuse military scenarios as scenario descriptions are standardized throughout the Army, Joint, and international communities and across simulation domains, e.g. training exercise, analysis, etc."*

Although MSDL was not utilized during the MSG-048 Technical Activity, it is recognized as one of the possible mechanisms for satisfying requirements such as scenario initialization. Similarly, in the following sections and particularly the section on C-BML benefits, it is assumed that such a mechanism is required in parallel with a C-BML-enabled capability.

## 2.4 VIEWS ON C-BML

Consistent with the foundational work on BML [2], three complementary views of BML can be identified: doctrine, representation and protocol. These views are considered in the following sub-sections.

### 2.4.1 Doctrine

Doctrine defines the collected knowledge and wisdom of military leadership regarding how to undertake tasks in operations. With respect to orders, doctrine is captured in the format of the different types of orders, such as the five-paragraph operation order. The structure of these orders is specified in the NATO STANAG 2014 "Formats for Orders and Designation of Timings, Locations and Boundaries" [48]. This document specifies how to communicate detailed information, such as assigning tasks to units (e.g. paragraph three "Execution", Sections B and C).

In support of NATO and other doctrine, the 5W paradigm can be used for tasking (e.g. Who, What Where, When and Why) [1]. This paradigm also provides the basis for formulating reports. The C-BML expressions for task assignments and reports employed during the MSG-048 experimentation used the 5W formulation. Doctrine also dictates the constituent information elements that are required to create meaningful C-BML expressions. These are described in the next section, on representation.

### 2.4.2 Representation

BML expressions have to be processable by computer-based systems, both for tasking (a central function of orders) and for reports. For example, tasks need to be generated by C2 systems and communicated to and processed by simulation systems. Similarly, reports have to be generated by simulation systems and communicated to and processed by C2 systems. To be processable by computer parsers, C-BML must be a formal language and thus must be defined by a formal grammar.

Since the doctrinal view (discussed above) suggests the use of the 5W paradigm, a C-BML grammar should structure C-BML expressions in a way that is consistent with the 5 Ws.

SISO C-BML bases the representation of expressions on the JC3IEDM, which serves as the underlying reference model. Additional business rules may be required to restrict the possible set of expressions to those that are processable.

Another element related to the representation of C-BML expressions is the requirement for a C2 ontology that will further constrain the formulation of expressions (e.g. orders and reports) such that these C-BML expressions respect not only the syntax but also the semantics of military communication. See reference [13] for more information.

### 2.4.3 Protocol

Once the C-BML expressions have been formulated correctly, it is still necessary to communicate these expressions to the appropriate systems. The protocol view deals with the manner in which expressions are transported from the C-BML expression producer to the C-BML expression consumer.

## 2.5 EXAMPLES OF C-BML EXPRESSIONS

During the MSG-048 Technical Activity, no balloted SISO C-BML standard was available on which to base the experimentation programme. Therefore, the experimentation programme based its experiments on available preliminary BML standards, tools and infrastructure.

For illustrative purposes, Annex C provides a few examples of BML expressions taken from the MSG-048 2009 Final Experimentation. The examples are simplified versions similar to those exchanged during the experiments. They were constructed based on a small set of types to support basic tasking and reporting based on a simplified version of the IBML schema – successor to the JBML [11][12][37] and inspired by the precursory work on the Command and Control Lexical Grammar (C2LG).

The three C-BML[2] examples provided in Annex C are extracts from:

1) A FRAGO issued to the Canadian UAV;
2) An ORDER issued to Norwegian 22nd Battalion; and
3) General Status Report from the French 66th Battalion.

In the examples, the high-level “W” elements are shown in yellow, for readability: Who, What, Where and When. Note that only 4 of the 5 Ws are present since no “Why” was addressed during the experimentation.

In the UAV FRAGO, the UAV is tasked to fire upon a candidate target that has been previously identified and reported on by the UAV. In the Norwegian ORDER, units of the 22nd Battalion are tasked to attack along a route but in accordance with control measures that are specified as part of the ORDER. The third C-BML example illustrates a General Status Report issued by the French 66th Battalion that reports on the position and operational status of a French unit.

On the one hand, the simplified nature of the examples included in Annex C – does not fully capture the richness of many of the C-BML constructs that are currently available. On the other hand, the significant interoperability capability that was achieved through the use of these and similar expressions during the final experimentation event provides encouragement for the future use of C-BML – when more complete syntax and richer semantics will allow for more elaborate expressions in support of more complete and detailed expressions. This will undoubtedly lead to further gains in interoperability and expanded capabilities.

## 2.6 POTENTIAL C-BML BENEFITS

This section highlights some of the benefits that are common to all application domains. Figure 2-4 presents an overview of the application domains that support the business processes related to military training,

[2] For consistency, we refer to these examples as C-BML since they were used in the context of Coalition Operations. These examples and the expressions exchanged during the MSG-048 TA were not based on SISO C-BML but rather on experimental versions of BML brought in by different Nations and agreed to by the group.

planning and mission execution activities as well as acquisition of systems to support those processes and elaboration of relevant related policy and doctrine. For each category of business process (e.g. Mission Rehearsal, Training, Planning), several types of activities are specified for illustrative purposes. Virtually all of these categories of business processes include activities that could potentially benefit from C-BML-enabled capabilities. After discussing some of the benefits that are common to the majority of the application domains, specific benefits to each of these areas are addressed in subsequent sections.


**Figure 2-4: Command and Control Application Domains [58].**

One common benefit to all applications is that the digitized form of the plans, orders, reports and other BML-expressed military documents can be stored easily for future access. This allows for an increased amount of information that can readily be made available for automated processing, analysis and exchange among systems.

The order of the application domains as listed in Figure 2-4 is consistent with a possible C2/simulation/robotic system development life-cycle and employment workflow – as shown in Figure 2-5.

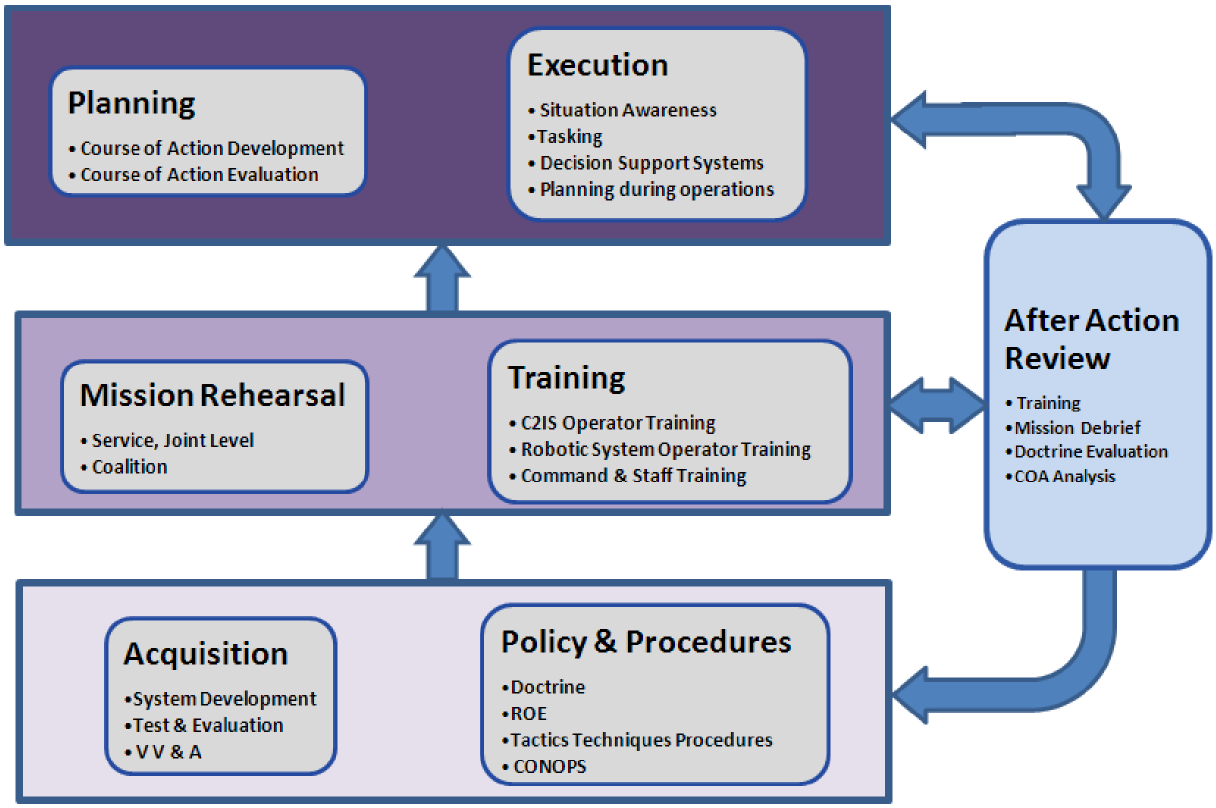


**Figure 2-5: C2IS Product Life-Cycle and Work-Flows [58].**

The three layers represent (from bottom to top):

- Acquisition, policy and procedure elaboration;
- Training, mission rehearsal activities; and
- Mission execution.

After-Action-Review is shown as a parallel activity that may be used in combination with virtually all categories of activities.

Figure 2-5 highlights a significant C-BML-related benefit: experience and data from different military enterprise activities (e.g. from theater or training exercises) can be shared with others in support of parallel activities. For instance, data collected from theater or training exercises can be shared with training, policy/procedure makers or system acquisition and procurement personnel. This could contribute to increasing the responsiveness and efficiency in communicating lessons learned and recommendations within different groups comprising the military enterprise.

Another benefit that is common to most categories of activities is that the digitized form of C-BML will eliminate sources of human error associated with entering or interpreting military information by restricting input to valid choices. This will lead to an increased robustness and accuracy in many systems.

The following sections describe other potential benefits that a C-BML-enabled approach could provide to the various activities and application domains discussed above in support of coalition operations.

The MSG-048 Technical Activity considered training, planning and mission rehearsal activities. These will be the focus of the following sections.

### 2.6.1 Policy and Doctrine

As new technology and communication and computing resources become available at an ever-increasing pace (e.g. Moore's law), there is a need to adapt and evolve existing capabilities and to elaborate new capabilities before introducing them into the changing battlespace. As these capabilities are leveraged in the form of new Concepts of Operation (CONOPS), a need also arises potentially to revise existing Techniques Tactics and Procedures (TTP) and, in some instances, doctrine.

It also is essential to ensure that Rules Of Engagement (ROE) remain consistent with evolving TTP and doctrine and to ensure that all of the above are assessed, validated and communicated as required.

If changes to TTP, doctrine or ROE are required, the ability to validate these changes using C-BML-enabled simulations may contribute to the early identification inconsistencies or problem areas and while introducing a significant time-saving.

One relevant example can be found with current soldiers who are adept at instant messaging and other social networking skills. How will smartphones and tablet PCs be used by the dismounted soldier while remaining in accordance with policy, procedures and doctrine?

Another area where C-BML-enabled simulation could assist policy-makers is in exploring the decision-making process of operations involving highly autonomous systems. For example, as higher levels of autonomy of C4I assets are achieved, more and more decision-making will be delegated to the automated systems of the platform itself. This creates challenges, from a legal perspective, in determining accountability when an autonomous system is in violation of the law of armed conflict [56].

### 2.6.2 Acquisition

The facility with which C-BML allows the interconnection of C2 and simulation systems will enable the rapid configuration of test and evaluation test beds. As future C2, simulation and robotic systems are designed, and as existing systems may be modified to support new capabilities, C-BML-enabled test-beds can be made available for conducting various system-level and integrated testing in support of system development.

Also, applying C-BML capabilities to Verification, Validation and Accreditation (VV&A) processes will allow for automated testing, including the generation of compliance or deficiency reports. The automated testing and subsequent analysis of test results will thus require less human intervention and also will increase the objectivity of the test and evaluation process while decreasing the cost associated with otherwise time-consuming manual tasks involving human interactions.

### 2.6.3 Training

Training is the area where a C-BML-enabled approach is likely to bring the most significant benefit in the short-term. Simulation systems will be able to receive orders from existing C2 systems and will subsequently be able to execute their own and enemy tasks for the designated units. The outputs of these simulations will then stimulate other C2 systems and thus provide for Command and Staff Training (CAST) as well as command post operator training. Similarly, in the area of robotic systems, C-BML-stimulated ground control stations systems will provide for significant UAV operator training opportunities.

