A Common Chemical, Biological & Radiological modelling capability: UK and NATO HLA-Evolved experimentation

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ABSTRACT: *The United Kingdom (UK) Ministry of Defence's (MOD) Defence Science and Technology Laboratory (Dstl) have sponsored two key development activities relating to the OneSAF Computer Generated Forces (CGF) system and development of a Common Chemical, Biological and Radiological (CBR) modelling capability. The first is an interface to enable OneSAF to operate in a High Level Architecture (HLA) 1516-2010 (HLA Evolved) federation. The second is an extension to the North Atlantic Treaty Organisation (NATO) Education and Training Network (NETN) Federation Object Model (FOM) to support CBR interoperability. This acts as an enabler for CBR M&S services to be provided to Live, Virtual and Constructive (LVC) simulation systems by a common CBR modelling capability. Although individually these two developments have much broader application, this paper presents a use case bringing the two together to demonstrate CBR federate interoperability with OneSAF and how this has been standardised, developed and experimented using support from the NATO Modelling and Simulation Community.*

1. Introduction and Research Context

UK Defence procurement policy identifies that simulation systems should follow a System Of Systems Approach (SOSA) to their development, to ensure that they are interoperable, reconfigurable and adaptable to meet current and future operational needs. In the UK MOD there is a drive to ensure that simulation capabilities are supported by common services and infrastructure to drive overall through life cost effectiveness. This is a common theme across the North Atlantic Treaty Organisation (NATO) nations and has seen a variety of NATO Modelling and Simulation (M&S) working groups and activities undertaken to help de-risk the approach to this.

A Training Transformation project was undertaken by the UK MOD from 2011 to 2013 which helped to identify a Service Oriented Approach (SOA) to the future delivery of simulation. This identified a set of common components and services that would enable the UK MOD to move towards the provision of Modelling and Simulation as a Service (MSaaS).

Dstl are undertaking research to de-risk the development of the identified common M&S components and runtime services. This paper will discuss the development of one of these services, a Common Chemical, Biological and Radiological (CBR) M&S Component that can be reused to support Operational Analysis, synthetic CBR training and table top gaming by linking to a range of Live, Virtual and Constructive (LVC) simulations.

To enable re-use of the Common CBR M&S Component with LVC systems, development of the CBR content of common simulation interoperability standards was required. This paper discusses how this has been undertaken through research collaboration with other NATO nations (notably France and Sweden) through the NATO Modelling and Simulation Groups (MSG) 096 and 106.

2. Common CBR M&S Component

Dstl have developed a common CBR M&S component, titled the CBR Virtual Battlespace (VB), for exploitation across Operational Analysis, Experimentation, Test and Evaluation, and Training and Education.

The CBR VB is a modelling framework that includes a dispersion engine for simulating the propagation of CBR materials and drives a number of mathematical models to calculate the effects of the dispersion on entities within the

battlespace. This includes effects such as casualties and detector alarms, taking into account factors such as the terrain and weather on the dispersion and the adopted Individual and Collective protection of personnel. Modelling is also performed to calculate the physiological burden caused by various protective postures.

