C2Sim: Simple Interoperation (Single Nation, Single Domain), National Interoperation (Single Nation, Multiple Domains)

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ABSTRACT

This paper is one of a coordinated set prepared for a NATO Modelling and Simulation Group Lecture Series in Command and Control – Simulation Interoperability (C2SIM). This paper provides insights into the development of C2SIM interoperability solutions that have been developed within the context of simple interoperation with a single nation and domain in either the land, maritime or air domains and at national level (single nation) but across multiple domains.

1.0 INTRODUCTION

This paper provides insights into work within National programmes into the progress of C2SIM interoperability solutions that have been developed within the context of simple interoperation with a single nation and domain in either the land, air and maritime domains and at national level (single nation) but across multiple or joint domains.

The specific C2Sim areas covered within this section include the following example cases:

- Army Operations as exemplified by a number of national programmes;
- Air Operations, drawing on work undertaken in the UK;
- Maritime Operations, drawing on the work of the MSG-085 Maritime CIG; and
- UK concepts developed to support Joint Operational Training.

2.0 DEFINITION

For the purposes of this lecture *Simple Interoperation* will cover systems from a single nation operating in a single domain, e.g. land, air or maritime and *National Interoperation* will extend this to multiple domains, e.g. land/air or air/maritime.

2.1 Simple Implies Easy

A simple, single nation, single domain C2Sim system may be easy to establish, it may have simpler objectives, fewer systems, smaller teams, etc, but the a number of factors may confound this notion and 'simple systems' may in fact become surprisingly complex, quite quickly. However, the interoperation between C2 and Simulation, the 'Execute' phase in DSEEP[1] terminology, should remain simple for the end users and C2Sim will help achieve that goal.

[1] DSEEP – Distributed Simulation Engineering and Execution Process.

3.0 INTEROPERATION IN THE LAND DOMAIN

3.1 C2Sim in the Land Domain

Much of the original development of C-BML and MSDL has been influenced by the interoperability requirements posed by problems in the land domain. Here we outline a number of national examples from MSG-085 participants where C2Sim has been proposed or used. Areas of interest in the land domain include: the representation of doctrinal orders and their execution and coordination in real-time or faster-than-real-time settings; the uses to which C2Sim systems may be given; mission planning, training, system and process familiarisation, etc.

MSG-085 supported a Land Systems Common Interest Group (CIG) which had a remit to investigate the use of MSDL and C-BML to support a number of land operations. This CIG's work has been reported by MSG-085 and at public events such as the SISO Simulation Interoperability Workshop (SIW) [1][2].

3.2 MSG-085 Land Operations CIG

Through both analysis of the military operational requirements and the running of a number of practical experiments this group was able to do a number of things:

- Map operational messages to C-BML, e.g. WARNO, ORDER, FRAGO, SITREP, and ACK;
- Extend C-BML and MSDL schemas to support specific operational requirements in the: Intel, Artillery, Logistics domains; and
- Evaluate system design requirements and agreements, leading to new systems engineering processes: the C2Sim Distributed Simulation Engineering and Execution Process (DSEEP) overlay.

3.3 Selected National Capabilities

The section here outlines some of the specific C2Sim capabilities in the domain which have been developed by the various nations participating in MSG-085. Separately from MSG-085, some of these nations have also made developments to support their own national and other coalition requirements, some of these are also referred to here.

3.3.1 USA

The USA Simulation to Mission Command Interoperability (SIMCI) programme is a well-established and continuing programme whose current aims and developments include:

- Developing better Mission Command systems capable of interoperating with simulations, including constructive;
- Developing and understanding data modelling and resolution, initialisation, AAR processes;
- Distributed, Collaborative Multi-Course Of Action (COA) Mission Planning (DCM2P) – uses graphical mission planning tools to develop and assess alternative COAs and generate orders;
- Operational Running Estimate (ORET) evaluates these orders using simulation.

3.3.2 France

In France the Armées DGA Industrie pour la Simulation (ADIS) group is a pan-defence organisation whose activities have supported the development and demonstration of a number of C2Sim projects. Of these the VULCAIN federation capability has been shown at annual Eurosatory events. France has developed a software service capability which includes support for C2Sim. This is known as: Expertise et Logiciels pour les Liens d'Interopérabilité Permanents des Simulations et de leur Environnement (ELLIPSE).

