20th ICCRTS

"C2, Cyber and Trust"

Using C-BML in a persistent Coalition C2-Simulation Experimentation Environment

Topics
Experimentation, Metrics, and Analysis
Modelling and Simulation
C2-Simulation Interoperability

Names of Authors

Adam Brook
QinetiQ Ltd

Michael Mifsud
Defence Science and Technology Laboratory

Points of Contact

Adam Brook,
QinetiQ Ltd,
Cody Technology Park,
Ively Road,
Farnborough,
Hants,
UK
GU14 0LX

tel: +44 (0) 1252 396427
email: rabrook@qinetiq.com

Michael Mifsud,
Defence Science and Technology Laboratory,
UK Ministry of Defence,
Portsdown West,
Portsdown Hill Road,
Fareham,
Hants,
UK
PO17 6AD
tel: +44 (0)30 6770 3444
email: mvmifsud@dstl.gov.uk

Abstract: *This paper describes how the Coalition Battle Management Language (C-BML) is being used in the Technical Cooperation Panel (TTCP) nations' (Australia, Canada, New Zealand, United Kingdom, United States of America) Coalition Attack Guidance Experiment (CAGE). CAGE functions in a persistent (readily-available), agile, distributed coalition C2-Simulation experimentation test-bed environment. C-BML provides a means of triggering the behaviours of simulated entities derived from operational plans developed using operational command and control applications. The CAGE series of experiments has been used to investigate and solve a range of problems relating to the management of coalition aviation, land and maritime assets and battle-space in increasingly complex environments: complex networks, complex integrated combined (multinational) and joint (cross environment) effects, coalition C2 system mixtures, underpinning simulations and operational processes.*

Some of the lessons identified and learned are shared in this paper. Consideration is also given to their further application in related areas including mission planning, training for live exercises and development of the CAGE environment to support investigation of electronic warfare and cyber domains.

Using C-BML in a persistent Coalition C2-Simulation Experimentation Environment

1 Introduction and Background

Simulations and synthetic environments are critical enablers used extensively across defence lifecycles, underpinning experimentation, evaluation and trials activities. Whether to support a small scale technology experiment or a full-scale trial or training exercise, significant overhead is required to set up the supporting infrastructure (e.g. networks, enterprise services), operational context (scenario and data), and simulation systems, particularly when operating in a geographically-distributed manner. This cost is repeatedly borne by each activity, often multiple times across (and within) projects.

Particularly within the international arena, including NATO [1] and the 5-eyes (AUS, CAN, NZ, UK, US) Technical Cooperation Program (TTCP) [2], the overhead costs of setting up distributed Live, Virtual and Constructive (LVC) simulations is increased due to the greater distances, differences in culture, different approaches, and separate governing entities and funding sources.

A key outcome from the TTCP Coalition Attack Guidance Experiment (CAGE) is the identification of the need for a readily-available, distributed, open, scalable and reusable capability to support experimentation across multiple initiatives. This environment would need to be pre-accredited (as far as possible) with a standard toolset including national C2 systems and simulations. The Coalition Battle Management Language (C-BML) is a key enabler to integrate Live C2 systems with the underpinning synthetic environment. As a result, TTCP has created a new initiative, the Virtual Interoperability Prototyping and Research Environment (VIPRE) to deliver this persistent, scalable environment.

This paper describes lessons learnt (from a UK Research perspective) from the most recent iteration of CAGE and the need for the “persistent” experimentation environment. This would deliver a starting capability that can be rapidly replicated across different environments (e.g. Land, Air, Maritime, Joint) to support requirements of multiple different domains (e.g. Training, Experimentation, Support to Acquisition, Test & Evaluation).

2 CAGE

The TTCP CAGE initiative is a series of distributed experiments / trials designed to investigate and evolve the TTCP nations’ ability to conduct coalition Command and Control, focusing initially on Joint Fires, whilst also providing a research, development, analysis, test and evaluation environment (enabled by simulation). CAGE is a pan-TTCP initiative supporting multiple panels including Joint Systems & Analysis (JSA), Aerospace Systems (AER), Electronic Warfare Systems (EWS), with interest from others.

The goals of CAGE are to:

- Identify the current barriers, and define improved techniques, to deliver effective coalition Network Centric Warfare (NCW);
- Provide recommendations for technologies, systems, tactics, and doctrine to improve coalition NCW effectiveness; and
- Extend and cross validate results by the appropriate experimental design and comparison of simulation and constructive modelling.

CAGE investigates not only technological interoperability, but also procedural (tactics, techniques, procedures / standard operating procedures) interoperability and enables coalition analysis. The context for CAGE was of a joint, coalition military force conducting operations in support of a United Nations mandate.