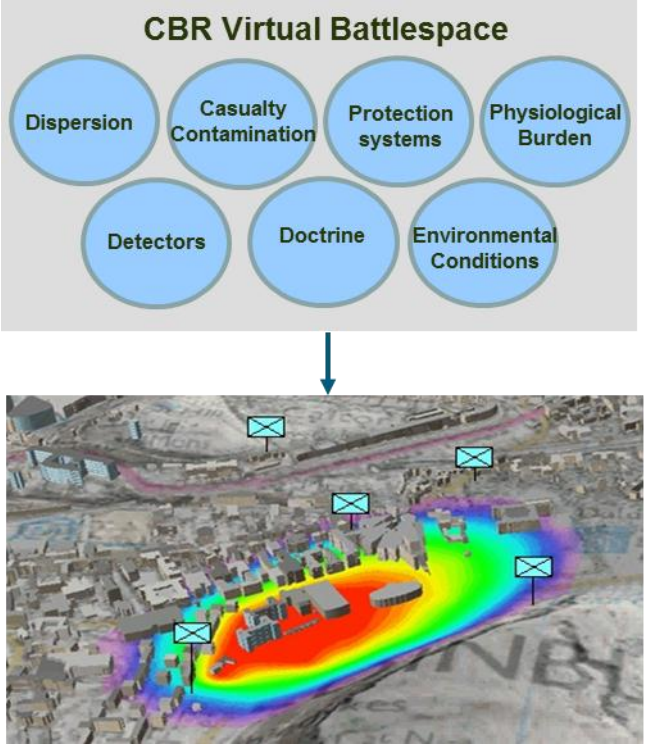

Figure 1: CBR Virtual Battlespace Overview

Given the complexity of CBR M&S, it is computationally expensive which has led to the CBR VB being developed as a discrete system. The concept of use for the CBR VB is to utilise this discrete system as a common CBR modelling component within a third party system through a tightly coupled (if computing resources allow) or a distributed approach. In either approach the third party simulation is responsible for modelling of the more generic tactical or operational vignette (i.e. Force manoeuvre, Tactics Techniques and Procedures (TTPs), Pattern of Life etc.) and the CBR VB only models the CBR specific aspects of the vignette.

In order to utilise the CBR VB as a common component in this way, there is a requirement to interoperate it with a range of different LVC simulation systems depending on the required use case. This is particularly pertinent as more generic LVC simulation systems often do not have CBR content or where it is implemented it is very simplistic.

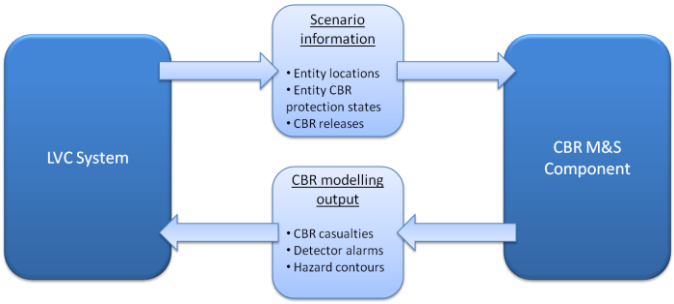

Figure 2: Example CBR M&S Federation Information Exchanges

In order to achieve interoperability with a range of different LVC simulation systems it is important to specify a common Application Programming Interface (API) for the CBR VB to enable re-use as a common component. To inform development of this API, Dstl performed an assessment of common simulation interoperability protocols to see if any standards existed. This assessment identified that simulation interoperability standards for CBR M&S systems did not exist, or were not published in the international simulation community. Therefore Dstl developed their own approach and looked to the North Atlantic Treaty Organisation (NATO) M&S community to for help on standardising this approach

3. NATO M&S Group 096

Work conducted by NATO MSG 049 [1] (Modelling and Simulation System for Emergency Response Planning and Training) also highlighted that there was a lack of standards for interoperating CBR M&S systems for use in Computer Assisted eXercises (CAX) using distributed simulation. Where interoperability mechanisms did exist, they were not aligned to NATO M&S guidance on use of standards.

Therefore Dstl submitted a proposal for a NATO M&S Group to overcome these identified capability gaps. As a result of this, NATO MSG 096 (Consequence/Incident Management for Coalition Operations) was initiated to research how CAX simulation systems can be developed to support enhanced modelling of CBR scenarios relevant to NATO operations to provide training benefit. A key objective of this group was to provide recommendations on how CAX simulation systems interoperate with specialised CBR simulation systems through common NATO standards.

A recommendation from MSG-096 was that no standalone CBR standards should be developed to support CBR M&S interoperability, instead the recommended M&S standards for NATO CAX specified in Annex C of Allied Modelling and Simulation Publication 03 (AMSP-03) [2] should be updated to provide specific CBR content.

Notably, recommendations were made for the use of the following standards:

- **CBR Executable Scenario Description:** Standards

for CBR executable scenario description do not currently exist. It is desirable to use the Military Scenario Definition Language (MSDL) to define the Executable Scenario description, however MSDL does not currently have any CBR content and therefore it was recommended that CBR aspects of this standard be developed in the future to provide this capability.