The ability to define, configure and conduct meaningful training exercises (e.g. service, joint and coalition) in a quicker and more efficient manner undoubtedly will provide significant training value and cost savings. For example, being able to modify and then execute scenarios rapidly or to easily elaborate and compare the results of variants of scenarios for subsequent training provides greater flexibility to the training organization. In some instances, using C-BML may allow for such changes to be made directly in the C2 system without the need for a simulation operator; this also represents a significant cost saving.

One of the significant cost benefits of a C-BML-enabled approach to training will be the relaxed need for simulator operators and other interactors – as these may be replaced by C2 and/or automated systems (e.g. command agents).

The effectiveness of training also may be increased since the use of C-BML will allow for the storage of plans, orders, and reports in a form that can be easily processed by automated training analysis tools, which could generate automated responses concerning training metrics and other results.

C-BML-enabled capabilities will provide more realism to training exercises in support of the "Train as you fight" paradigm, as explained in this quote[3]:

> *"... we're absolutely going to make mistakes, and how we respond to those mistakes is just as important, maybe more important, than minimizing them. The only way we can do this is if you "train like you fight". In training, you need to run practical scenarios that emulate, as closely as possible, the chaos of the real world."*

The combined use of simulations with real assets has created a plethora of potential training scenarios with significant benefits. The *Live, Virtual and Constructive* simulation (LVC) training paradigm calls for a high level of coordination among simulated and real entities forming a unified coherent training environment. BML will act as a key enabler in ensuring the proper integration of multiple simulations within the context of LVC training.

A persistent storage capability that allows for the ability to record and playback training events in the form of C-BML expressions will provide the basis for instructor brief and debrief activities. This can be considered as part of the After Action Review capability, discussed below.

### 2.6.4 Mission Rehearsal Exercises

C2-simulation interoperability requirements for Mission Rehearsal (MR) Exercises are similar to those associated with training exercises, discussed above, and often involves the same systems. However, the following distinction could be made: training generally focuses on acquiring skills and achieving operator proficiency, whereas MR focuses on achieving a high level of preparedness with respect to a specific mission and context, often, involving a specific actual force deployments.

The same flexibility and advantages discussed above with respect to training also could have advantages for MR. However the focus of MR would probably be on risk mitigation and team-building rather than on operator proficiency and reducing the required number of interactors.

[3] http://securosis.com/blog/train-like-you-fight/.

### 2.6.5 Planning

Planning complex endeavours such as coalition operations in a net-centric operations and effects-based operations context relies heavily on analytical means for elaborating and evaluating plans based on various what-if scenarios, often, involving intelligence [45]. Providing an automated capability for evaluating COA will greatly increase the flexibility of the planner since the assessment cycle will be much quicker and thus allow for a greater number of variants involving factors such as enemy COA (eCOA), INTEL and external factors such as environmental conditions. This capability should prove to be a significant factor in augmenting coalition mission planning effectiveness as plans will be able to be elaborated, evaluated, modified and then re-evaluated in a highly automated, efficient manner.

### 2.6.6 Mission Execution

The above-mentioned augmented coalition mission planning capability can also be leveraged during mission execution for “planning during operations” scenarios and/or for use with Decision Support Systems (DSS).

In addition to pre-mission planning, in time, DSS also can benefit from built-in simulation capabilities and seamless interface that will, in turn, simplify the “what-if” analyses for both planning during operations and time-sensitive decision-making.

During mission execution, C-BML-enabled technologies can be expected to provide for a more efficient, manageable flow of information to all relevant echelons. This will be required in order to supply DSS with the required information (e.g. INTEL). This also will likely enhance situation awareness by facilitating the elaboration of a Common Relevant Operational Picture (CROP) through the combined use of C-BML with other enabling technologies such as data-fusion.

The digitized representation of C-BML-expressed military information also lends itself to information management functionality such as interest management. This may be required to mitigate the information overload, both from machine resource and human cognitive perspective, as suggested by reference [47].

### 2.6.7 After Action Review (AAR)

C-BML provides a well-defined interface that can facilitate the rapid integration of C-BML-enabled technologies in AAR systems. The ability to capture, record and replay the relevant events (e.g. tasks and reports) that occur during an operation or during a training exercise is a key enabling cross-cutting capability that can support several important military enterprise processes. AAR of training exercises can support the current training exercise, but AAR from actual operations can also provide the trainer with relevant scenarios in which to place the training audience. Similarly, the other recorded data from theater can be communicated to policy and doctrine makers in order to illustrate and communicate specific experience and lessons learned. Today, this might take place through the use of written reports, video recordings and even aural or other human intervention. In the future, a digitized account of a battlefield experience will likely be of interest to many stakeholders.

### 2.6.8 Robotic and Automated Forces

Over the last decade, a tremendous effort has been deployed toward developing and integrating unmanned robotic and automated force capabilities as part of many armed forces transformation efforts. The similarities between simulation and robotic system interfaces indicate great promise in the application of C-BML-enabled technology to the control of robotic and automated forces. Many of the benefits cited above also apply to applications involving the operational use of robotic systems and/or automated forces as part of coalition and other operations.

These benefits may involve providing higher levels of automation to reduce the load on robotic system operators such as UAV navigation or payload operators. Currently typical UAV Ground Control Station (GCS) operators may be subject to monitoring as many as 1400 information elements that may be displayed during a given mission [49]. C-BML may act as an enabler for managing these information elements in a more efficient, prioritized manner and thus reduce the workload on the operators and thus increase their availability for other tasks thereby increasing their overall efficiency.

In addition to improving operator efficiency, C-BML-enabled automation also will support higher levels of autonomy of robotic platforms, capable of performing decision-making in support of mission objectives and requiring less external intervention (e.g. from a UAV GCS). This is consistent, for example, with the US Army UAS Roadmap that calls for increasing levels of autonomy and automation of UAVs [50].

## 2.7 IMPACT ON THE FUTURE OF THE MILITARY ENTERPRISE

C-BML is not *only* a new technology for representing orders, plans and reports, but also will likely spark a revolutionary change in the way military operations are planned, rehearsed and conducted. In other words, C-BML-enabled technology will probably be a disruptive technology – or at least will likely have a disruptive component. Until recently, almost all orders and reports have been transmitted in the form of spoken or written words (i.e. in the form of "free text"). C-BML replaces this with a representation based on data structures and relationships in the form of a vocabulary, grammar (i.e. production rules and/or business rules) for constructing valid expressions.

Therefore we can expect several benefits from using C-BML that will directly result from an improved efficiency in the way actual operations are planned, rehearsed and executed. However, we also should expect benefits that are currently not identified since they will come from a new way of preparing and conducting operations that will be made possible by C-BML-enabled technology and other disruptive technologies.

# Chapter 3 – C-BML REQUIREMENTS

This chapter presents the principal high-level requirements for C-BML that were identified as part of the MSG-048 Technical Activity. An exhaustive set of requirements for C-BML is out of the scope of this document. In the following sections, highlights of requirements that were identified during the Technical Activity are discussed. These are based primarily on reference [20] and work performed in the last two years of experimentation. These requirements are intended to serve as a starting point for further requirements elicitation and for input to the C-BML standardization development efforts.

Section 3.2 highlights the operational requirements that drive the need for the C-BML language. Section 3.3 presents some considerations and requirements that will be imposed on current and future systems that are designed and/or re-designed to benefit from BML-enabled capabilities.

## 3.1 CHARACTERISTICS OF A COALITION BML

The requirements have been elaborated by considering the various potential applications for C-BML and how the C-BML producing and consuming systems (e.g. C2, simulation and robotic systems) will collaborate to achieve the operational goals and objectives of the different coalition mission activities. The following sections identify some of the desired properties and characteristics that a BML infrastructure will have to possess.

### 3.1.1 Common Interface

A driving force behind C-BML has been the need to provide a seamless common interface among C2, simulation and robotic systems. This allows the operational user to interact with a C2 system and apply the same procedures in a real operational context or in a training exercise or for Mission Rehearsal. It allows for a single C2 system to exchange information with multiple simulation systems without requiring different C2-simulation interfaces to each simulation system.

As automated forces and robotic systems achieve higher levels of autonomy and automation, BML-enabled C2 systems also will provide a common interface in support of transmission of requests, transfer of control (e.g. sharing of robotic assets) or sharing of INTEL. For instance, there would be considerable advantages for a dismounted soldier to be able to control a Micro-UAV through a BML-enabled PDA or smartphone for information gathering and to be able to disseminate information rapidly and efficiently within his unit or to other units. Although this example is out of the scope of Coalition BML, this use-case illustrates a lower-echelon utilization of BML that will benefit from the definition of a common interface.

### 3.1.2 Expressiveness

The definition and specification of C-BML must enable the expression of all relevant actions to be performed by receiving force units (real or simulated) and robotic systems (e.g. tasking, reporting). In particular, it should be able to express a 5-paragraph OPORD and support for the military reports and tactical messages.

### 3.1.3 Unambiguousness

The unambiguous nature of C-BML expressions will allow for the construction of mathematical or machine representations of information such as tasks and orders such that simulations or robotic forces can process in an automated manner. This implies the use of a formal grammar and requires significant analysis in order to support concepts such as the *command intent* and *desired end-state*.

### 3.1.4 Parseable

C-BML expressions must be able to be transferred across information systems with no human intervention in order to enable direct and automatic data transfer between C2, simulation and robotic systems. This will help to eliminate situations involving manual data transfer such as the so-called swivel-chair interface where an operator must assimilate and transfer information from one system to another. Similarly, this will allow for the phasing out of simulator operators that are required to support training scenarios by manually transferring orders to the simulation. These processes are both slow and error-prone.

### 3.1.5 Usability

The C-BML language must be easy to use: it must be straightforward to construct valid BML expressions and easy to learn to use C-BML interface for the exchange of message. The language should be designed to facilitate easy and quick input for specifying an order and/or submitting a report. C-BML is based on the JC3IEDM as an underlying data model, but should not require that all C-BML users (e.g. developers) be JC3IEDM experts.

## 3.2 OPERATIONAL CONSIDERATIONS FOR COALITION BML

The following sections provide some of the operational requirements for C-BML.

### 3.2.1 Support for WARNOs, OPORDs and FRAGOs

C-BML will need to support WARNOs, OPORDs and FRAGOs.

OPORD support should include the NATO five-paragraph OPORD.

Support for WARNOs is required in order to allow simulations to account for differing levels of readiness before executing an OPORD. This would likely translate into varying delays as simulated forces performed additional tasking or mission preparation activities.

FRAGOs are of course essential to many use-cases including, in particular, training and mission rehearsal.

### 3.2.2 Support for Doctrines

C-BML shall be able to support representation of doctrine. However, it should not be specific to a given national, joint or service doctrine but should provide the necessary elements to support a set of doctrines.

### 3.2.3 Support for Different Applications and Domains

C-BML should be independent of applications (e.g. training and course of action analysis) and be expandable to include new domains (e.g. maritime domain, air operations).

C-BML should be able to express the contents of tactical messages such as those specified in STANG 5500, the Allied Data Publication-3 (ADatP-3) [54].

**Air Operations** – C-BML should support air operations and therefore allow for constructing Air Tasking Orders (ATO) and Airspace Coordination Orders (ACO).

**Naval Operations** – C-BML should support naval operations and therefore allow for constructing messages in formats such as:

- General operational message (OPGEN);
- Operational Task (OPTASK);
- Operational Statistics (OPSTAT); and
- Naval OPORD.

### 3.2.4 Support for Levels of Command

C-BML should be applicable to multiple levels of command (i.e. not tied to one specific level such as brigade).

### 3.2.5 Rules of Engagement

C-BML should support a digitized form of rules of engagement.

### 3.2.6 Order of Battle and Task Organization

C-BML should support a digitized form of the Order of Battle (ORBAT). This requirement may be partially satisfied by the MSDL standard. During scenario execution, it is also necessary to be able to specify a Task Organization that may be different from one issued previously.

### 3.2.7 Common Operational Picture

C-BML should support information sharing required for C2 systems and simulations to interoperate and will provide a realistic operational context that includes information elements required to generate a Common Operational Picture (COP).

### 3.2.8 Weapons and Sensor Performance

C-BML should support information sharing of information elements that include performance data of sensors, weapons and platforms.