The UK’s involvement is currently sponsored by the Ministry of Defence’s Joint Forces Command (JFC) Capability for Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (Cap C4ISR) [3].

CAGE I was conducted in Canada in May 2010 and all activities were co-located. From CAGE II onwards the experiments were conducted at distributed sites. The UK had observer status in CAGE I and II, but in CAGE II (2012) the UK supported Canada in the use of C-BML to process Airspace Control Orders, Airspace Control Measure Requests and Air Tasking Orders (ACOs, ACMREQs and ATOs). The UK participated more fully in CAGE IIIa (October 2013) introducing: a simulated, agent-controlled unmanned aircraft system; a UK C2 node; and a Computer Generated Force simulation (JSAF).

Figure 1 – UAV Feeds from CAGE IIIa

CAGE IIIb, which took place in January 2015, is the latest of the series of experiments which aimed to improve operational targeting and battle-space coordination between coalition joint forces. It included the active participation of Australia, Canada, the UK and the US, with New Zealand as observers. Canada was the lead nation on CAGE IIIb and coordinated the infrastructure necessary to support it.

The focus of CAGE IIIb at the coalition level was to:

- Perform coalition-level deliberate and dynamic targeting
- Refine ability to conduct cross boundary joint fires, Information Surveillance and Reconnaissance (ISR) and Air / Aviation coordination
- Refine distributed experiment control procedures with 5-eyes allies
- Refine ability to conduct distributed simulation

Each nation also used CAGE to undertake national-specific objectives. For the UK this also included:

- Demonstration of a baseline distributed, experimentation environment that can be rapidly deployed, scaled and replicated
- Further validation of the UK C2-Simulation testbed in a complex coalition context, integrating C2 Systems (NATO Integrated Command and Control (ICC), Networked Interoperable Real-Time Information Services (NIRIS)) and Simulations (OneSAF, JSAF, VBS2) with coalition assets.
- Integration (operationally and technically) of new simulation capabilities including Weather (US) and Electronic Warfare EW (AUS)

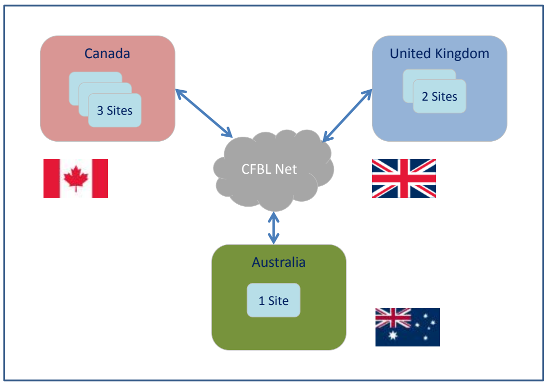

Figure 2 – CAGE IIIb Federation

CAGE IIIb was conducted at:

- Canada (3 Principal sites: CFWC & CFAWC Ottawa, CFMWC Halifax)
- Australia (1 Site: DSTO Canberra)
- UK (2 Sites: Dstl Portsdown West, Dstl Porton Down)
- US elements were located in Canada

National command and control (C2) and distributed simulation systems were connected using the Combined Federated Battle Laboratories Network (CFBLNet) [4]. CAGE IIIb was also set up to be a Canadian national training exercise and provided an excellent opportunity for the training, and development of TTPs, for the C2 and Joint Fires elements of Canadian Division Headquarters and component commands. It is not the intent to cover this particular aspect in this paper but there were significant implications for the whole CAGE system as it was required to provide credible effects to a training audience as well as technical goals.

CAGE IIIb was established following traditional systems engineering processes and implemented in a number of incremental integration spirals. A C2-Simulation (or C2-Sim) test-bed has been developed in the UK and this was deployed at one of the two UK sites.

3 UK C2-Sim Test-bed

3.1 Overview

In the UK Dstl has implemented a reconfigurable C2-Sim test-bed to permit experimentation in this field to be conducted. The test-bed is able to accommodate a number of the main operational C2 and simulation systems used in the UK. To date these include C2: Bowman Combat Infrastructure Platform (BCIP), the NATO Integrated Command and Control System (ICC) (plus its associated gateway, NIRIS), the Joint Automated Deep Operations Coordination System (JADOCS) and JCHAT. Test-bed simulations include JSAF, OneSAF and VBS2. The use of defined C2 messaging and simulation interoperability standards permits interoperability with coalition partners and the use of MSDL and C-BML permits the exchange of information between C2 and simulation systems. The test-bed includes messaging middleware to support MSDL and C-BML exchange, data logging and replay and analysis tools.

The C2-Sim test-bed has been designed to use or support any of the components or capabilities in the following table.