- **CBR M&S Interoperability**: The Institute of Electrical and Electronics Engineers (IEEE) 1516-2010 version of the High Level Architecture (HLA) standard is identified in AMSP-03 as the recommended standard to be used for interoperability between models and simulations in NATO/Multinational exercises. However, a CBR Information Exchange Data Model did not currently exist within the standard. Therefore, it was recommended that a CBR Federate Object Model (FOM) was developed and integrated within the NATO Education and Training Network (NETN) FOM as the recommended Information Exchange Data-Model.

  The IEEE 1278 Distributed Interactive Simulation (DIS) standard was identified as an alternative approach but likewise does not have any CBR capability and would need to be extended to include a CBR DIS enumeration set within a CBR Protocol Data Unit (PDU).

Following these recommendations, a CBR Task Team was initiated within NATO MSG-106 to follow up on the recommendations of NATO MSG-096.

4. CBR FOM Module

A CBR FOM module was developed by Dstl and Riskaware Ltd. to allow CBR modelling information to be exchanged within HLA federations. This built upon previous work undertaken by Dstl and QinetiQ to develop an Atmospheric Dispersion Base Object Model (BOM) [3]. The CBR FOM Module covers a description of the initial CBR event through to the effects of that CBR event. The CBR FOM module can be broken down into the following sections:

- **Source release modelling:** Enables the transfer of information regarding a CBR release i.e. the source term parameters for an instantaneous chemical release (such as the mass and release location).
- **Detector modelling:** Enables the transfer of information required to perform detector modelling and the outputs from a detector model i.e. the CBR materials that a detector can detect or a detector's alarm state.
- **Effects modelling:** enables the transfer of information that is output from a CBR effects model i.e. the exposure data for a human or contamination status of a platform.
- **Protective measure modelling:** enables the transfer of information required to perform the modelling of protective measures as well as the output of the models i.e. individual and collective protective posture and protection factors.
- **Hazard area information:** enables the transfer of contour information for a CBR release i.e. the contours of the concentration, deposition and dosage of a CBR release as calculated by a dispersion model.

This information is summarised as the information that is imported in to a CBR M&S simulation federate so that it can perform dispersion modelling of the release, and the resulting information that can be extracted from this dispersion modelling. This is summarised in Figure 3.

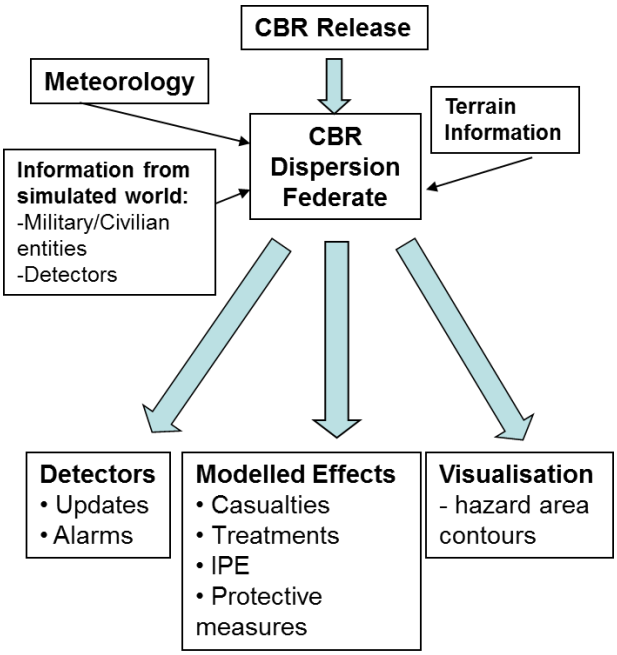

Figure 3: CBR FOM Module overview

5. NMSG-106 NETN FOM

NATO MSG-106 (Enhanced CAX Architecture, Design and Methodology) was established to: provide recommendations for the Governance of NATO CAX; provide guidelines for Exercise Controllers and Simulation Controllers; and develop a reference federation architecture and implementation for use in NATO distributed simulation.

