C2SIM Lessons learned and near future plans

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ABSTRACT

Significant progress has been made in advancing standardisation of C2SIM interoperation providing a capability that can improve decision-making and training in coalition military operations. Starting with a concept, the community involved in C-BML/MSDL, both in NATO and SISO, has achieved continued progress toward the goal that, in the not too distant future, military coalitions will be able to come together and benefit from interoperating C2 and simulation systems across all participating nations.

1.0 NATO C2SIM TECHNICAL ACTIVITIES LESSONS LEARNED

1.1 Past NATO activities

1.1.1 MSG-048

The NATO Modelling & Simulation Group (NMSG) conducted a Technical Activity (TA) called "Coalition BML" (C-BML) - MSG-048 - from 2006 to 2009. The Technical Activity Proposal (TAP) expressed the following need:

> *"An open framework is needed to establish coherence between Command & Control (C2) and Modelling & Simulation (M&S) type systems in order to provide automatic and rapid unambiguous initialisation and control of one by the other. To accomplish this, C2 and M&S 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 M&S 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[1] or Nations..."*

The activity involved an assessment of the concept of C-BML. The assessment focused on evaluating C-BML as an enabler to increased effectiveness of various activities in support of coalition operations - including training, planning and mission execution. It was mainly comprised of experimentation in a

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[1] SISO: Simulation InteroperabilityStandard Organization

coalition context and focused on sharing of digitized military information among coalition member C2[2] and simulation systems.

A 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.

In addition, MSG-048 organized a workshop (MSG-079) dedicated to C-BML that took place in Farnborough UK from February 24-25th 2010.

The MSG-048 included participation from Canada, Denmark, France, Germany, Great Britain, NC3A, the Netherlands, Norway, Spain, Turkey and the United States.

1.1.2 MSG-085

The NATO Modelling & Simulation Group (NMSG) conducted a Technical Activity (TA) called "Standardization for C2-Simulation interoperation" - MSG-085 - from 2010 to 2014. The Mission Statement was as follows:

> *"Assess the operational relevance of Coalition Battle Management Language (C-BML) while contributing to C2SIM standardization and assist in increasing the Technical Readiness Level of C-BML technology to a level consistent with operational employment by stakeholders."*

If the proof of feasibility of a C-BML-enabled approach was demonstrated by MSG-048, the MSG-085 TA has demonstrated the proof of concept of C2SIM in establishing a clearer scope and refining set of operational and technical requirements for C2SIM interoperability.

During the TA execution, it has become evident that C-BML alone was not sufficient to meet the requirements for C2SIM interoperation, but rather should be utilized in concert with other standards to cover other aspects of C2SIM federation definition, design, development and execution. Therefore, MSDL[3] was identified as a key enabling technology for C2SIM interoperation.

Common Interest Groups (CIG) were formed to explore specific themes or topics and to focus efforts on specific military domain enterprise activities where C2SIM interoperability issues needed to be addressed for the following focus areas:

- Autonomous Air Operations
- Land Operations
- Maritime Operations
- Joint Mission Planning
- Technical MSDL/C-BML Messaging Infrastructure
- Requirements Recommendations & Specifications (2RS)

One of the main goals of the 2RS CIG was to provide a comprehensive set of Requirements and Recommendations (2R) to the standardization bodies while proposing a concrete means to produce the required Specifications (S) – or 2RS. This activity focused on the definition of a proposed standard

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[2] C2: Command Control

[3] MSDL: Military Scenario Definition Language

development process based on systems engineering principles. It has established a draft C2SIM DSEEP[4] overlay for the development of federations comprised of simulation and C2 systems.

A final experimentation, conducted in December 2013 at the Mission Command Battle Laboratory (MCBL) at Fort Leavenworth, Kansas, has demonstrated the values of C2SIM for coalition planning and featured six national non-US C2 systems and five national simulations.

In addition, MSG-085 organized a workshop (MSG-119) dedicated to C2-Simulation interoperability that took place in Orlando USA December 5th 2012.

The MSG-085 included participation from Belgium, Canada, Denmark, France, Germany, Great Britain, NC3A, the Netherlands, Norway, Spain, Sweden, Turkey and the United States.

1.2 Lessons learned

1.2.1 Variability of C2SIM Interoperation Requirements

C2SIM Interoperation requirements vary across services, nations and also depend on the themes and focus areas of specific training, mission rehearsal or experimentation events.

Inherent differences in the manner in which military operations are conducted by different forces must be taken into account in the development of C2SIM interoperability standards. It is critical to track stakeholder requirements as part of the standardisation process via a C2SIM Interoperability Standardisation and Extension Process.