### 3.2.9 Logistic Data

C-BML should support information sharing required for C2 systems and simulations to interoperate and will provide a realistic operational context that includes logistics data.

### 3.2.10 Geospatial Data and Cultural Data

C-BML should provide for providing information elements of geospatial and cultural data in support of tasking and reporting.

### 3.2.11 Communications Infrastructure Data

C-BML should provide for providing information elements including data describing the availability of the network and communications infrastructure.

### 3.2.12 C-BML Expression Persistence

C-BML should be able to be stored and retrieved independently of the existence of an operational database (e.g. JC3IEDM).

### 3.2.13 Annotations[1]

C-BML should provide for the ability to add annotations to C-BML expressions for the benefit of human-machine interfaces that might display this information to an operator or for maintenance purposes. Even if one of the underlying goals of C-BML is to reduce or even eliminate the need for human intervention, human interactors will remain in the loop and could benefit from such annotations. In addition, support for annotations could be an element of a technology insertion plan that will facilitate the introduction of C-BML technology for use with legacy and new C2 systems.

## 3.3 C-BML-ENABLED SYSTEM CONSIDERATIONS

In order to fully benefit from C-BML-enabled capabilities, C-BML producing and consuming systems will need to comply with requirements that will allow for the successful exchange and subsequent interpretation of the C-BML expressions. In addition to C2, simulation and robotic systems, some of the requirements for the C-BML communications infrastructure are included in the following sections.

### 3.3.1 Standardization

C-BML should be made available through an international standards body such that national systems can be modified or extended as per a normative specification. Furthermore, this specification should be considered for adoption as a NATO Standardized Agreement.

C-BML should utilize established C2 standards, such as the MIP-JC3IEDM as applicable. However, this does not imply that C-BML cannot be used without the presence of a JC3IEDM database nor does it preclude the use of C-BML with other databases and data models.

### 3.3.2 C-BML Infrastructure Requirements

**Time Management**[2] – The C-BML infrastructure should provide for basic information management operations based on time-stamps that indicate when the message was issued (e.g. internal to the expression) and/or disseminated or published.

1) **Multiple Time-References** – The C-BML infrastructure should support several simultaneous time references, including: Physical time (i.e. the time being modelled), Simulation time (i.e. the simulation's representation of physical time) and Wall-clock (i.e. the time when the simulation is executed).

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[1] The need for including free-text annotations is not unanimous within the group and therefore requires further analysis and clarification and will therefore be addressed as part of the MSG-085 Technical Activity.

[2] Definitions are taken from Fujimoto.

2) **Synchronization** – The C-BML infrastructure should provide for time synchronization across C-BML connected systems (e.g. using coordinated universal time UTC).

3) **Publication Time** – The C-BML infrastructure should provide for a publication time for each C-BML message that is published (e.g. Wall-clock and/or Physical time from C2/robotic systems and Simulation Time from simulation systems).

4) **HLA Time Management** – Although it cannot be assumed that all simulations will interoperate within an HLA federation, C-BML infrastructure time management services should be at least consistent with HLA time management services (e.g. available from HLA Run-Time Infrastructures (RTI)).

**Persistence** – In addition to the operational requirement to be able to store and retrieve C-BML expressions, there are several technical requirements that the C-BML infrastructure should also support.

1) **Storage of BML Expressions** – The C-BML infrastructure should provide for retrieving messages based on time-stamps, as discussed above.

2) **Filtering** – The C-BML infrastructure should provide for filtering criteria:
   - Scenario/simulation run;
   - Organization affiliation;
   - Expression type (e.g. position report, task status report, order);
   - Time criteria (e.g. wall-clock or physical time); and
   - User-defined filtering tag.

**Validation** – The C-BML infrastructure should ensure that published C-BML messages contain valid C-BML expressions (e.g. comply with the schema and business rules). Validation may also be required by C-BML expression-consumers.

**Acknowledgement** – The C-BML infrastructure should provide a mechanism for acknowledgement to publisher (i.e. C-BML message producer), when messages have been successfully received by C-BML message consumer.

**Error-handling** – The C-BML infrastructure should comply with a standard set of error-codes that provide feedback concerning errors with C-BML message validation or dissemination (e.g. acknowledgement). In the latter case, if there is a network disturbance, the C-BML message producer may want to be notified that his message has not been able to be received and also why it has not been able to be received (e.g. system failure, network anomaly, C-BML messaging service error, etc.).

### 3.3.3 C-BML Language Requirements

**IEM Independence** – C-BML language should be independent of C-BML Information Exchange Mechanisms (IEM).

**XML-Based** – Consistent with the NATO's orientation toward XML to promote the use of standardized message formats for military information exchange, C-BML should support an XML-based language [51].

[3]**Formal Language** – In order to be parseable, as mentioned in the first section of this chapter, C-BML must be a formal language; it therefore should be based on a formal grammar with a set of production rules.

[3] The possibility to include annotations is not contradictory with the requirement that C-BML be a formal grammar. It implies that they are parsed and possibly redirected to a graphical user interface, but are not interpreted by the C-BML message consumer.

### 3.3.4 Simulation Requirements

**Faster Than Real-Time Execution** – In order to support activities such as Course of Action Analysis (COAA) in a timely manner (e.g. in support of decision-support systems) it is necessary to run the simulation at rates that largely exceed real-time – otherwise it likely not to be possible to analyse a sufficient number of own COA and enemy COA fast enough to satisfy the commander's planning or decision-support needs. This requirement also has implications on the possible need to control simulation reporting rates, discussed below.

**Simulation Report Management** – Simulations may produce reports at rates that are higher than those that operationally relevant or realistic. It may be required by simulation systems to be able to restrict the rates at which reports are published in order to avoid overloading C2 systems that may not have been designed to accept high reporting rates.

**Measures of Performance (MOP) and Measures of Effectiveness (MOE)** – In the context of COAA, it is unlikely that the reports generated by simulations will be able to be used directly by C2 systems in order to rank the different plans and scenarios. As suggested above, C2 systems generally are not designed to process and display data originating from reports that are generated at high rates. It has been suggested by Abbott et al. [52] that the evaluation of plans based on simulation results will require the simulations to be equipped with metrics that can measure task performance based on Measures of Performance (MOP). These measures can then be used as the input for calculating the mission effectiveness in terms of higher-level metrics that measure the extent to which the mission goals have been achieved, i.e. Measures of Effectiveness (MOE). The definition of MOP and MOE as part of the C-BML language itself should be explored.

**Simulation Initialization** – Before executing a COA issued by a C2 system, simulation systems must be initialized with data including some or all of the following: scenario ID, time definition, weather, terrain, friendly/enemy/neutral/unknown organization and equipment status and position and initial tasking. Many of these requirements are covered by the existing SISO Military Scenario Definition Language (MSDL). Further analysis and additional work should be undertaken to adapt MSDL and C-BML for use together.

**Simulation-to-Simulation C-BML Exchange** – Although the focus of C-BML is not on simulation-to-simulation interoperability, there is potential benefit for simulations participating in the same federation to be able to exchange C-BML messages. Therefore, a case could be made for the definition of C-BML Federation Object Model (FOM) and the possible use and benefits of a C-BML FOM should be explored. This is consistent with the requirement that the C-BML language be defined independently of the IEM that is used as a vehicle for exchanging C-BML expressions (see Section 3.3.3).

### 3.3.5 Command and Control System Requirements

The following considerations do not apply to all C2 systems, but rather offer some general insight based on the observations and experience of those that participated in the MSG-048 experimentation programme.

**Increased Usability** – As C-BML empowers C2 systems with the capability to rapidly assess plans, in some instances, they may need to be modified in order to provide for rapid plan modification – which may not have been a requirement at the time the C2 system was designed.

**Native C-BML Interfaces** – Many benefits of C-BML may be achieved without modifying existing C2 systems, as demonstrated during the MSG-048 experimentation programme. However, in time, in order to fully benefit from advanced C-BML-enabled capabilities, C2 systems may require upgrades to include native C-BML interfaces, either in current or future systems.

### 3.3.6 Robotic Forces and Automated Systems Requirements

Robotic Force systems, such as Unmanned Air Systems (UAS), have similar interface requirements as simulations, but there are significant differences. Existing standards for interfaces to UAS, such as STANAG 4586 [53], should be examined and analyzed in order to determine how C-BML expressions could be leveraged for tasking UAS and for receiving reports from UAS. In particular, STANAG 4586 calls for the use of a sub-set of ADatP-3 as the basis for tactical messages for the UAV Ground Control Station Command and Control Interface (UAV GCS CCI). Similarly, the Joint Architecture for Unmanned System (JAUS)[4] specification currently under development by the SAE International also defines a set of interfaces for tasking Unmanned Vehicle Systems (UVS).

Further work is required to investigate the suitability of C-BML to interface directly with UVS.

[4] http://www.openjaus.com/understanding-sae-jaus.

# Chapter 4 – EXPERIMENTATION PROGRAMME OVERVIEW

During its four years of development and experimentation, MSG-048 has made some pragmatic decisions that govern the scope of its endeavours. Work started with a two-Nation C-BML system, then added Orders for several Nations, followed by Reports for several Nations, followed by scaling up through a publish/subscribe capability. This incremental development approach resulted in accomplishment far beyond that normally associated with voluntary efforts of multi-national groups.

The MSG-048 experimentation programme was divided into a successive series of experiments concluding with an operational experimentation. The goals for the experiments were to align knowledge and experience among the international participants and to prepare the foundation for the operational experimentation; it advanced the state of knowledge of C-BML considerably.

The experiments were done in the form of demonstrations while the operational experimentation was performed to assess C-BML with the military end user in the loop. The goal was to address different military areas of interest to include training, mission rehearsal and planning.

The MSG-048 2007 demonstration showed orders issued from C2 systems could be executed by simulations. The scenario description used can be found in [25]. The 2008 demonstration improved over the 2007 work by adding reports flowing from the simulators to the C2 systems to the previous orders. It also introduced Air C2 and simulation in addition to the Ground components previously included. The scenario was upgraded for the 2008 demonstration and can be found in [26].

The 2009 experiment expanded the number of systems interoperating using C-BML. In the 2009 experimentation programme [24] and scenario description [27] the high level organizational, technical and scenario plans can be found. The infrastructure was extended with a publish/subscribe capability so that the various C2 systems could subscribe to reports of interest and the simulation systems could subscribe to orders of interest, avoid the need to poll the SBML[1] Web Service for updates and thus increasing both computational and communications efficiency. Systems from Canada (BattleView and UAV Simulation), France (SICF and APLET), Netherlands (ISIS), Norway (NORTaC-C2IS), Spain (SIMBAD), UK (ICC and the US-produced JSAF), and the USA (MCS and OneSAF) participated in the experimentation. The BML Web Service used to support these was the Scripted BML Web Service [18]. The C2LG GUI order interface middleware from Germany played a supporting role which is discussed in [8].

The sub-sections below briefly describe the goals, setup and results of the demonstrations/experimentations in the years from 2007 to 2009.

## 4.1 2007 DEMONSTRATION

The 2007 demonstration was presented at the 2007 Interservice/Industry Training, Simulation and Education Conference and Exhibition (I/ITSEC) in Orlando, Florida, in early December. Six Nations (DEU, ESP, FRA, NLD, NOR, USA) participated in the demonstration with a system as part of an architecture of C2 and simulation systems.

[1] "SBML" refers here to the communication infrastructure that was used for the experimentation.

### 4.1.1 Goal

The goal of the 2007 demonstration was to align knowledge and experience among the participating Nations and to show to the international audience of I/ITSEC 2007 that C-BML holds promise for the exchange of orders between C2 systems and constructive simulators [8][23][39].

### 4.1.2 Architecture

The architecture illustrated in Figure 4-1 was implemented. Note that only one C2 system was combined with one simulation system at a time. The demonstration included following combinations of C2 and simulation systems:

- C2PC/CAPES with JSAF;
- ISIS with SCIPIO;
- ISIS with SIMBAD; and
- NORTaC-C2IS with SCIPIO.