The reference architecture built upon work conducted in NATO MSG-068 to develop an IEEE HLA 1516-2010 Federation Object Model (FOM) for use in NATO Education and Training Networks (NETN) (termed the NETN FOM). This work built upon the Real-time Platform

Reference (RPR) FOM to exploit the new capabilities introduced HLA-Evolved, mainly the use of FOM modules. The NETN FOM was developed by first breaking down the RPR FOM into FOM modules; the NETN FOM then extended these modules to add new functionality.

NATO MSG-106 took the NETN FOM developed by NMSG-068 and developed Version 2 (V2) of the NETN FOM. V2 further extended the capability of the NETN FOM by adding new FOM modules for:

- **Transfer of Modelling Responsibility (TMR):** The TMR module allows simulations to transfer the modelling responsibility for certain aspects of the modelling of an entity. This can be used for load balancing across a federation or to allow simulations which are better at performing a certain modelling capability to perform the modelling but not take full control of the simulation entity.
- **Multi Resolution Modelling (MRM):** The MRM FOM module allows the modelling of an aggregated entity to be performed at the disaggregated level. An MRM Service Provider (SP) is required to manage the aggregation and disaggregation of entities including creating and removing disaggregated entities from the federation.
- **Coalition Battle Management Language (CBML):** CBML is supported in the NETN FOM by using two modules to translate the CBML messages into HLA interactions. The FOM modules are broken down to represent high and low level CBML messages.

The CBR FOM module developed by Dstl and Riskaware Ltd. was peer reviewed by the nations participating in the group and also incorporated into the NETN FOM. The NETN FOM dependencies of the CBR FOM Module are shown below in Figure 4.

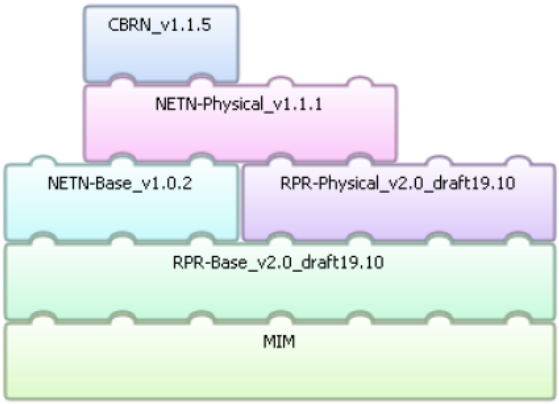

Figure 4: CBR FOM Module dependencies within the NETN FOM

6. NMSG-106 Experimentation

During the development of the CBR FOM module, Dstl led a number of distributed and face to face tests during NMSG-106 meetings to verify and validate the design of the CBR FOM module as well as the implementation of the CBR VB.

As well as the CBR VB (UK) the CBR FOM module has also been implemented within the SWORD (France), Pitch Actors (Sweden) and OneSAF (UK) systems.

A number of tests were performed which focused on verifying the exchange of CBR release, CBR effects and CBR contour information between the systems.

Later tests investigated how the benefits of the HLA 1516-2010 standard and the NETN FOM could be demonstrated through CBR use cases. These use cases included the use of the following capabilities:

- TMR was used to enable the CBR VB to take ownership of the CBR attributes of entities owned by the other systems. This allows the other systems which can't model CBR to hand over the CBR modelling aspects of the federation to the CBR VB which is specialised in CBR modelling.
- MRM was used to allow CBR modelling effects to be calculated on an aggregated unit. In this case the CBR VB disaggregates a unit when it reaches a CBR hazard and performs the CBR modelling for the individual entities. Once the unit has cleared the hazard the CBR VB will aggregate the unit back to its original state to pass back to the owning system with the CBR effects included.

The following diagram shows the MSG-106 experimentation federation that was used to validate the CBR FOM module.