Furthermore, various organisations have different goals and roadmaps concerning their expectations concerning the Return on Investment (ROI) of employing C2SIM interoperability technologies. For example, for some stakeholders, the desired goal may be to reduce the number of simulator operators required to hold a specific training event. This is an example of a cost-reduction measure for a sustaining capability. Other stakeholders are focused on future capability development that ultimately implies a changing how military operations are conducted. For example enhanced automated information exchange as an enabler for self-synchronisation of the battlefield is an example of a disruptive technology for a future capability.

As different communities and nations work toward establishing common data interoperability standards, it is essential that differences in requirements and expectations among stakeholders are properly recorded and managed such that an appropriate C2SIM interoperability standard roadmap that is suitable to all parties can be constructed.

1.2.2 Combined Standard Scenario Definition, Initialisation and Execution

Military enterprise activities such as Command Post training generally require scenario definition, scenario initialisation and scenario execution.

The SISO MSDL and C-BML standards can be made to function together but new, harmonised versions are required for most effective C2SIM interoperation.

In addition, maintaining separate standards for scenario definition (i.e. MSDL) and for scenario execution (i.e. C-BML) leads to significant time being spent in defining and evolving these standards and also in applying these standards to systems. These standards should be merged in order to form a coherent, unified standard for Military Scenario Initialisation and Execution.

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[4] DSEEP: Distributed Simulation Engineering and Execution Process

The MSDL and C-BML standards are sufficient for basic operations of manoeuvre warfare, but insufficient to meet the broader need of other military operations and support functions. Creating a single massive schema leads to impractical complexity. Thus, an approach that standardises a core data model and methods for extending that model to needs of a specific instance is the clear path forward.

1.2.3   Manage Standard Products

Utilise a standardised approach and process to develop and maintain a logical data model and to generate derived products such as XML schemas.

C2SIM interoperability often is achieved through the sharing of XML schema that define the structure and content of the information to be shared. Therefore it is tempting to standardize sets of XML schema. However, for all but the simplest of data models, this has proven to be problematic since it rapidly becomes difficult to evolve schemas to satisfy new requirements.

Using a Model-Driven Architecture (MDA) approach, it then becomes possible to generate derived products such as XML schemas. Furthermore, this approach allows for the parallel production of other equivalent derived products such as HLA-FOM modules. Beyond the advantage of saving time and ensuring a coherent set of derived standard products, this approach also avoids human-error that may occur when manually modifying XML schema.

Toward the goal of employing a MDA based on an extensible core logical data model, it becomes important to define a process by which stakeholder requirements can be collected, managed and effectively traced to the derived standard products. The process should include important steps such as verification of requirements and also validation of the derived products. Standardising the process will facilitate the extension process such that communities can define and build community specific extensions in the same way.

1.2.4   C2SIM Infrastructure

There is a need to be able to work simultaneously with various versions of C2SIM interoperation standards.

Dealing with multiple versions of the BML specification is a practical necessity. This is because the schema of choice for each participating C2 and simulation system was selected and implemented, at the time that system first joined a coalition environment; while some updates to interfaces of individual systems may occur, the national proponents generally are not willing to invest resources in each major schema revision. The discrepancy among schema formats can be dealt with by a translating server, which parses order/request/report XML input and converts it to a common internal data model, then produces equivalent XML documents under the schemas used by other participating systems. This approach is applicable wherever the semantics of the schemata are aligned, regardless of the syntax employed.

1.2.5   Process for Building C2SIM Federations

Advanced interoperability within a coalition of C2 and simulation systems needs simulation-based process standards to develop reference architecture like DSEEP

Data exchange agreements are necessary to ensure understanding of even simple C-BML based orders such as movement orders that could potentially include movement routing information constructed from a variety of waypoint-based, referencing based, or start and end-point based data elements. To this end, existing simulation-based process standards such as the Distributed System Engineering and Execution Process (DSEEP) and associated federation agreement activities should be included as part of any standards-based

interoperability approach.

In addition, various C2SIM infrastructures exist (like FKIE C-BML server, SBML GMU server, CBMS VMASC server) and a member application usually functions with only one specific infrastructure. It is likely that federation design will lead to the use of several C2SIM infrastructures. To facilitate this integration, reference architecture should be defined or standardized

1.2.6   Communication infrastructure

Made use of "smart" technologies to lower reporting rates

High reporting rates was measured during the execution of scenario experimentation events. The generalized situation of information overload is mainly due to a higher level of automation and increased digitization of military information. It created load on BML infrastructure (e.g. Server), contributed to information overload of C-BML clients & infrastructure and led to information bottlenecks. High throughput rates must be assumed and the judicious use of Publish & Subscribe mechanism had greatly improved information flow. Also, the development of interest management mechanisms (e.g. more "smart-push") and work on automated information processing technologies (e.g. Intelligent agents, Intelligent Adaptive Interfaces) are options to solve the overload issue.