ELLIPSE provides services and specifications for:

- Sim-Sim (DIS and HLA);
- Sim-C2 (MSDL and C-BML);
- Sim-Live systems (Standard Interface for Multiple Platform Link Evaluation (SIMPLE): STANAG 5602, LINK16: STANAG 5516);
- Schema verification;
- Mapping (cartography – Web Map Services (WMS)); and
- Environmental information and services (weather, ionosphere, ocean, natural environment).

VULCAIN applications have included:

- C2: SICF (BDE and above), SIR (BN and below); and
- Simulation: APLET (Land planning), SWORD (Joint CGF), ORQUE (Maritime), WAGRAM (Land CGF – aggregate level).

3.3.3 Germany

Germany, together with the USA led the development of a formal definition of the C2 Lexical Grammar (C2LG) required to define C-BML. This has been implemented in the C2LG-GUI application, a C2 planning prototype able to prepare and create C-BML orders and display C-BML reports. This tool has been used in a number of national and coalition C2Sim events.

Germany has also developed its own C2Sim web services and these have been used in experimentation by MSG-085 and the French-German COMELEC cooperative programme.

3.3.4 Denmark

The Danish Defence Acquisition and Logistics Organization has supported the extension of the Systematic SITAWARE planning tool to enable C-BML messages to be created and displayed.

3.3.5 Spain

The TALOS C2 application, an indirect fires planning tool, was extended to be able to create C-BML Call-for-fire orders and the system participated in the MSG-085 final demonstration.

3.3.6 Netherlands

Early work by TNO in the Netherlands entailed modifying the national C2 system of the time, ISIS, for experimentation purposes with MSG-048. Further work included feasibility studies to develop the TACTIS collective LVC training capability to integrate C2 systems using C-BML.

> *A proof of concept project called "Information Roundabout" has been successfully finalized this year (2015) to look into the possibility of using MSDL and C-BML for the Netherlands Command and Staff Trainer (NL-CST). It is understood that MSDL is planned to be used for C2 integration into TACTIS and C-BML and MSDL are planned to be used for the C2 integration into NL-CST based on the gained experience.*

More recent work in the Netherlands has been undertaken in conjunction with FFI in Norway to look at the use of multi-agent systems to develop low-level behaviours to be executed on the receipt of higher level C-BML orders.

3.3.7 Norway

Norway, jointly with the Netherlands has investigated using Context-Based Reasoning (CxBR) and Belief, Desire, Intent (BDI) Multi-Agent Systems as described above.

3.3.8 Sweden

Saab Training Systems has developed the 9Land BMS C2 planning tool to operate with C2Sim standards and GMU Scripted BML web service middleware.

4.0 INTEROPERATION IN THE AIR DOMAIN

4.1 Air Planning Support

The use of C2Sim chosen to illustrate interoperation in the Air Domain is for Air Planning Support. Air Mission Planning tends to run on a fixed cycle so most missions and resources are pre-allocated. An Air Tasking Order (ATO) will determine the resourcing (which aircraft will be used) and missions (what, when and where the aircraft will be doing for their tasks). Air Operations build on these plans and ATO changes are made if required on the day. The associated Airspace Coordination Order (ACO) is developed to define geographic, functional and temporal areas of air space.

The purpose of this system is to provide Air Mission Planning personnel with a simulated environment in which to practice their mission planning skills. These include:

- Resource allocation, selecting and requesting suitable aircraft, taking into account their geographic locations, transit times, etc;
- Scheduling, ensuring that aircraft are on station, at target, at rendezvous at the correct times;
- Refuelling calculations;
- Airspace deconfliction, validating aircraft routing and timings, deconfliction with air defence, UAV and indirect fire zones; and
- Targeting, both predetermined, pre-allocated and dynamic, time-sensitive.

The system aims to provide operationally credible scenarios which increase the realism of the training activity. The use of simulation to complement and stimulate the planning system permits a transition from Planning mode to Operational mode without the need to fly live aircraft. In turn, this can be used, for example, to de-risk planning for LiveEx events and to help planning staff use their planning applications. When suitably skilled staff is in short supply, it may become necessary to retrain someone from a completely different discipline to use the planning tool; a C2Sim-enabled system gives a low-risk way to support this. This work has been reported on more fully in the MSG-085 final report and by the MSG-085 Air Operations CIG [1][3].