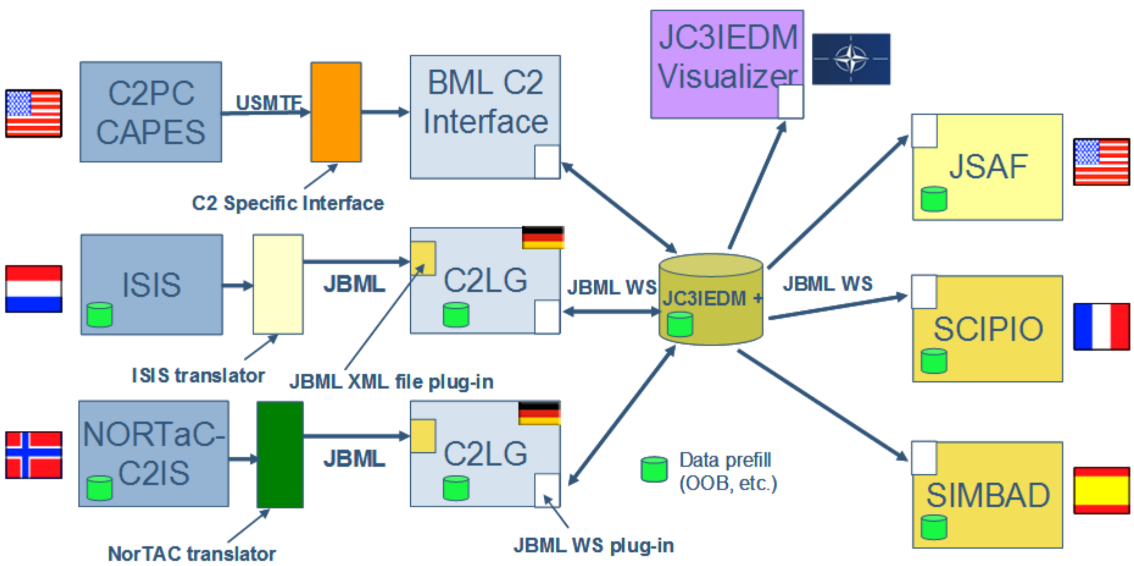


**Figure 4-1: MSG-048 2007 Experimentation Architecture.**

### 4.1.3 Results

The demonstration given at I/ITSEC 2007 was successful in showing the audience the initial BML capability for tasking. In addition, the participants gained significant knowledge and experience from each other.

## 4.2 2008 DEMONSTRATION

The 2008 demonstration was presented at the 2008 I/ITSEC at Orlando, Florida, in late November. Six Nations (DEU, FRA, GBR, NLD, NOR, USA) participated in the demonstration with a system as part of an architecture of C2 and simulation systems.

### 4.2.1 Goal

The goal of the 2008 demonstration was to show to the international audience of I/ITSEC 2008 that BML is promising for not only exchanging orders between C2 systems and constructive simulators (as was shown in 2007) but also for exchanging reports [19][39][8][41].

### 4.2.2 Architecture

The architecture shown in Figure 4-2 was implemented. The demonstration included the following combinations of C2 and simulators systems:

- ICC with JSAF;
- ISIS with POLLUX+; and
- NORTaC-C2IS with SCIPIO.

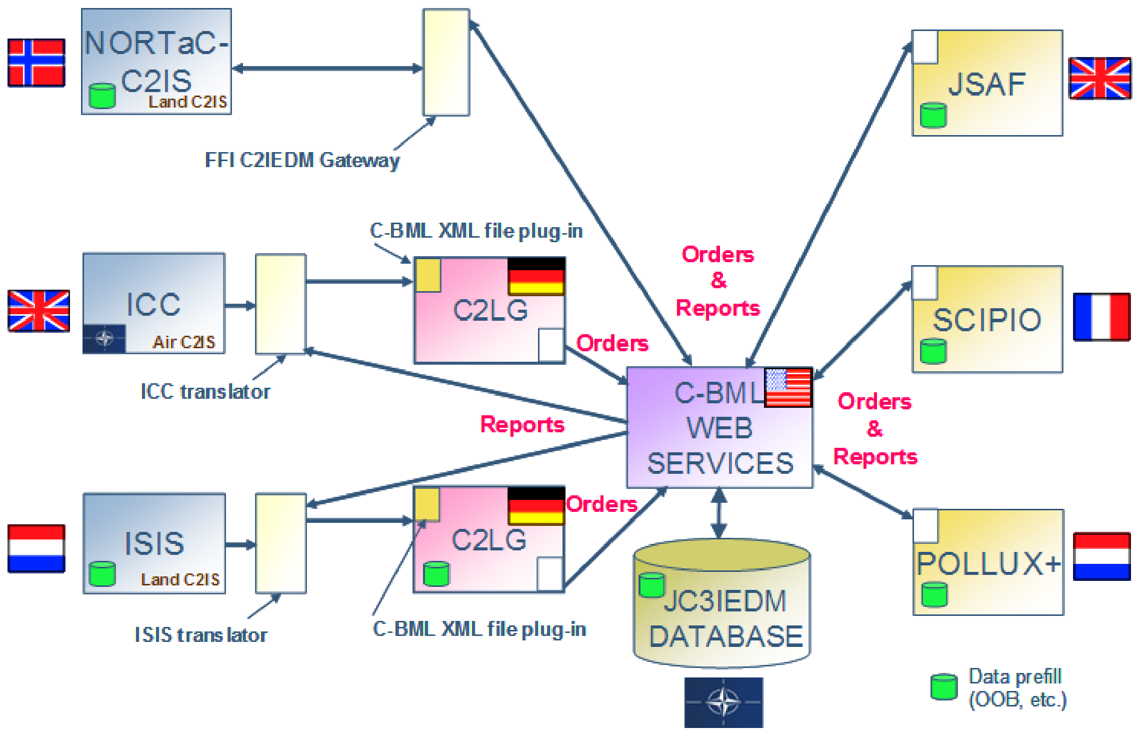


**Figure 4-2: MSG-048 2008 Experimentation Architecture.**

In the demonstration that included ICC and JSAF, an air component was introduced.

### 4.2.3 Results

The demonstration given at I/ITSEC 2008 was successful in showing the audience the new C-BML tasking and reporting capability.

## 4.3 2009 EXPERIMENTATION

Unlike the demonstrations of 2007 and 2008, in 2009 an experiment was held at the campus of George Mason University in Manassas, Virginia. The experiment was conducted with military users and a limited audience. Eight Nations (CAN, DEU, ESP, FRA, GBR, NLD, NOR, USA) participated in the demonstration providing one or more systems that comprised an extensive architecture of C2 and simulation systems.

### 4.3.1 Goal

The goal of the 2009 experimentation was to expose military end-users to the C-BML capable systems. In particular, to demonstrate the combined tasking and reporting capabilities-enabled by C-BML in a coalition context and to collect their feedback about military usefulness and utility [29].

### 4.3.2 Architecture

The experimentation was comprised of three “vignettes”. Each vignette covered one of the following specific military activities of interest: planning, training, and mission rehearsal.

Figure 4-3, Figure 4-4 and Figure 4-5 present the architectures used for these three vignettes.

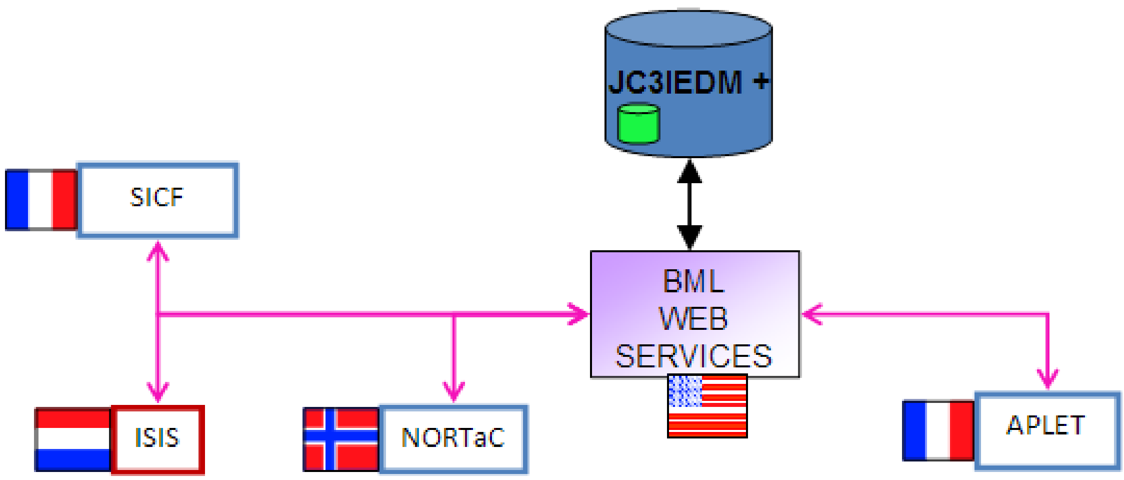


**Figure 4-3: MSG-048 2009 Planning Vignette Architecture.**

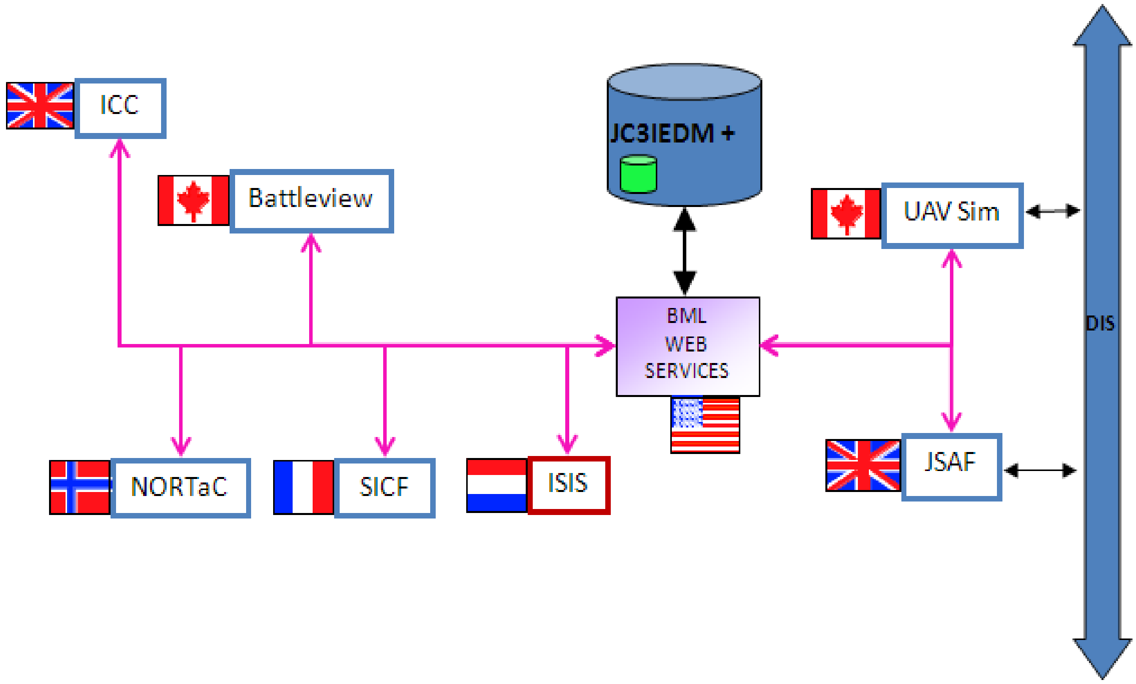


**Figure 4-4: MSG-048 2009 Training Vignette Architecture.**

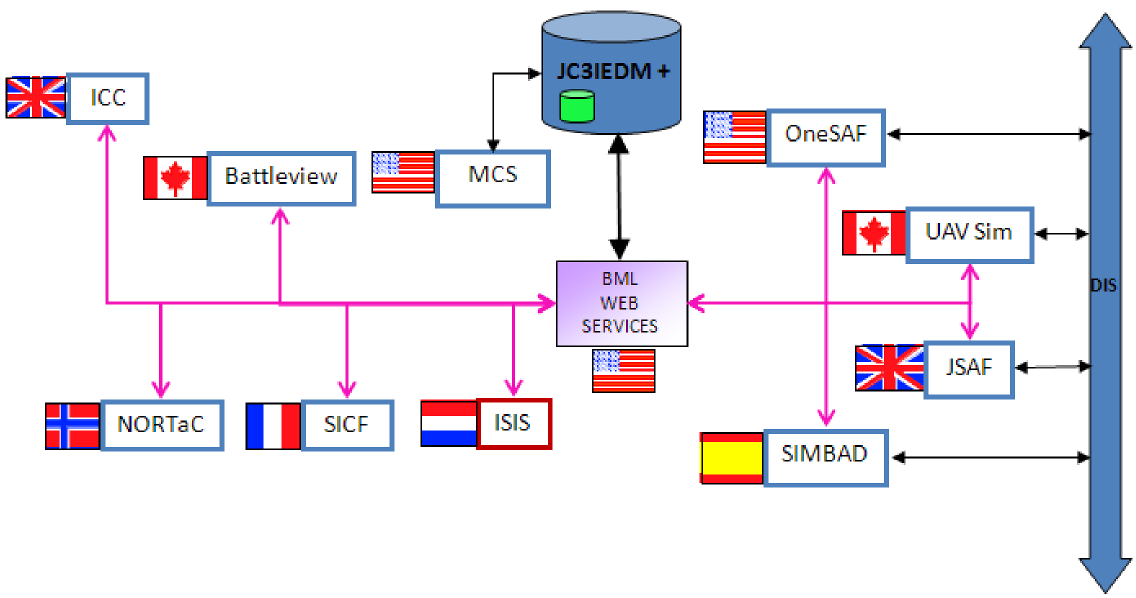


**Figure 4-5: MSG-048 2009 Mission Rehearsal Vignette Architecture.**

The planning vignette was used to play a number of Courses of Action (COAs) with two Battalions, commanded via the Norwegian and French C2 systems, NORTaC-C2IS and SICF, respectively, and simulated by the French simulation APLET. The aim was to show how planning could benefit from C-BML.