Define a core of services

Definition of communication infrastructure services needs to be standardized (mandatory or optional services) in order to address requirements that are important for an operational use of the C2SIM federation like:

- Late joining federates
- Save and restore points
- Information assurance of C-BML expressions
- Error handling
- Acknowledgement
- Transaction success
- Record & Playback

Manage time consistency across C2SIM Federation

What distinguishes simulation systems from most other type of systems is the ability to and necessity to manipulate time. Usually, C2 systems are locked to the current real-world time, whereas simulations manipulate time as a variable. And this may results in some unprocessed messages or errors inside the C2 system during the federation execution. For example during CIG Land Operation experimentation, the French SIR system popped up a dialog warning the operator that a message hasn't been processed because of a DTG (Date Time Group) in the future.

For the long time-frame, time management services should be defined and standardised in a Reference C2SIM federation, and implemented by infrastructures, C2 and simulations systems.

1.3   C2SIM capabilities of current national C2 and simulation systems

MSG-085 TA participating Nations, to contribute during a series of experimentation events, have improved their C2 and/or simulation systems.

The table 1-1 below summarizes for each system theirs capabilities and the implemented schemas.

Table 1-1: Current National C2 and simulation systems C2SIM capabilities

System	Description and capabilities
C2 Systems (operational or surrogate)	
SIR (FRA)	Operational C2 system at Battalion and Company level Schemas supported: IBML 2.22c and MSDL V1++ Capabilities: • Export / import MSDL (aggregated units) • Send Warno, Order, Frago • Receive and send situation reports (BFT) • Receive intelligence report (about aggregated units) • Receive equipments / resources reports • Receive personnel reports • Send call for fire, receive fire accepted / rejected, send start Firing / Suspend firing, receive firing reports
SICF (FRA)	Operational C2 system at Brigade level Schemas supported: IBML 2.22c and MSDL V1++ Capabilities: • Export / import MSDL (aggregated units, limits, boundaries) • Send / receive Order • Receive situation reports (BFT) • Receive intelligence report (about aggregated units) • Receive equipments / resources reports
C2LG GUI (DEU)	Surrogate C2 system Schemas supported: IBML 2.22c and MSDL V1++ Capabilities: • Export / import MSDL • Send / receive Order • Receive / send situation reports (BFT) • Receive / send intelligence report • Receive / send equipments / resources / personnel reports • Send / receive call for fire, receive / send fire accepted / rejected, receive / send firing reports

System	Description and capabilities
SITAWARE (DNK)	Fully scalable C2 software (developed by Systematic) Schemas supported: IBML 2.22c and MSDL V1++ Capabilities: • Export / import MSDL • Send / receive Order • Receive situation reports (BFT) • Receive intelligence report • Receive equipments / resources / personnel reports
TALOS (ESP)	Artillery C2 system (include also a simulation of artillery fires and damages) Schemas supported: IBML 2.22c and MSDL V1++ Capabilities: • Receive situation reports (BFT) • Receive intelligence report • Send / receive call for fire, receive / send fire accepted / rejected, receive start Firing / Suspend firing, receive / send firing reports • Send Order
9 LAND BMS (USA and SWE)	Operational C2 system (developed by Saab and used for training and operations by SWE) Schemas supported: CBML V1.0 and MSDL V1.0 Capabilities: • Import MSDL • Receive situation reports (BFT) • Receive intelligence report • Send Order
NATO ICC (GBR)	C2 system of Air operations Schemas supported: IBML 2.2 and MSDL V1.0 Capabilities: • Import MSDL • Receive situation reports (BFT) • Receive intelligence report • Send Order (Air Tasking Order)
JADOCS (GBR)	Joint Automated Deep Operations Coordination System Schemas supported: IBML 2.2 and MSDL V1.0 Capabilities: • Import MSDL • Receive situation reports (BFT) • Receive intelligence report • Send Order (Call for Fire order)
Simulations	