4.2 Systems Used

Figure 1 shows the main systems used for the Air Planning Support. These are: the NATO Integrated Command and Control (ICC) application (one of the NATO Functional Area Service FAS applications); Networked Interoperable Real-time Information Services (NIRIS); C-BML web services; and Joint Semi-Automated Forces (JSAF) a Computer Generated Forces (CGF) simulation.

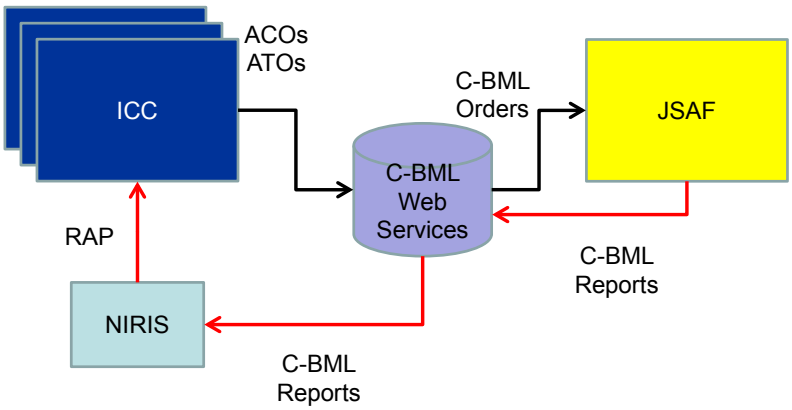

Figure 1: Air Planning Support, System Used.

4.2.1 ICC

ICC has a planning role and an operational role. For planning it can be used to prepare ACOs and ATOs. It can also be integrated with the Joint Targeting System/Flexible Advanced C2 Services for NATO Joint Time Sensitive Targeting (JTS/FAST) systems and ISTAR information using the NATO Coalition Shared Database (CSD) and Multi-sensor Aerospace-ground Joint ISR Interoperability Coalition (MAJIIC) systems. In the operational role it can display a Recognised Air Picture (RAP) and Common Operational Picture (COP). A number of ICC systems are incorporated to permit concurrent activity to be undertaken.

4.2.2 NIRIS

NIRIS is a network gateway which can process a number of regular C2 message formats, form and exchange tracks and populate the ICC RAP and COP.

4.2.3 C-BML Web Services

The C-BML Web Services are used to exchange C-BML messages between the systems.

4.2.4 JSAF

JSAF is used to fly the missions as tasked by the ATOs and to provide a synthetic environment to permit dynamic operational functions to be carried out, e.g. to fly the missions; stimulate sensors; provide targets; generate reports.

4.2.5 Translators

Translator software, for clarity not shown in Figure 1, is used:

- To generate and publish C-BML orders based on the ACOs and ATOs
- To subscribe to MSDL and C-BML Orders and populate and task JSAF;
- To publish C-BML reports based on the running of JSAF; and
- To subscribe C-BML reports and send them in an operational format such as NATO Friend or Foe Identification (NFFI) to NIRIS in order to create a track table and RAP in ICC.

In a fully integrated system separate translator would not be necessary because the key applications would have been designed and built with a native or inherent C2Sim capability.

4.3 C2Sim Aspects

Information extracted from example ACOs/ATOs requires that the C2Sim messages (C-BML and MSDL) and the simulation should be able to manage the following items:

- Air base International Civil Aviation Organization (ICAO) codes;
- Aircraft types;
- Air ORBAT and disposition;
- Standard Conventional Loads (SCLs);
- IFF Codes;
- Refuelling capabilities/requirements; and
- Mission types.

Not all this information is currently supported by C2Sim standards. Where this is not supported then work-arounds are used to augment the systems; in the longer term these extra requirements will be fed into the SISO C2Sim Product Development Group.

For Close Air Support (CAS) and Air-to-Air refuelling the C-BML messages are based on the information in Allied Tactical Publications, ATP-3.3.2.1 and 3.3.4.2, [4][5] respectively.