The training vignette was used to play out a scenario with two Battalions, commanded from the Norwegian and French C2 systems, NORTaC-C2IS and SICF, respectively, an air component commanded from ICC and a UAV commanded from Battleview with the ground components and air component simulated in JSAF and the UAV simulated in UAVSim. The aim was to illustrate how training could benefit from C-BML.

The mission rehearsal vignette provided the scenario for a mission rehearsal exercise based on the training scenario augmented with a Reconnaissance (RECCE) Battalion that was commanded from the US ABCS C2 system and simulated in OneSAF. For this vignette SIMBAD, the Spanish simulation system, was responsible for simulating one of the Battalions previously simulated in the training scenario by JSAF. The aim was to show the benefit of C-BML during a mission rehearsal exercise.

### 4.3.3 C-BML Exchange

The C-BML expressions that were exchanged as part of the experimentation were constructed from a small set of C-BML types agreed to by the Nations to support basic tasking and reporting as per the experimentation requirements. These selected expressions were based on a simplified version of the IBML schema – successor to the JBML work [7][12][37].

Annex C – provides some examples of C-BML expressions that were exchanged during the experiments. The first example is a FRAGO to direct the UAV to conduct close air support, the second is part of an order to a Company of a Norwegian to conduct an attack and the third is an extract from a French General Status Report. Air operations were limited by the constraints of the MSG-048 C-BML schema and complete implementation of ATOs, etc. remains as a future activity.

### 4.3.4 Results

Integrating and interoperating the various systems proved challenging and prevented Nations from fully executing all three vignettes. The first vignette, *planning*, was able to be executed, but took longer than the allotted time. Nonetheless, this vignette demonstrated the usefulness of C-BML for coalition mission planning.

The large number of systems present in the Training and Mission Rehearsal vignettes resulted in even greater complexity that presented significant integration and coordination challenges. These vignettes were not fully executed, as planned. However, a number of advantages and challenges concerning the future of use of C-BML were identified during the execution of these vignettes.

Despite the technical challenges experienced, the C-BML demonstrated effective C2 to simulation interoperability for potential operational military application.

The 2009 experimentation event brought together many Nations with a great variety of requirements and expectations. One of the main outcomes of this event was the elaboration of a set of “lessons learned” and recommendations for the future development of C-BML. These are addressed in the following chapter.

# Chapter 5 – LESSONS LEARNED

This chapter highlights the lessons learned during the four-year Technical Activity of MSG-048. In addition to valuable insight and feedback provided by operational SME throughout the MSG Technical Activity, many of the lessons learned were of a technical nature. The following section focuses on the technical lessons learned while the successive section presents the operational lessons learned, including the results of analysis and feedback provided by active and retired military personnel during the final experimentation, as described in the previous chapter.

## 5.1 TECHNICAL LESSONS LEARNED

Technical lessons learned deal with C-BML issues, from a standardization perspective (e.g. digitizing military information), from an implementation perspective (e.g. software development, integration, application initialization and execution, validation and error-handling) and from a software infrastructure perspective (e.g. network and system performance considerations).

### 5.1.1 Managing Orders

Procedures need to be established for the correct handling of C-BML orders. This permits different classes of order (such as: Warning Orders, Main Orders and Fragmentary Orders) to be used in representative ways. This is a non-trivial task.

### 5.1.2 Managing Reports

**Entity Tracking –** MSG-048 experiments indicate that the reporting frequency required for blue force tracking varies as a function of level of aggregation (e.g. lower level of echelon requires higher update rates) and service (e.g. air entities generally require higher update rates than ground entities).

**Limiting Simulation Reporting Rate –** Simulations, operating individually or as a federation, are typically able to generate reports at rates that can easily overload C2 systems. As a consequence, it will be necessary to either limit the rate at which simulation reporting occurs and/or provide for intermediate applications that can process/filter/queue reports before sending them to the C2 system.

**Bundling of Reports –** It was found to be useful to provide a mechanism for bundling multiple reports into one message in order to reduce the message payload overhead. In addition, there are differences among C2 systems regarding which organization echelon the C2 system is designed to receive and visualize data from reports. If possible, future infrastructure should have services for combining reports (e.g. entity position reports) into aggregated company position reports. Report bundles require headers to indicate the type of reports contained in the bundles.

Future report management also may require the use of geographic and report type filtering.

### 5.1.3 System Execution Management

Experience from utilizing C-BML has illustrated the value of a C-BML management facility for initialization and synchronization. The need mostly is bound to cases where C-BML is exchanged between C2 and simulation systems, but is also necessary to handle cases where multiple C2 systems collaborate on the same scenario. The requirements for system execution management can be separated as follows:

**System Initialization –** Concerned with starting up and synchronizing all participating systems in the correct sequence, in addition to ensuring that all systems are initialized with the same set of scenario data and pre-conditions (task organization, unit positions, time, etc.).

**Synchronization –** The MSG-048 experimentation identified the need for synchronizing participating systems with regards to time, in addition to ensuring that all systems have access to the same underlying data (e.g. definition of units discovered during run-time).

**Traceability and Debugging –** It is inevitable that errors and performance problems occur when a heterogeneous set of applications are set to exchange C-BML messages. In order to enable tracing and debugging of such C-BML exchange, it is necessary to exchange meta-data such as identification of sending application and sent timestamp together with C-BML messages. Future work must consider whether such C-BML meta-data fits best in a kind of C-BML message header or such meta-data should be provided by the communication infrastructure utilized. In addition, the infrastructure should offer the capability to capture and replay the C-BML traffic for debugging and analysis.

**Validation of C-BML Expressions –** When exchanging C-BML expressions, the C-BML messaging infrastructure should be capable of validation at both the sending and receiving sides. Furthermore, some level of validation also should be performed by the C-BML expression producing and consuming systems. As system configurations are tested and optimized, it may be necessary to deactivate some levels of validation for performance reasons; however validation mechanisms are required in order to proceed with initial system configuration and testing.

### 5.1.4 Performance and Architecture

Specific C-BML-enabled use-cases and scenarios will have different configurations and requirements. For example they may utilize significantly different network topologies, (e.g. a distributed mission rehearsal versus an embedded decision support system) and may operate at different reporting rates.

The variety of architectures leads to varying needs for the C-BML communications infrastructure. For example, as mentioned above, reporting rates may require that the C-BML system be tailored to specific performance needs. Similarly, C-BML-enabled command and control involving robotic systems may involve wireless networks that require additional message validation, acknowledgement and re-transmission mechanisms.

Other performance considerations have already been mentioned in the above paragraphs (e.g. bundling of reports and simulation reporting rate limits).

**Use of Publish and Subscribe –** The early MSG-048 demonstrations used a simple client-server architecture where C2 systems had to poll a server for new reports, an approach which does not scale. The 2009 experiment also utilized client-server architecture, but supplemented the polling with a service that published reports to subscribing clients according to pre-defined “Topic” expressions. This architecture clearly illustrated performance gains of using publish and subscribe subscription mechanisms in contrast to polling.

**Subscription/Filtering Mechanisms –** Reports must be delivered to and ingested by all subscribing C2 systems within a short period of time to avoid differences in the Common Operating Picture (COP). C2 systems differ in maximum supported report frequency. Furthermore, the required report rate may depend on the echelon at which the C2 system is operating. If possible, future infrastructure should offer the possibility to filter reports by rate per object and by other attributes such as geographic area, force, echelon, perceived/ground truth, etc.

**Faster Than Real-Time Scenario Execution –** It was found that simulations had different approaches to report frequency when running faster than real-time. Some systems kept the reporting rate constant when scaling simulated time, while others scaled the reporting rate equivalent to simulated time scaling, producing a higher overall reporting rate. Experience from the 2009 experiment showed that keeping the report frequency constant probably is the best approach.

This is because the operational picture gains little with increased frequency while high reporting rates put strains on the C2 systems and communication infrastructure.

**C2 Systems in Faster Than Real-Time Scenario Execution –** C2 systems typically are not designed to handle time and information progressing faster than real-time. This caused issues such as overloading the processing capability of some C2 systems and time related issues associated with delayed receiving reports and sending of orders. Future work can address the former through better support for filters/topics and by keeping report frequency constant (see earlier sections). The latter category of issues partly can be addressed in part by system execution management services (see previous section); however, it is likely that some C2 systems also will require some custom modifications.

### 5.1.5 C-BML-Specific Language Lessons Learned

This section describes some of the lessons learned related to C-BML language constructs and, in particular, how these constructs need to evolve in order to support requirements for C-BML-enabled coalition operations.

**C2LG Grammar –** The Command and Control Lexical Grammar (C2LG) developed by Schade and Hieb was used to motivate the original JBML schema that has evolved under MSG-048 usage in 2007, 2008 and 2009. This grammar ensures that tasks expressed in C-BML do not have ambiguous parsing. Furthermore we are convinced by our experience interfacing several C2 and simulation systems that the simple, straightforward representation obtained by using the "5 Ws" concept in a schema motivated by the C2LG has been a major factor in rapid implementation of C-BML by MSG-048. Associated with the C2LG is an editor that allows BML-encoded Orders and Reports to be inspected, and if necessary, modified as they flow from C2 or simulation client to the BML server and back. This is both a strong aid to debugging and a powerful way to transition clients that are not yet fully BML-capable. The MSG-048 group endorses the continued use of the C2LG in C-BML systems, expanding its use into the operational context.

**Role of the JC3IEDM –** In principle, C-BML could be implemented over any data model. However, the experience in MSG-048 is that the choice of the JC3IEDM as a lower-level representation has two distinct advantages:

1) JC3IEDM provides C-BML with a well-developed vocabulary for military operations and avoids the need to develop a new dictionary that would duplicate all the previous effort that has gone into the JC3IEDM; and

2) Some national C2IS are based on the JC3IEDM, so that interfacing them to a C-BML system that has been designed to be fully JC3IEDM compatible greatly reduces implementation effort.

### 5.1.6 Collaborative Internet Meeting and Testing

**Open Facilities, Open Source and Open Internet Access –** Because of the number and variety of participants, development of BML capabilities is greatly expedited when it occurs in open facilities where participants can come and go with minimal impediments. Availability of common supporting software under open-source licensing extends the benefits of minimal barriers to the technical environment. Further, this principle extends strongly to distributed development: the ability to use a server and available copies of the server software, located on the open Internet, for development and testing proved to be a tremendous enabler of development by individual national groups, two-nation teams and, to a lesser extent, the full MSG-048 technical group. As BML approaches operational status, it may become necessary to give up this benefit, or employ different network infrastructures because of security requirements.

**Collaboration Software –** The power of the Internet extended far beyond providing communications for distributed operation. The participants in MSG-048 were spread across eight Nations and major parts of two continents. Information support for successful collaboration was facilitated by two software suites.