Item
C2 Systems
Simulations
Robotic Systems
Exercise Management Systems (including logging/replay and analysis tools)
Translator Capability
Standards and Schemas
Middleware
Networking Capability
Supporting Infrastructure
Human-Machine Interface Functions

Table 1 Key C2-Sim Test-bed Systems and Capability Requirement Areas

The system architecture allows designers to develop and understand the information exchange requirements between component systems. For example, different C2 systems will have different messaging requirements, formats and wire protocols so these are specified and recorded in the test-bed architecture. The Ministry of Defence Architectural Framework (MODAF) has been used to support this work and this is outlined in greater detail in [5].

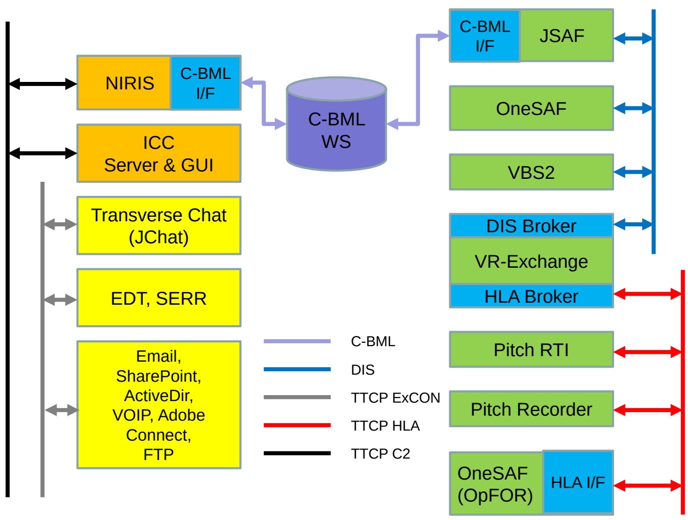

Figure 3 – System View of UK C2-Sim Test-bed Configured to Support CAGE IIIB

Figure 3 shows the system view of the UK C2-Sim test-bed as configured during CAGE IIIb. This view also includes a number of exercise support tools and capabilities which do not form part of the test-bed itself, e.g. email, SharePoint and VOIP telephone systems which are necessary for the conduct and execution of the experiment.

Lessons learned and identified during earlier experimentation led to the development of a number of supporting scripts to simplify the sequencing, running, pausing, resetting and stopping of the main applications in the test-bed.

3.2 Virtualisation

For CAGE IIIb the UK used an architecture where the component applications were deployed on virtual machines (VMs). This gives considerable hardware resilience to the complete system and makes component applications easier to deploy, as well as increasing the scalability of the system. Many require complex installation processes, background services, environment values, etc and virtualisation helps save effort by encapsulating fully configured systems. Once a VM has been configured for a particular purpose it is relatively easy to transfer a copy to another machine, possibly on another network. If problems occur it is also easy to roll-back VMs to a last-known good state.

4 C2-Sim Background – C-BML and MSDL

Command and Control (C2) systems have been used in conjunction with simulation systems for many years and for a number of purposes. The simulation systems have been used as means of stimulating C2 systems and their users by sending reports of simulated activities and events emulating the effects produced by real end users and their systems. A number of operational messaging systems and formats exist and they can be used to permit this, e.g. the NATO ADatP-3 system [6].

To a much lesser extent, because it is a harder problem, simulation systems have been stimulated by C2 systems. Here the equipment and personnel under simulation are required to respond in a realistic manner to command tasking inputs as though they were real. For this to happen, the simulation must include a behavioural element, such as a software agent or a finite-state machine to execute this tasking. Much effort has been expended to develop a standard, the Coalition Battle Management Language (C-BML), to enable the expression of orders, reports and requests in a standardised form using an XML schema and according to unambiguous rules of grammar [7] so that simulations can act correctly.

The use of C-BML permits a wide variety of C2 planning tools and simulation systems to be federated and this has been achieved on numerous occasions with both national and coalition systems. With complex systems-of-systems there is a requirement to have consistent data for each system, especially data relating to taskorg which covers unit and entity composition, hierarchy and disposition. The Military Scenario Definition Language (MSDL) can be used for this purpose [8].

In summary, MSDL is used for consistent initialisation of C2 and simulation systems and C-BML is used during the execution process to permit orders, reports and requests to be exchanged. The two related standards, C-BML and MSDL, together with the Distributed Simulation Engineering and Execution Process (DSEEP) [9] required to make them practical propositions form the basis of the SISO C2-Sim Product Development Group's work [10].

5 Use of C-BML and MSDL within CAGE IIIb

In CAGE IIIb C-BML and MSDL were used in the UK test-bed for the following purposes:

5.1 Producing Situational Awareness Reports for display on a COP

The C-BML reporting software is able to generate a number of operational message formats for tracks including OTH-Gold [11], the NATO Friend or Foe Identification (NFFI) [12] and certain UK-specific messages. These messages were generated in C-BML and forwarded to a Canadian system, the Global C2 System-Joint (GCCS-J), to be merged into a coalition-wide COP. Both OTH-gold and NFFI formats were used during the integration testing. The test-bed has the ability to generate multiple feeds and it was possible to compare the latency of a local feed with a COP feed processed by a C2 system at a remote site.