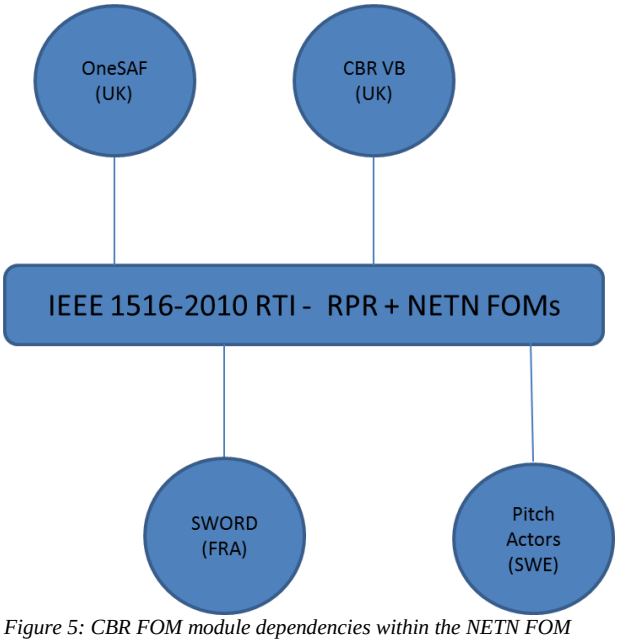

Figure 5: CBR FOM module dependencies within the NETN FOM

The following sections (6.1, 6.2 and 6.3) discuss the roles and information exchanges for the systems used in this federation.

6.1 SWORD

SWORD [4] is a land constructive simulation developed by the MASA Group and designed for command post training (at division or brigade level). Units in SWORD are aggregated at company or section levels and include a doctrine compliant intelligent automation. SWORD has the advantage of implementing a large portion of the NETN FOM, while also being capable of handling CBR events.

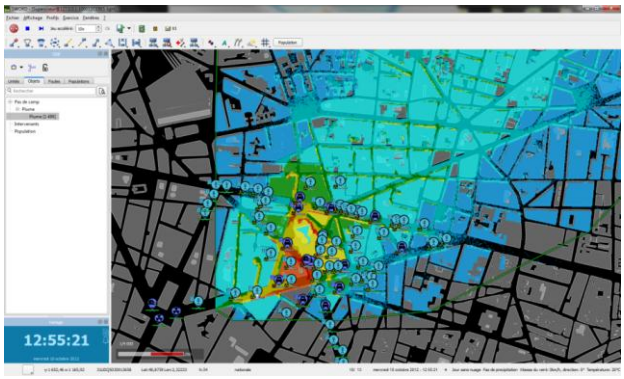

Figure 6: CBR event displayed in SWORD

During the CBR experimentation, SWORD was used to model the theatre of operation and the aggregated units. After the CBR event occurred, SWORD received the CBR source release interaction which defined the threat (chemical cloud). In order to assess the damage in the aggregated unit, SWORD used the MRM process to split the unit into individual entities. Once the threat had passed the same MRM process was used again to aggregate the CBR contaminated aggregate unit the opposite way, back into the SWORD simulation.

6.2 Pitch Actors

Pitch Actors is a Computer Generated Force (CGF) system mainly used in testing as a federate to stimulate other federates and for demonstration purposes. It was primary designed for the RPR FOM but has now been adapted for NETN V2 to manage NETN Logistics, TMR, MRM and low level Battle Management Language (BML) orders and reports. Entities can be given a sequence of actions to conduct in a script and entities react to warfare interactions.

During the CBR experimentation, Pitch Actors had the role of a MRM Service Provider which creates the high resolution units (humans and platforms) according to the Orders of Battle (ORBAT) defined in a Military Scenario Definition Language (MSDL) file. These high resolution units were then assigned to OneSAF to manage the dynamic properties like movement and damage assessment. Static properties like identification, type, etc. were managed by the MRM Service Provider. The CBR damage attributes defined in the CBR FOM module on the high resolution units were then transferred to the CBR VB to model these values using the TMR process. Pitch Actors reflects these CBR FOM attributes and then updates the damage attributes of the high resolution units as defined in the RPR FOM.