4.4 Observations on Missions

Taking typical missions from the air planners it is soon realised that not all missions are tasked, many are 'On Alert'. This is a way of allocating or reserving aircraft which may be used 'as required' during operations. In the C2Sim domain these aircraft would be tasked operationally as required. In the system described here this is via C-BML sent orders over a simulated Link-16 network.

Another observation is that the simulation flies the missions exactly as defined in the planning tool, not necessarily as a pilot would fly them. This is not currently a serious problem but an extra layer of planning capability or enhanced behaviours in the simulation could address this problem.

4.5 Current Developments

Several developments of this system are currently being considered, some supporting the end user, others more of a technical nature. These include integration with JTS/FAST, operational request for dynamic mission tasking as opposed to simulation operator tasking. Further tasking options and extension into the Joint domain are also being studied.

5.0 INTEROPERATION IN THE MARITIME DOMAIN

A number of MSG-085 members (TUR, NOR, CAN, FRA, DEU & BEL) formed a maritime operations CIG to investigate the suitability of C-BML to support maritime C2Sim interoperability. Their work has been reported in the MSG-085 final report and at the SIW [1][6]. The operational scenarios used by this CIG enabled a critical analysis to be made regarding how C-BML could be adapted and extended to cover use in the domain.

5.1 Experiences, Challenges and Findings

The effort available to this CIG constrained the study to a limited part of the Anti-Surface Warfare (ASUW) domain, a representative set of taskings and orders. Status updates and reports were not studied. Analysis of

ASUW messages showed that not all messages/message fields were relevant or applicable for C-BML modelling. An operational scenario and relevant operational message samples based on that scenario were found very helpful for the validation of the requirements.

Earlier work (before the establishment of MSG-085) by US Naval Postgraduate School before the establishment of MSG-085 [7] investigated the use of BML to support:

- Tomahawk Mission Plans and Orders – capturing the content of US Message Text Format (USMTF) Launch Sequence Plan and INDIGO messages.

5.2 Selected National Capabilities

To date no specific national or NATO maritime C2 systems have been adapted for use with C2Sim systems although a number of CGF simulations have been, or could be easily, adapted, e.g. OneSAF has been adapted to do C-BML Naval Gunfire Support (NGS). The French ORQUE maritime simulation has been used in a C2Sim environment (e.g. the ADIS VULCAIN federation referred to earlier).

6.0 INTEROPERATION IN THE JOINT DOMAIN

The UK's Joint Operational Training System (JOTS) Capability Concept Demonstration (CCD) illustrates the use of C2Sim in the joint domain. JOTS was developed to: "*understand and inform the Joint Training and Experimentation requirements, and enable the development of the Future Force 2020 and beyond*". The CCD was established at a number of centres representing, typically, a Joint Force HQ, Land and Air Component Commands (LCC, ACC) and a separate J2/J3 cell. These four centres were located at separate, geographically distinct sites.