First and foremost, the open-source Trac/Subversion system provided a shared repository for documents, with integral version management, which could be updated by any team member using a free client and accessed by all, through ordinary web browsers. The Trac/Subversion repository was used asynchronously and greatly facilitated MSG-048 information sharing.

Beyond this, there is an important role for focused, synchronous discussion. MSG-048 held weekly teleconferences over the audiographic, open-source Network Education Ware (NEW) Internet teaching/conferencing system from the GMU C4I Center.

The resulting coordination and shared communication strongly supported collaborative, distributed development. It is an important lesson learned that this style of blended asynchronous-synchronous group communication should be a part of any distributed development activity.

### 5.1.7 System Engineering Support for Experimentation

The MSG-048 TA included an experimentation programme of significant complexity that required considerable preparation, organization and collaboration. Technical Activities that undertake experimentation of comparable or greater amplitudes should ensure system engineering support and put into place measures to facilitate integration and testing such as:

1) Commitment to design documents or technical agreements;
2) Component validation to optimize system integration of national systems; and
3) Dedicated system engineering support for tasks such as configuration management, coordination of integration/testing and schedule tracking.

## 5.2 OPERATIONAL LESSONS LEARNED

While MSG-048 was focused more on technical capabilities than on operational considerations, the 2009 effort included aspects intended to begin the process of evaluating the operational benefits of coalition BML. Data collection during the MSG-048 2009 experiment was based largely on qualitative measures such as observing the experiment and interviewing the military participants. A questionnaire was used to collect the opinion of the participants with respect to both the concept of BML and the capability provided for the experiment. The overall feedback from the military users, who were recruited, based on having limited exposure to BML, was that they very much supported the BML concept.

### 5.2.1 Operational SME Assessment of 2009 Experimentation

Due to the number of Subject-Matter Experts (SME) available, these results are based on a limited number of responses. Statistical analysis is therefore considered irrelevant. All operational participants strongly supported the BML concept after participating in the experimentation.

**Impact on Preparation and Execution of Military Operations –** All suggested applications of BML (training, mission rehearsal, and analysis of plans) were endorsed by the SMEs. Based on the their experience with the experimentation vignettes that were executed, the use of BML was considered least likely to improve conducting operations and to be most valuable for warfare preparation phases of training, planning and mission rehearsal.

**C-BML STANAG –** C-BML was considered a key element to improving interoperability in coalition forces, including NATO. Participants agreed that a NATO STANAG should be developed, however only after further experimentation, in order to establish a more mature C-BML.

**Need for Further Experimentation –** All SMEs agreed that the technical capability was not mature and lacked capabilities with respect to tasks, control measures, task coordination and reports. Further experimentation was suggested. The questionnaires indicated that the capability provided was not thoroughly exposed to the experiment participants. This reflected primarily the C2 and simulation interfaces, since the underlying C-BML was not seen by the users.

Further experimentation should include additional capabilities for coordinating tasks. This might involve both temporal coordination and using control measures. For Brigade operations there was a requirement to coordinate the operations of the two battalions. This was not possible with the BML capability used in the 2009 experiment. A complete experimental environment should include a staff and C2 system for the highest echelon involved, correctly interfaced to the maneuver elements. Lack of such a capability detracts from realism and credibility of the overall activity.

**Scenario Definition –** The scenario was considered sufficient and relevant but could be improved. Future experiments should include a wider spectrum of operations such as irregular warfare and stabilization operations. Future experiments also should support a wider range of combat functions (artillery, engineering, etc.).

One participant indicated that the scenario was too complex and that there were too many systems. The BML capability was hidden in that complexity. That participant recommended starting with a battalion level exercise. Another participant thought that the Brigade level was relevant but more battle functions such as logistics and artillery should be included in the simulations.

### 5.2.2 Obstacles and Barriers in Adopting BML

Obstacles to the success of BML that were identified fell into technical and cultural categories in addition to challenges in development of a standard.

**Cultural/National Differences –** Ideally, SMEs would use only national systems with which they are thoroughly familiar. The use by an SME of C2 systems from other Nations is difficult due to differences in doctrine, tactics and procedures. One example is that the Norwegian forces have integrated reconnaissance capability while French forces use a dedicated company. Such details must be considered when tasking the units.

Similarly, the use by SMEs of other Nations' simulation models is not optimal as there are differences in tactics and doctrines. For example, simulation models have differences in information requirements depending on the domain modelled, the echelon targeted, the degree of automation, complexity and probably also on national distinctions. For each participating simulation (model service interface), information requirements should be captured and briefed to SMEs. An example is that one of the simulations used requires a path consisting of exactly two points to perform reconnaissance or a support task.

The following table indicates the wide variety of order types (JC3IEDM action codes) issued by the different national C2 systems during the MSG-048 2009 Operational Experimentation.

**Table 5-1: Examples of Action Codes Used During MSG-048 Experimentation.**

| CAN (UAV) | FRA | NLD (OPFOR) | NOR | UK (AIR) | USA (RECCE) |
|---|---|---|---|---|---|
| TCARRC<br>CLARSP | DESTRY<br>FIX<br>PLAN<br>RECCE<br>SCOUT<br>SUPPRT | ANARWF<br>ATTRIT<br>COVER<br>HARASS<br>SUPPRS | ATTMN<br>FIX<br>SECURE<br>SEIZE | AIRDEF<br>ARCCTL<br>CLARSP | MOVE |

**Modelling and Simulation Challenges –** For modelling and simulation in support of planning and decision-making (course of action analysis) the results from Manassas indicated that the biggest challenge is the simulation and underlying models, not BML itself.

### 5.2.3 Conclusions

Despite these limitations, participants unanimously agreed that the BML technology has the potential to change the way coalition warfighting is conducted in a very positive way.

## 5.3 NATO MSG-079 C-BML WORKSHOP[1]

A key activity under the terms of reference of MSG-048 is that of education and dissemination of information relating to C-BML and the activities of the group itself. The MSG-079 C-BML Workshop was organised by a sub-committee from MSG-048 to help fulfil this requirement and was held at Farnborough in the UK in February 2010.

### 5.3.1 Overview

*The NATO Modelling and Simulation Group MSG-048 organized an unclassified workshop in Farnborough, United Kingdom, on 24 – 25 February 2010 on the subject of C-BML. An audience of approximately 60 participants attended the workshop with representatives from NATO, NATO/Partners-for-Peace (PfP) and other Nations. The audience was diversified and was composed of attendees from the military, government R&D laboratories and a significant representation form industry. A total of 25 presentations were provided during the two days, preceded by three keynote presentations.*

[1] This section is taken, in part, from reference [55]. Paraphrased or extracts are shown in italics.

*Participation included representation from 12 Nations including: Canada, Denmark, France, Germany, Great Britain, NATO NC3A and RTO, the Netherlands, Norway, Spain, Sweden, Turkey and the United States of America. Participation was divided evenly between government and industry (45%/45%) with 10% participants from academia.*

### 5.3.2 Presentations

The presentations were divided into eight sessions that covered the following areas.

| **Day 1 – Feb 24th 2010** | **Day 2 – Feb 25th 2010** |
|---|---|
| 1) BML Operational Requirements | 5) Perspectives on BML |
| 2) MSG-048 (C-BML) Overview | 6) C2-Simulation Interoperability |
| 3) BML in Theory and Practice | 7) JC3IEDM and BML |
| 4) BML Coalition Developments | 8) Other BML Research Activities |

The workshop programme and presentations are available on the NATO RTO site at:

http://www.rta.nato.int/meetings.aspx.

### 5.3.3 Workshop Summary

The following paragraphs are taken from the MSG-079 C-BML Workshop Technical Evaluation Report [55]:

*"The C-BML technology is gaining both attention and recognition from the military, in particular with the latest achievements of the MSG-048 group. As this group is completing its last round of activities, a conference on the theme of C-BML was highly anticipated in order to:*

1) *Measure the technical readiness level of the technology;*
2) *Provide a forum for discussion amongst the C-BML, Community of Practice (CoP) and to a larger extent in the Community of Interest (CoI); and*
3) *Present the latest developments in the C-BML arena. This report will provide a summary for each of the previously stated objectives, and make recommendations based on the current C-BML technology technical situation and observed trends for its development."*

*"This conference also provided a unique opportunity for a wide audience to present and discuss some key challenges facing C-BML development, and in some cases potential solutions. Also, of equal importance to the challenges are the limitations of the technology, whether they are based on technical basis, or as will be explained later in the report on cultural causes. It is of prime importance to understand these limitations in order to provide the adequate solutions, or to restrain the employment of the technology to a limited scope. This report will also provide a portrait of the current challenges and make recommendations for future actions, as applicable."*

The workshop received positive feedback from attendees. It provided an update to the C-BML community on the state-of-the-art of C-BML. It also served an educational role by giving up-to-date information on:

- Background of C-BML;

- Theoretical Description of C-BML;
- Practical Experience with C-BML; and
- Future Work with C-BML.

During the workshop, several discussions and exchanges took place among representatives from MIP, SISO, NATO, Industry, Government and the Operational Community.

The following recommendations are also extracted from the Technical Evaluation Report [55]:

1) MSG-085 should consider creating and organizing a C-BML Community of Interest (COI) as part of its programme of work.
2) The C-BML COI should investigate means to facilitate communication and collaboration between interested industry and government stakeholders.
3) The C-BML COI should also liaise with the industry and national partners to promote a common understanding of what C-BML is and the benefits of utilizing a C-BML approach.
4) The elaboration of an international standard for C-BML is a high priority and should be supported by the C-BML COI through active involvement in C-BML standardization activities.
5) Most if not all of the C-BML COI efforts should be directed toward the development of the SISO C-BML as the standard for C2-simulation and C2-robotic systems interoperability.
6) As part of the SISO C-BML standardization activity, measures should be taken to ensure coordination with the SISO MSDL Product Development Groups (PDG) is effective, with the intended objective to align both standards.
7) NATO should consider initiating a C-BML STANAG development activity in order to leverage and build upon the SISO C-BML standardization activity and to ensure the latter includes all of the relevant NATO requirements.
8) There needs to be an increased interaction with the operational community in the development of the SISO C-BML standard in concert with the MSG-085 Technical Activity, including coordination with the MIP and NC3A.
9) A significant portion of the C2 systems that exist in the various Nations are neither JC3IEDM, nor C2IEDM-based, therefore it is essential for the C-BML (future) standard to position itself independently from these two MIP standards.
10) On a technical note, it is recommended that C-BML specification be decoupled from the transport mechanisms, as a C-BML implementation could be used for different applications that may or may not require: web services, publish and subscribe or other communication schemes; asynchronous versus synchronous communications; high or low volume of data transfer; speed of transfer; etc.

## 5.4 SUMMARY OF LESSONS LEARNED

The MSG-048 Technical Activity included a three-year experimentation programme and an international Workshop on C-BML in collaboration with the NATO RTO (i.e. MSG-079). This Technical Activity has provided a set of valuable lessons learned described above. Much of this experience and insight has been shared with stakeholders and organizations such as SISO.

As the C-BML question moves from "if" to "how", it is time to seek closer ties and involvement with the operational community. The following chapter articulates a set of recommendations based primarily on the lessons learned and seeks to promote, amongst other things, to facilitate the communication and coordination among C-BML stakeholders.

# Chapter 6 – RECOMMENDATIONS

The recommendations presented in this chapter are based primarily on the lessons learned in defining, preparing and executing the three experimentation events that comprised the MSG-048 Experimentation Programme. Many of the lessons learned and related recommendations emerged from the work performed during the final 2009 experimentation, but others are the fruit of many analyses, discussions and exchanges among MSG-048 members.

Many of the recommendations described in this chapter form the basis for the Technical Activity Proposal (TAP) for MSG-085, the follow-on Technical Activity to MSG-048.

## 6.1 C-BML DEVELOPMENT AND EMPLOYMENT

This section deals with suggested guidelines and recommendations for the benefit of software developers, integration specialists and systems architects.

### 6.1.1 C-BML Extensions to Other Areas

It is recommended that C-BML be developed to support air (e.g. ATO/ACO) and joint air-land operations (e.g. close air support). Similarly, there should be investigations for extending C-BML to support maritime operations.

### 6.1.2 Grammar

A grammar is important to ensure an unambiguous C-BML. MSG-048 recommends continued development and experimentation with the C2LG in concert with C-BML.