5.2 Processing ACOs and ATOs and Tasking Aircraft

Canada, the CAGE lead had the responsibility of preparing ACOs and daily ATOs which were distributed to player sites. In practice, ACOs seldom varied, but the ATOs changed daily. C-BML was used to task aircraft. A number of aircraft were available in the UK OrBat and they could be scheduled to fly where and when they were needed. C-BML coped with both ACOs and pre-tasked aircraft.

Some aircraft, however, were not tasked through an ATO but were on stand-by or ground alert. These aircraft would be tasked using 9-line briefs and in CAGE via chat. This capability does not exist in the test-bed and is one of the areas worthy of future development. For the demonstrations given by NATO Modelling and Simulation Group 085 (MSG-085) C-BML task status reports had been integrated into an OpenFire JCHAT system – simulated units could send text reports to a chat room. Here the converse is required, an application (possibly chat-based) which can be used without 'swivel-chairing' by an aircraft controller to generate dynamic tasking for aircraft.

5.3 Initialisation of translator applications with MSDL

MSDL was used to initialise translator applications to ensure that the correct MilStd 2525C codes would be included in the track reports. To support air operations a number of domain-specific data items are needed which are not included in the SISO MSDL specification, for example the assignment of aircraft IFF codes. MSDL has two extension mechanisms which may be used for this purpose and it is proposed that these are adopted for future test-bed implementations.

6 Further Application and Development

The C2-Sim test-bed is suitable for a number of further applications, not just the series of CAGE events. Two areas of exploitation currently being worked on, a third is being considered.

6.1 Support to LiveEx

The first is the preparation for military live exercises (LiveEx). For these the directing staff has a requirement to be able to train using their planning tools in advance of the LiveEx. This is difficult to achieve since the LiveEx players have but limited time and resources to work with the directing staff. Use of a C2-Sim test-bed helps them:

- Train to use their planning tools and processes; and
- Develop plans and scenarios in advance of LiveEx players arrival and participation.

6.2 Joint Mission Planning

The second is a continuation of earlier work begun under the auspices of NATO Modelling and Simulation Group 085 [13] investigating the use of C2-Sim to support Joint Mission Planning in a coalition context to support the NATO Comprehensive Operational Planning Directive (COPD) [14]. The COPD gives a set of processes which may be used to develop and test operational plans at a number different echelon levels for a variety of operational activities. The COPD covers a multitude of potential activities: six main phases from situational awareness through planning and execution to transition; some forty functional areas of expertise, e.g. intelligence, rules of engagement, engineer support; and echelons from the national/multi-national policy, through the strategic to the operational. The C2-Sim test-bed is being developed further using the OneSAF simulation running in a faster-than-real-time (FTRT) mode to provide the simulation support to help evaluate alternative Courses of Action (COAs).

6.3 Coalition Interoperability Assurance & Validation (CIAV)

CIAV is an activity which aims to ensure the correct interoperation of national C2 systems in advance of their use on coalition operational networks. The C2-Sim test-bed has the potential to use simulation to stimulate CIAV test environments and is seen as a potential future use case.

7 Conclusions

Following the use of the C2-Sim test-bed in CAGE IIIb, a number of observations were made. Some are very specific to CAGE itself, intricacies of the systems and their operation but others are more general and worth sharing here:

- MSDL was used within the UK systems but not by the other CAGE members, the full benefits of using MSDL as demonstrated by MSG-085 were not realised;
- Both C-BML and MSDL need extension to be of greater benefit both in the air and maritime domains. These extensions will be recommended to the SISO C2-Sim PDG for incorporation in the new C2-Sim data models;
- A number of operational message and track formats were used by the different systems and being able to create these using C-BML was advantageous;
- Scripting to orchestrate the main C2-Sim test-bed applications greatly simplified the user's work-load;
- The use of MODAF to record and extend the test-bed is very promising and its use will be continued through follow-on and related initiatives (e.g. the TTCP Virtual Interoperability Prototyping and Research Environment: VIPRE);
- The use of the DSEEP overlay for C2-Sim helped ensure good systems engineering practice was followed;
- Systems which did not embrace C2-Sim techniques fully still depended on slow, clumsy swivel-chair interfaces.

When C2-Sim standards were used by the UK in CAGE IIIb the following comment was made by one of the technical leaders in Canada:

> *My keen interest in this case is looking at trying to make C2-Sim, Sim-C2 and Sim-anything easier to implement, at least here at CFWC.*

8 References

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