System	Description and capabilities
APLET (FRA)	Course Of Action analysis for Decision Support at Brigade Level Schemas supported: IBML 2.22c and MSDL V1++ Capabilities: • Export / import MSDL V1++ (aggregated units, holdings, limits, boundaries) • Receive / send Order • Send reports (BFT, intelligence, equipments / resources, personnel) at a parameterized frequency
SWORD (FRA)	Training simulation for Brigade and Battalion HQ Schemas supported: IBML 2.22c and MSDL V1++ Capabilities: • Import MSDL V1++ (aggregated units, holdings, limits, boundaries) • Receive Order • Send reports (BFT, intelligence, equipments / resources, personnel) at a parameterized frequency • Receive call for fire, send fire accepted / rejected, send firing reports
OneSAF (USA)	Entity-level simulation that supports both Computer Generated Forces and Semi-Automated Forces applications Schemas supported: CBML V1.0 and MSDL V1.0 Capabilities: • Import MSDL • Receive Order • Send reports (BFT, intelligence)
JSAF (GBR)	Joint Semi-Automated Forces. Provides entity level simulation of air, ground and maritime forces Schemas supported: IBML 2.2 and MSDL V1.0 Capabilities: • Export / Import MSDL • Receive Order • Send reports (BFT, intelligence)
Servers and viewers	
KFIE CBML Server (DEU)	C-BML server using a simple file storage Schemas supported: IBML 2.22c and MSDL V1++ Capabilities: • Exchange all CBML messages, using Web Services and JMS (Java Messaging Service)
WISE-SBML Server (USA)	C-BML server using a database (schema derived from the union of all the schemata supported). Schemas supported: IBML09, CBML V1.0 (Full and Light), IBML 2.22c and MSDL V1.0 Capabilities: • Exchange CBML reports and orders in various format, using Web Services and STOMP (Streaming Text Oriented Message Protocol) • Aggregating MSDL • Schema translation among all of the schemata supported for both reports and orders, using WISE transformations tool.

System	Description and capabilities
ESRI / COP (USA)	C-BML viewer Schemas supported: IBML09 Capabilities: • Receive CBML reports

2.0 PLANS FOR THE FUTURE

2.1 SISO C2SIM PDG

As MSDL moves toward Version 2 and C-BML moves from phase 1 to phases 2 and 3, there is a growing consensus among stakeholders that the way forward should include a merging of these two activities to generate a unified, more manageable and easier to deploy C2SIM interoperation solution.

The C2SIM PDG/PSG[5] replaces the following PDGs:

* Military Scenario Definition Language (MSDL): provides all information necessary for initialization across interoperating C2 and Simulation Systems

* Coalition Battle Management Language (C-BML): provides all information necessary for tasking and situational awareness across interoperating C2 and Simulation Systems

In addition, the C2SIM PDG encompasses the Military Scenario Definition Language PSG.

The C2SIM PDG assumes maintenance of both MSDL (SISO-STD-007-2008) and C-BML (SISO-STD-011-2014).

The newly C2SIM PDG, started mid-2014, will be in charge to develop the following products:

* C2SIM-LDM: it will provide, at a logical level (i.e. independent of how the data will be communicated), a core set of data elements common to most C2 and Simulation systems, combined with a standard way of adding to that core a collection of additional elements specific to a particular domain and/or context.

* C2SIM-Initialize: it will supersede the MSDL v1 standard and is an XML message format developed with the purpose of initializing the operational environment (OE) in a wide variety of simulations and connected systems in the US-DoD and NATO-nation agencies. Applications of the initialization messages include description of partial or complete start conditions for simulation execution (e.g, events and exercises) and contextual information defining the truth or belief conditions of actors in simulations. Other applications include defining simulation checkpoint (snapshots of past simulation condition for reset or rollback operation), describing multiple courses of action (CoAs), or contexts in the past, present or future (e.g., planned, preset, anticipated, objective states).

* C2SIM-TaskingReporting: it will supersede the C-BML v1 standard is an XML message format developed with the purpose of describing task and report assertions in operational or simulation environments. The new product expands the range of tasking and situational awareness information relative to the C-BML v2 standard. Task and report messages may be utilized during execution of simulations as runtime messages between real or simulated entities and as a common format for conveying information to and from tactical message formats based on the C2SIM LDM.

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[5] PDG/PSG : Product Development Group / Product Support Group

2.2 Expected future NATO activity

Currently a NATO Exploratory Team (ET) is defining the scope for a future TA which will be in charge to move forward the operationalization of C2SIM approach. This TA is not yet approved but interested Nations already expressed their great expectations to participate. This TA should start January 2016 after NMSG commitment in October 2015.

The aim is to operationalize the C2SIM interoperability standards and technologies.

The objectives of the proposed TA are as follows:

- Develop extensions to the unified C2SIM (MSDL/C-BML) core Data Model for specific functional areas

- Encourage nations to use the standards and motivate suppliers to develop products

- Exploit C2SIM in use cases through an operational, conceptual and executable scenario development process

- Inform the standards development process

- Make recommendations for covering the C2SIM standard with a STANAG

- Educate the community of practice on C2SIM technology employment

The topics of the proposed TA include:

- Outreach to military stakeholders

- Use case extensions and a minimum set of information exchange

- Development process, products and tools for implementation

- NATO Architecture Framework (NAF) and other methods to describe scenarios and interoperability requirements

- Automation of M&S initialization

- Experimentation and validation of the standard

- Services to enable persistent C2SIM interoperability

- STANAG development

- Progress demonstrations and workshops

- Tutorials