### 6.1.3 C-BML-Enabled Systems Integration

Although not specified as part of a C-BML standard, there is a need for procedures and services for the initialization of systems and run-time coordination between systems employing C-BML. The use of MSDL (discussed below) should address some of the needs for initialization. Developing and testing these procedures and services should be an important task in the follow-up TA MSG-085.

## 6.2 COORDINATION WITH STANDARDS BODIES (SISO)

SISO has released a first version of MSDL as a standard for initializing simulations with military scenarios and is currently working toward the release of a C-BML standard. Recent progress with respect to the SISO C-BML drafting work indicates that these standards should be used as the basis for the MSG-085 experimentation programme and possibly become a STANAG.

### 6.2.1 SISO C-BML

Available open-source SISO C-BML-compliant reference implementations should be considered for use in the context of the MSG-085 experimentation programme.

### 6.2.2 SISO MSDL

SISO MSDL should be used and evaluated as a means for initialization of simulations in the context of the MSG-085 experimentation programme.

### 6.2.3 C-BML STANAG

After its first release as a standard, NATO should consider SISO C-BML and MSDL for adoption as a STANAG. However, this will require that the C-BML and MSDL standards be harmonized to provide complementary capabilities.

### 6.2.4 SISO

The NATO MSG has maintained a significant level of coordination with SISO through the participation of MSG-048 members in SISO PDG and DG activities. It is recommended that this coordination continue and possibly be strengthened through co-located workshops and/or meetings. SISO should also consider integrating C2LG as the basis for the C-BML grammar which is the object of phase 2 in a three-phase development plan.

## 6.3 COORDINATION WITH THE MIP

For C-BML to get accepted by the C2 community C-BML should be based on C2 standards such as the MIP-JC3IEDM. This brings upon the need for closer interaction between MIP and the C-BML community in order to ensure that C-BML is relevant for integration with C2 systems.

In order to ensure that standards activities such as SISO MSDL and C-BML and technical activities such as MSG-085, lead to a relevant, useful and coherent standard for C2-simulation interoperability, it is recommended that there be a closer involvement with the MIP organization. This should include fostering a closer collaboration within several sub-groups of the MIP.

### 6.3.1 MIP-C-BML Community Of Interest (COI)

In light of the above stated MIP-related areas, it is recommended that a dedicated MIP-C-BML COI be formed in order to ensure consistency in the approaches, to keep the MIP community informed concerning the progress of C-BML and to facilitate the transition of C-BML as it progresses toward operational deployment.

**MIP-DEM Roadmap –** Need to consult with the MIP concerning their plans to revamp and/or replace the MIP-DEM in order to consider how it will impact the use of the MIP-DEM as a candidate IEM for C-BML implementations.

**Validate Use of MIP-JC3IEDM –** Need to consult with the MIP concerning the proper use of the BML as it relates to the JC3IEDM data model and associated business rules.

**Explore Possible Closer Integration with MIP –** Explore the possibility of a closer integration with the MIP – e.g. C-BML becoming a possible sub-view or the use of the MIP-MDA approach to modelling. This should be done in concert with the appropriate standards bodies (i.e. SISO).

## 6.4 COORDINATION WITH THE OPERATIONAL COMMUNITY

The follow-on technical activity MSG-085, should establish a continuing involvement with the operational community in order to ensure the operational relevance of C-BML as it is used in the experimentation programme and toward the goal of bringing C-BML toward operational deployment. Given the high relevance of C-BML to training and the focus of NATO on training, this operational area should be among the first explored.

## 6.5 FURTHER EXPERIMENTATION – MSG-085

Coordination with the operational community should also include exploring C-BML deployment scenarios that leverage existing C2 system infrastructures. As specified in the TAP for MSG-085, the follow-on Technical Activity to MSG-048:

> *"... should investigate approaches for the deployment of C-BML capabilities with existing operational C2IS exchange mechanisms; this will be tailored to specific application domains in order to extend C2IS linkages to synthetic environment ..."*

The lessons learned from the experiments conducted by MSG-048 indicated that there is a need for further experimentation on the operational use of C-BML in order to develop a mature capability.

As mentioned above, this experimentation should employ available open-source C-BML implementations, including SISO C-BML reference implementations. Furthermore, it should provide guidance to the community as to how C-BML capabilities may be successfully utilized within their programmes.

## 6.6 IMPROVING THE ROBUSTNESS OF EXPERIMENTAL C-BML SYSTEMS

As described in Section 4.3.4, the technical capability achieved at the end of MSG-048 was tenuous in certain areas. Before future serious operational experimentation can proceed, a consistent and sufficient technical readiness level and an acceptable level of performance in all components of supporting infrastructure and the BML extensions of the national systems should be ensured for the full range of BML capabilities.

## 6.7 PROMOTING THE USE OF C-BML

As an integral part of the follow-on activity, there should be an educational component that serves to inform the community as to the state-of-the-art of C-BML.

**Organization of C-BML Workshops –** In February 2010, MSG-048 organized a workshop on C-BML within the NATO MSG organization of the RTO. MSG-079 allowed for representatives from industry, from the research community, from the standards bodies and from the operational community to exchange ideas, experience and requirements related to future use of C-BML. It is recommended that similar workshops be organized on a regular basis by the NATO RTO to continue similar exchanges and promote the use of C-BML.

The MSG-079 represented a significant step toward fostering a better understanding of C-BML – in terms of its potential benefits as discussed in Chapter 2 and also its relationship to other related activities, such as the MIP-JC3IEDM, as discussed in Annex B. As C-BML continues to evolve, it will be important to continue this education process in order to clarify other areas; such as the need for ontologies.

# Chapter 7 – SUMMARY AND CONCLUSIONS

This chapter offers some conclusions and introduces the follow-on MSG Technical Activity to MSG-048: MSG-085 [59].

The MSG-048 Technical Activity (TA) has conducted a series of experiments from 2006 to 2009 that has led to the conclusion that Coalition BML (C-BML) holds promise for enabling C2-simulation interoperability. The Simulation Interoperability Standardization Organization (SISO) C-BML Product Development Group (PDG) is chartered to elaborate the C-BML specification and MSG-048 has provided inputs to improve and extend the existing draft specification based on a reference implementation and coalition experimentation.

Where MSG-048 was confined to the assessment of the SISO C-BML technical specifications, the new TA will address the technical readiness of existing technologies along with the emerging need for future C2-simulation interoperation – as expressed by military organizations. The new TA will pursue ongoing work to propose relevant recommendations concerning the use of C-BML with respect to current military processes. More specifically, it will investigate approaches for the deployment of C-BML capabilities with existing operational C2IS exchange mechanisms; this will be tailored to specific application domains in order to extend C2IS connectivity to the synthetic environment.

The MSG-048 Technical Activity has contributed to confirming the feasibility and the usefulness of a BML approach for the exchange of military information in support of coalition information exchange requirements. It also has confirmed the need for a specification to standardize this information exchange in line with the forthcoming SISO C-BML specification and has provided guidance and recommendations concerning the requirements for such a specification.

However, although the elaboration of a specification for C-BML is a necessary element toward the operational employment of C-BML, it is not sufficient; there is also a need to define a coherent process by which C-BML-enabled solutions will be deployed and utilized by the coalition.

Ensuring the coherence of a C-BML-enabled approach, from both procedural and technical perspectives, among the Nations, with the MIP and in particular, with the operational community will be addressed by MSG-085 Technical Activity.

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# Annex A – EVOLUTION OF BML

BML began in work sponsored by the US Army's Simulation-to-C4I Interoperability Overarching Integrated Product Team (SIMCI OIPT). Carey et al. [5] describe the overall process used to show the feasibility of defining an unambiguous language, based on manuals capturing the doctrine of the US Army. This first BML project started by analyzing more than 70 doctrinal manuals related to tasking and reporting, beginning with general manuals, such as the Field Manual 3.0 on Operations and the US Joint Staff's Universal Joint Task List. The review included field manuals of Army elements such as Field Artillery, Air Defense Artillery, Engineers, Military Police, down to the platoon level. This work resulted in definition of an unambiguous Operational Order (OPORD) using the traditional "5 Ws" (who-what-when-where-why) to describe military tasks [1], including a prototype for battalion operations orders, in 2003.

Under sponsorship of the US Defense Modeling and Simulation Office (DMSO) and the US Joint Forces Command (JFCOM), the Extensible BML (XBML) project was chartered to build on the US Army's initial work, with two main objectives:

1) Using Service Oriented Architecture (SOA) technology for information exchange among the systems' interfaces; and
2) Using the MIP's Command and Control Information Exchange Data Model (C2IEDM, an earlier version of the JC3IEDM) as a basis to represent the information to be exchanged between the systems.

JFCOM was particularly interested in the XBML project's potential to increase interoperability between C2 systems and simulations of the US military Services. The Air Operations BML (AOBML) effort was supported by JFCOM J7 to evaluate whether the concepts of BML are applicable to air forces as well as ground forces, using Theater Battle Management Control System (TBMCS) and Air Warfare Simulation (AWSIM) systems with positive results [6]. XBML also became the basis for an international experiment, driven by interest of the Exploratory Team formulating the proposal that led to MSG-048 [7].

Expanded interest in applying BML to the Joint environment led to JBML, which expanded BML into a combination of the ground, air and maritime domains and urban warfare and was successfully demonstrated in May 2007. JBML achieved considerable technical progress by creating a revised Web service schema, based on lexical grammar and designed to facilitate expansion into other military realms, which was implemented in the open source JBML Web Services as described below [3][4]. In parallel with JBML, the US Army Topographic Engineering Center (TEC) has been developing a geospatial BML (geoBML) which will bring a wealth of geospatial data to the C2-M&S environment [8]. The JBML schema was based on the Command and Control Lexical Grammar (C2LG) [11][12]. To ensure that the orders can be processed automatically, C2LG defines how orders are to be expressed in a BML that is a formal and unambiguous language.

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 arising from significant differences among doctrine and human language barriers; thus the agility to train and rehearse rapidly before the actual operation is highly important [9]. The NATO Modelling and Simulation Group (MSG), in recognition of this need, chartered Technical Activity MSG-048 to explore the promise of BML in coalitions combined with SOA technologies [10]. During the same time period the SISO C-BML standards process began [13].

Successive MSG-048 activities in 2008 and 2009 advanced the state of knowledge of BML considerably. The MSG-048 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 [15].

The 2009 effort improved over previous work by expanding the number of systems interoperating and undertaking experimentation using the C-BML system of systems. In order to do this, it expanded the Service Oriented Architecture (SOA) communication pattern to include publish/subscribe, so that the various C2 systems could subscribe to Reports of interest and the simulation systems could subscribe to Orders of interest, avoid the need to poll the BML Web service for updates and thus increasing both computational and communications efficiency. Systems from Canada (BattleView and UAV-SIM), France (SICF and APLET), Netherlands (ISIS and Pollux), Norway (NORTaC-C2IS), Spain (SIMBAD), UK (ICC and the US-produced JSAF), and the USA (ABCS and OneSAF) participated in these. The BML Web Service used to support these was the Scripted BML Web Service, an innovative approach developed by the GMU C4I Center and supported by the US Army Simulation – C4I Interoperability (SIMCI) program, designed for rapid service evolution in a prototyping environment [14]. The C2LG GUI [11] order interface middleware from Germany also played a supporting role.

# Annex B – RELATIONSHIP BETWEEN C-BML AND MIP

In this section, the relationship between C-BML and the MIP is discussed. First, an overview of the MIP is (Section B.1), followed by a summary of the key MIP-specific capabilities (Section B.2). Then an overview of C-BML is provided (Section B.3) as well as key C-BML capabilities (Section B.4). On that basis, the similarities (Section B.5) and differences (Section B.6) between the C-BML and MIP approaches are considered. A conclusion of this comparison is given in Section B.7.

## B.1 THE MULTI-LATERAL INTEROPERABILITY PROGRAMME (MIP)

The Multi-lateral Interoperability Programme (MIP) is intended to define an interoperability protocol for Command and Control (C2) systems between a large number of Nations, comprised mostly of NATO countries. The most important product to come from MIP is the Joint Consultation Command and Control Information Exchange Data Model (JC3IEDM).

The JC3IEDM has been adopted by NATO as STANAG 5525 and most NATO member countries are dedicating considerable resources to ensure that their C2 systems are compatible with the JC3IEDM. The JC3IEDM has its roots in ground-based C2 requirements and has gradually expanded it into other Joint functional areas. The MIP has also produced the Data Exchange Mechanism (DEM) which is an automatic data-push mechanism.

