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).

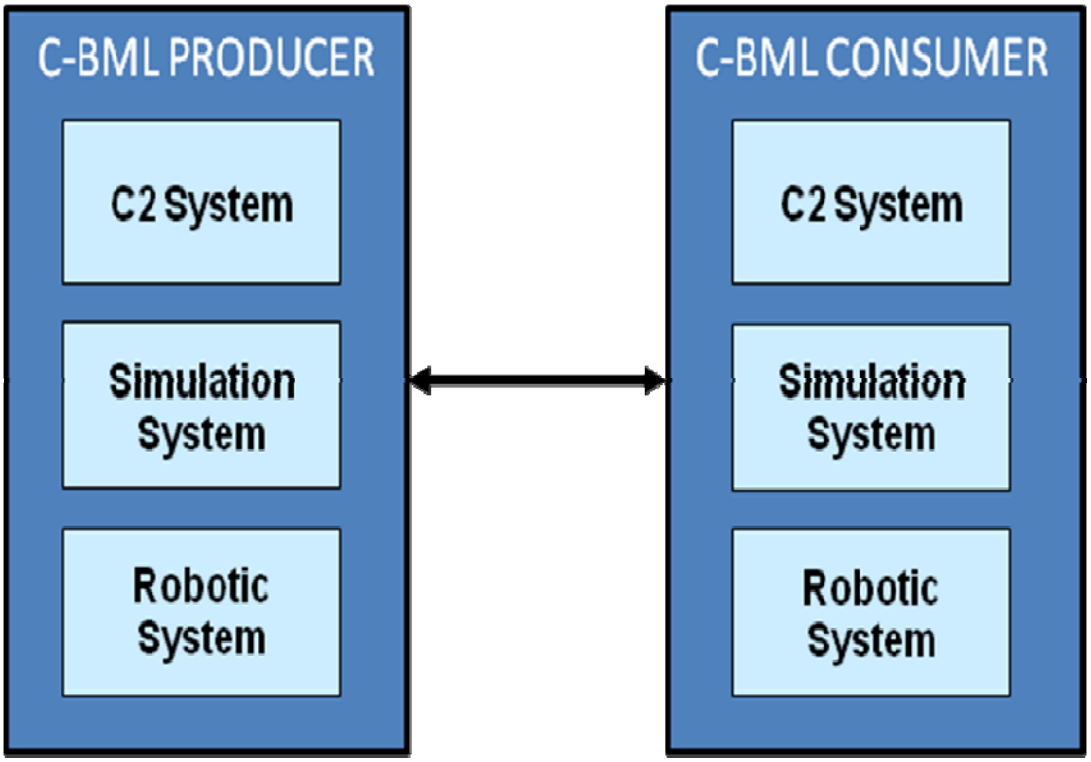

Figure 2-1: C-BML Producers/Consumers [58].

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.

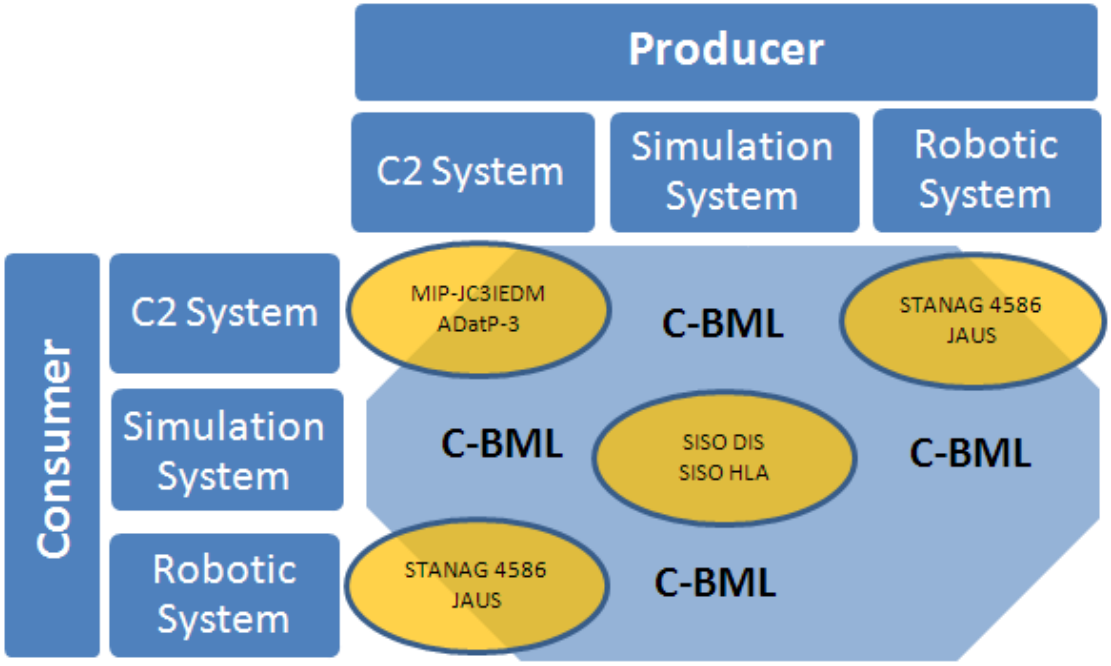

Figure 2-2: C-BML Producer/Consumer Matrix [58].