6.3 OneSAF

The One Semi Automated Forces (OneSAF) system is a CGF system developed by the United States (US) Army Program Executive Office for Simulation Training and Instrumentation (PEO-STRI). Dstl have funded development of a HLA 1516-2010 interface for OneSAF which has been delivered by an industry led consortia.

This HLA 1516-2010 interface has been developed against the NETN FOM including the CBR FOM module allowing OneSAF to be included in the NMSG-106 experiment.

During the experiment OneSAF took ownership of the disaggregated entities that were created by Pitch Actors from the SWORD units following the completion of the MRM process. The CBR effects on the disaggregated entities were modelled by the CBR VB, with OneSAF using the outputs whilst performing its behavioural modelling of the entities. Once the CBR threat had passed OneSAF then aggregated and returned the entities back to SWORD.

6.4 CBR VB

During the CBR experiment the CBR VB was waiting for the CBR source release interaction to initiate the MRM process for the aggregated entities that were in the vicinity of the CBR release. Once the disaggregated entities were created by Pitch Actors, the CBR VB took ownership of the entities CBR attributes. These attributes were then updated as the CBR VB performed its CBR modelling, which also included creating contour objects based on the dispersion of the CBR release. When the CBR threat had passed, the CBR VB initiated the MRM aggregation process.

7. Summary

The work undertaken in this paper has demonstrated that:

- A common M&S component has been developed for the modelling of CBR incidents.
- This common CBR M&S component can be utilised to interoperate with a range of constructive simulation systems to provide enhanced modelling of CBR incidents.
- A common API for interoperating CBR information has been developed as a CBR FOM Module within the HLA 1516-2010 standard and incorporated within the NETN FOM.
- The development of the CBR FOM Module has been

undertaken with assistance from the NATO M&S community to help de-risk the implementation and agree upon a standard approach.

- The use of discrete CBR M&S systems that can interoperate through distributed simulation means that they can be used to provide enhanced CBR M&S to NATO or National CAX over a Wide Area Network (WAN).
- The CBR experimentation also demonstrated other benefits of the HLA 1516-2010 NETN FOM. Specifically the benefits of TMR and MRM FOM Modules which help enable the calculation of CBR effects on different types of simulation.

The NETN FOM Version 2.0 is due to complete development by NMSG-106 in December 2014. This FOM will then be offered to the Simulation Interoperability Standards Organization (SISO) as an extension to the RPR FOM to see if there is willing by the community to engage in its development. The CBR FOM Module will be included as part of the NETN FOM. The presentation of this paper at the SISO Simulation Interoperability Workshop (SIW) aims to act as a stimulus to ask the wider SISO community if there is interest in the standardisation of the CBRN FOM Module in the context/coordination of future development of the RPR FOM.

A demonstration of the CBR experiment will be given on the NATO booth at the 2014 Inter-service/Industry Training, Simulation and Education Conference (I/ITSEC).

References

[1] NATO MSG-049 - Modelling and Simulation System for Emergency Response Planning and Training. Vol. 2: Annexes D - International/national crisis staff. February 2011

[2] AMSP-03: M&S standard profile for NATO and Multinational Computer Assisted eXercises with Distributed Simulation. Edition (A) Version 0.10. May 2014

[3] An HLA Base Object Model for Atmospheric Dispersion - R. Penny & P. Hoare. QinetiQ/S&E/APC/TWP032563

[4] MASA SWORD : Automated, aggregated constructive simulation for efficient training and analysis http://www.masagroup.net/products/masa-sword/

Author Biographies

JON LLOYD is a Principal Scientist working in Modelling and Simulation for the UK MOD Dstl for the past 14 years. During this time he has primarily worked as a technical specialist in the development of Synthetic Environments for CBR Modelling and Simulation and the development of CBR interoperability standards. He has chaired two International Research Collaboration groups including NATO MSG-096 and a CBR Task Team in NATO MSG-106. Jon also leads research in Dstl and Industry on the development and use of Computer Generated Forces for the UK MOD, more recently focussing on enabling re-use of such capabilities in the Joint environment.

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