## B.2 MIP-SPECIFIC CAPABILITIES

**Compatibility with a Broad Spectrum of C2 Systems –** The driving force for MIP is the ability to interface C2 systems from different Nations. Some of the C2 systems may have specific mandatory requirements that in turn become a mandatory requirement for MIP. These requirements may include the need for accurate timing, for example.

**Need for Complete Expressions –** C2 systems often offer the ability to convey information in plain language (e.g. Commander's intent, assessment, etc.) and this information has significant value in terms of interpretation and decision-making. The MIP protocol must not impede the ability to amplify information in a language intended to be interpreted by humans. The JC3IEDM Plan-Order structure is such an example effectively reproducing the five-paragraph OPORD, however the human-readable portion is likely difficult or nearly impossible to accurately interpret by a computer-based system.

**Field Usability –** C2 systems are designed to operate in the harshest environments and under conditions that are not always favourable for good communications. The MIP protocol may also be limited in bandwidth by field grade communication systems. The MIP protocol has the additional requirement that it must remain usable even when subject to such unreliable and unfavourable conditions.

## B.3 COALITION BATTLE MANAGEMENT LANGUAGE (C-BML)

C-BML has its source in the modelling and simulation domain and although the concept is far from new, the term BML has only been in existence for about nine years. In the context of joint, combined and coalition operations, C-BML is being developed to define standardized representations, consistent with C2 and simulation system requirements and based on an operations-centric common reference model (e.g. JC3IEDM). It defines a digitized form of C2 information such as orders, plans, reports, and requests such that they can easily be represented to military personnel through C2IS and simulation interfaces and processed by simulated or robotic forces.

## B.4 C-BML-SPECIFIC CAPABILITIES

**Compatibility to Simulation Systems –** A driving force for C-BML has been the need to provide a seamless interface between simulation systems and C2 systems. As such, the compatibility to both C2 and simulation systems is crucial. C-BML expressions must be made in a language that can express all relevant actions performed by both C2 and constructive simulations. These expressions have a one to one relationship with simulated behaviour and new behaviour may be developed, as required.

**Ability to Work Faster than Real Time –** In the case of course of action analysis it is usually preferable to run the simulation at rates that exceed real-time. The C-BML language infrastructure must not only support high data rates, it must also be designed such that the language is effectively independent from the real-time. This may not be desirable in real-time C2 to C2 interfaces.

**Unambiguous Expressions –** The use of unambiguous expressions is a mandatory criterion for C-BML when interfacing a C2 system with a simulation. In the case of the simulation, the messages are being interpreted by a computer that is not capable of comprehension of free text information.

**Semantic Interoperability –** Exchanging computer-parseable, unambiguous expressions is a pre-requisite for *semantic interoperability* or the ability of a C-BML-consumer to properly interpret the C-BML expressions in the way it was intended to be interpreted when constructed and sent by the C-BML-producer. Ensuring correct interpretation and exchange of *meaning* requires a shared knowledge often represented in the form of ontology. The SISO C-BML Product Development Group has defined the development of C-BML ontology as part of their product development plan.

## B.5 SIMILARITIES BETWEEN MIP AND C-BML

Both MIP and C-BML share common characteristics as follows:

**Scope and Compatibility –** Both MIP and BML are intended to provide a means to ensure C2 information compatibility between systems.

**Doctrinal Relevance –** Both C-BML and MIP support the current military doctrine.

**Need for Acceptance –** Just as for any standards, MIP and C-BML need wide spread acceptance in order to have any value.

## B.6 DISTINCTION BETWEEN MIP AND C-BML

**Scope –** MIP is intended to provide interoperability among C2 systems of different Nations. C-BML is intended to provide focused Joint C2 (Plans, Orders, Reports, and Requests) interoperability among C2 systems and simulated forces, as well as automated/robotic systems. From a linguistic point of view, the information exchange in the MIP is assertive (descriptive) whereas in C-BML only the report exchange is assertive, but order (and request) exchange in BML is directive (i.e. intended to initiate an action).

**Structure –** MIP is focused on JC3IEDM to JC3IEDM interoperability. C-BML could use any Data Model that contains the required information and could provide for interoperability between data models. C-BML is layered on top of a data model (e.g. JC3IEDM) as an application that provides the structure and content of the language.

**Unambiguity –** There must be no ambiguity in information exchange related to the exchange of BML expressions. MIP allows for exchanges containing free text that could include ambiguous statements.

**Communications –** Currently, MIP uses the DEM for communications to transport JC3IEDM information between systems. Most current C-BML implementations use a standard form of a Web Service. However, neither the JC3IEDM nor the C-BML applications are forced to use any particular information exchange mechanism.

## B.7 CONCLUSION

It is clear that both MIP and C-BML both are required. It is evident that there must be synergy and close collaboration between the two programs that will lead to a coherent set of standards. Ongoing efforts have identified this need for collaboration and plans are in place to ensure that there is bilateral representation both at MIP and in MSG-085 to enable this integration/convergence.

# Annex C – BML EXAMPLES

The following BML expression examples are based on actual messages exchanged during the MSG-048 final experimentation programme. They were constructed based on a small set of BML types to support basic tasking and reporting based on a simplified version of the IBML schema – successor to the JBML work [7][12][37] inspired by the precursory work done with C2LG [11][12].

## C.1 CANADIAN FORCES UAV FRAGO


```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<OrderPush>
  <OrderPush>
    <Task>
      <AirTask>
        <TaskeeWho>
          <UnitID>CA-UAV</UnitID>
        </TaskeeWho>
        <What>
          <WhatCode>CLARSP</WhatCode>
        </What>
        <Where>
          <WhereID>14010000784100000427</WhereID>
          <AtWhere>
            <JBMLAtWhere>
              <WhereLabel>OMF195-B12</WhereLabel>
             <WhereCategory>
                 GENCOORDINATE
              </WhereCategory>
             <WhereClass>PT</WhereClass>
             <WhereValue>
                   <WhereLocation>
                     <GDC>
                          <Latitude>40.062195</Latitude>
                          <Longitude>47.57694</Longitude>
                          <ElevationAGL>3000.0</ElevationAGL>
                     </GDC>
                    </WhereLocation>
             </WhereValue>
             <WhereQualifier>AT</WhereQualifier>
            </JBMLAtWhere>
         </AtWhere>
       </Where>
       <StartWhen>
          <WhenTime>
            <StartTimeQualifier>AT</StartTimeQualifier>
            <DateTime>20091022141229.359</DateTime>
          </WhenTime>
        </StartWhen>
        <AffectedWho>  <UnitID>OMF195-B12</UnitID>    </AffectedWho>
        <TaskID>14099999000000000019</TaskID>
      </AirTask>
    </Task>
 <OrderIssuedWhen>20091022141443.000</OrderIssuedWhen>
 <OrderID>14099999000000000030</OrderID>
   <TaskerWho>        <UnitID>1-HBCT</UnitID>     </TaskerWho>
    <TaskOrganization>    <UnitID>1-HBCT</UnitID>
      <TaskOrganization>    <UnitID>CA-UAV</UnitID>       </TaskOrganization>
    </TaskOrganization>
  </OrderPush>
</OrderPush>
```

# C.2 NORWEGIAN FORCES 22ND BATTALION ORDER (EXTRACT)


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<OrderPush xmlns="http://netlab.gmu.edu/IBML">
  <OrderPush>
    <TaskersIntent>Kill the enemy</TaskersIntent>
    <Task>
      <GroundTask>
        <TaskeeWho>             <UnitID>1-221</UnitID>
        </TaskeeWho>
        <What>
          <WhatCode>ATTMN</WhatCode>
        </What>
        <Where>
          <WhereID>ROUTE_ALONG_AXIS_CORVETTE</WhereID>
          <AtWhere>
            <JBMLAtWhere>
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              <WhereCategory>ROUTE</WhereCategory>
              <WhereClass>LN</WhereClass>
              <WhereValue>
                <WhereLocation Sequence="0">
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                    <Longitude>47.136887</Longitude>
                    <ElevationAGL>0.0</ElevationAGL>
                  </GDC>
                </WhereLocation>
                <WhereLocation Sequence="1"> ... </WhereLocation>
                  <WhereLocation Sequence="2">... </WhereLocation>
                  <WhereLocation Sequence="3">... </WhereLocation>
                  ...
                </WhereValue>
              <WhereQualifier>ALONG</WhereQualifier>
            </JBMLAtWhere>
          </AtWhere>
        </Where>
        <StartWhen>
          <WhenTime>
            <StartTimeQualifier>AT</StartTimeQualifier>
            <DateTime>20091013131909.000</DateTime>
          </WhenTime>
        </StartWhen>
        <TaskControlMeasures>
          <ControlMeasureLabel>Bde_boundary_north</ControlMeasureLabel>
          <ControlMeasureLabel>Bde_boundary_south</ControlMeasureLabel>
        </TaskControlMeasures>
        <TaskID>20912ATTACK_ALONG_CORVETTE_1</TaskID>
      </GroundTask>
    </Task>
    <OrderIssuedWhen>20090916090025.000</OrderIssuedWhen>
    <OrderID>20911NOR_COA_001</OrderID>
    <TaskerWho>
      <UnitID>1-22</UnitID>
    </TaskerWho>
    .
    .
    .
    .
```


*(Norwegian 1-22 Batallion Order continued)*

.
.
.
.

```
<ControlMeasures>
      <ControlMeasure>
              <WhereID>Bde_boundary_north</WhereID>
              <AtWhere>
                 <JBMLAtWhere>
                    <WhereLabel>Bde_boundary_north</WhereLabel>
                    <WhereCategory>BOUNDARYLINE</WhereCategory>
                    <WhereClass>LN</WhereClass>
                    <WhereValue>
                       <WhereLocation Sequence="0">
                          <GDC>
                             <Latitude>40.6297</Latitude>
                             <Longitude>47.0288</Longitude>
                             <ElevationAGL>0.0</ElevationAGL>
                          </GDC>
                       </WhereLocation>
                       <WhereLocation Sequence="1">
                                        ...
                       </WhereLocation>
                      </WhereValue>
                    <WhereQualifier>AT</WhereQualifier>
                 </JBMLAtWhere>
              </AtWhere>
           </ControlMeasure>
           <ControlMeasure>
              <WhereID>PL_AUSTIN</WhereID>
              ...
           </ControlMeasure>
        </ControlMeasures>
     </OrderPush>
</OrderPush>
```


## C.3 FRENCH FORCES 66TH BATTALION REPORT (EXTRACT)


```
<?xml version="1.0" encoding="UTF-8"?>
<BMLReport>
   <Report>
      <CategoryOfReport/>
      <TypeOfReport/>
      <StatusReport>
         <GeneralStatusReport>
            <ReporterWho>
               <UnitID>FRA-6611</UnitID>
            </ReporterWho>
            <Context>MyContext</Context>
            <Hostility>FR</Hostility>
            <Executer>
               <Taskee>
                  <UnitID>FRA-6611</UnitID>
               </Taskee>
            </Executer>
            <OpStatus>OPR</OpStatus>
            <WhereLocation>
               <GDC>
                  <Latitude>40.600643157959</Latitude>
                  <Longitude>46.8854713439941</Longitude>
               </GDC>
            </WhereLocation>
            <When>20090814030514.977</When>
            <ReportID>7</ReportID>
            <Credibility>
               <Source>AOBSR</Source>
               <Reliability>A</Reliability>
               <Certainty>RPTFCT</Certainty>
```

</Credibility>
</GeneralStatusReport>
</StatusReport>
</Report>
</BMLReport>

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This technical report describes the results and conclusions of the NATO Modelling and Simulation Group MSG-048: Coalition Battle Management Language (C-BML). C-BML is a standard for an unambiguous language that can communicate military information among command and control systems, simulation systems and autonomous systems and support a great number of military enterprise activities. The work described in this report deals primarily with the assessment of preliminary versions of the C-BML standard and initial prototype implementations of C-BML communications software to support military activities such as training and mission planning.

This report provides a set of requirements for C-BML that have been developed during the execution of the MSG-048 Experimentation Programme. The experiments comprising the experimentation programme provided many lessons learned that form a major part of this document. Finally, this report provides recommendations concerning the future use of C-BML, including the coordination with other standardization bodies.

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