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.

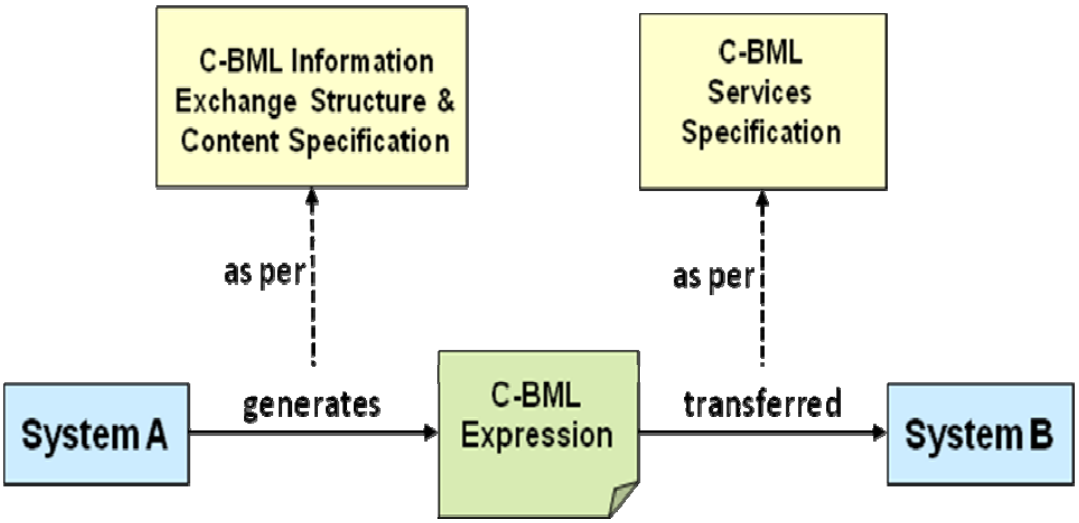

Figure 2-3: SISO C-BML Specification Overview [57].

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.

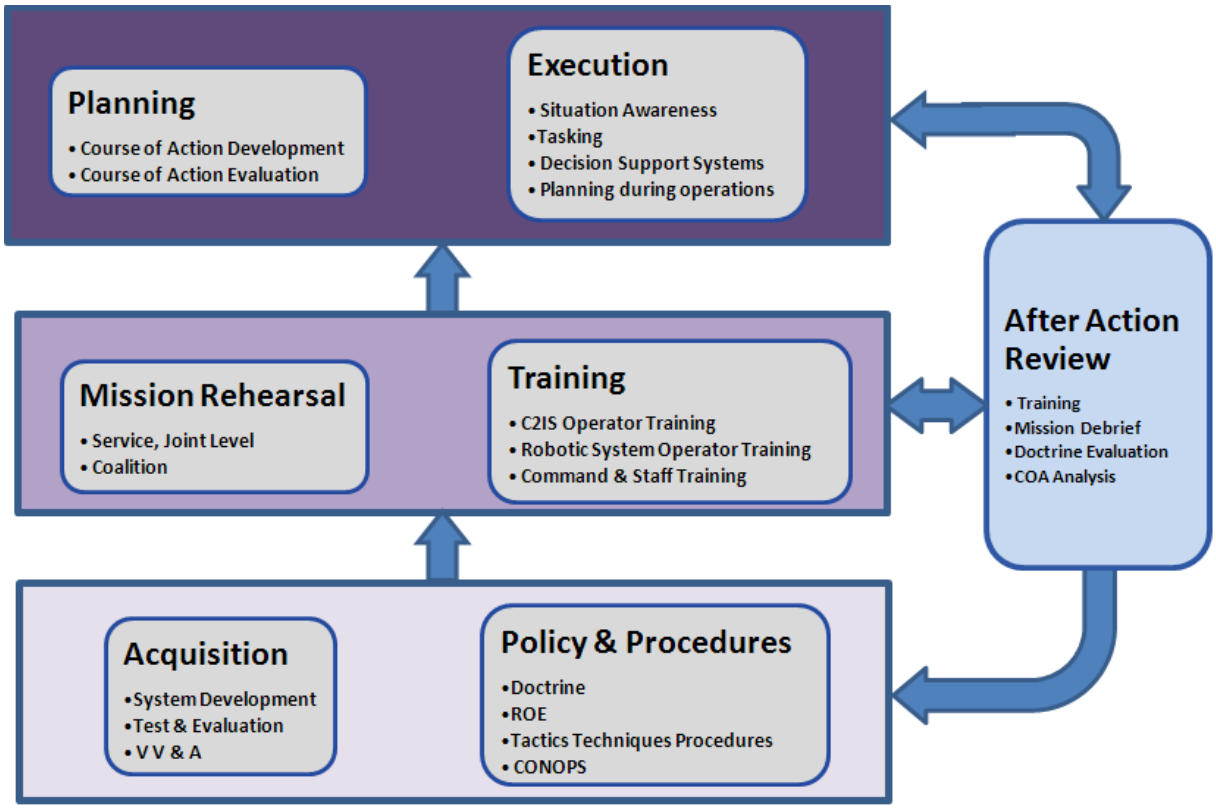

Figure 2-5: C2IS Product Life-Cycle and Work-Flows [58].

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.