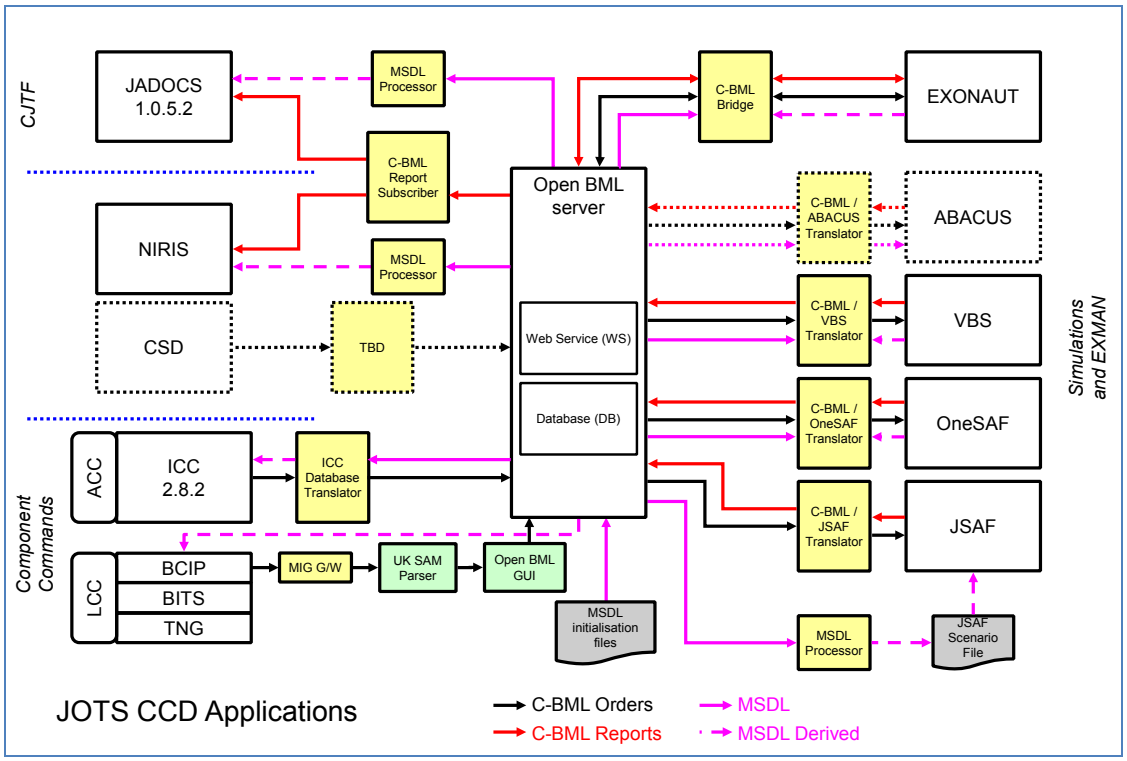

Figure 2: JOTS CCD Applications.

The JOTS CCD demonstrated how open standards-based, integrated and wide area distributed C2Sim can be used to support the following four themes:

- Joint Warfare Individual Training & Education (JWITE);
- Joint Collective Training (JCT);
- Joint Mission Planning (JMP); and
- Joint Warfare Development (JWD).

MSDL and C-BML were used with the JSAF CGF simulation and operational C2 systems: NATO ICC with a NIRIS gateway, Joint Automated Deep Operations Coordination System (JADOCS), Bowman ComBAT Information Platform (BCIP) in the JCT and JMP themes. C2Sim-enabled systems were part of a much broader, heterogeneous set of systems and capabilities representing typical component command systems, e.g. Voice Over IP (VOIP) phones, Exonaut exercise manager, Microsoft Office Shared Services.

7.0 CONCLUSIONS

"Simple" C2Sim interoperability has been demonstrated and proven in many different cases and can be made to work in a practical manner. With common middleware, well-defined processes and a small degree of determination practical systems have been developed which will readily combine to build more complex, and more usable, interoperable multi-national federations.

8.0 REFERENCES

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[5] ATP-3.3.4.2 Air-to-Air Refuelling (ATP-56), NATO, November 2013.

[6] MSG-085 Maritime CIG: Hakan Savasan; Akay Caglayan; Faruk Yildiz; Ole Martin Mevassvik, Geir Sletten; Ulrich Schade; Bastian Haarmann; Kevin Heffner; Towards a Maritime Domain Extension to Coalition Battle Management Language: Initial Findings and Way Forward, SISO paper 13S-SIW-022, San Diego 2013.

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9.0 ABBREVIATIONS

Abbreviation	Expansion
ACC	Air Component Command
ASUW	Anti-Surface Warfare
ATP	Allied Tactical Publication
BCIP	Bowman Combat Information Platform
C2Sim	C2-Simulation
CAS	Close Air Support
C-BML	Coalition Battle Management Language
CGF	Computer Generated Force
COA	Course Of Action
COP	Common Operational Picture
DCM2P	Distributed, Collaborative Multi-Course Of Action (COA) Mission Planning
DSEEP	Distributed Simulation Engineering and Execution Process
ELLIPSE	Expertise et Logiciels pour les Liens d'Interopérabilité Permanents des Simulations et de leur Environnement
ICC	Integrated Command and Control
IFF	Identification Friend or Foe
JADOCS	Joint Automated Deep Operations Coordination System
JCT	Joint Collective Training
JMP	Joint Mission Planning
JOTS	Joint Operational Training System
JSAF	Joint Semi-Automated Force
JTST	Joint Time Sensitive Targeting
JWD	Joint Warfare Development
JWITE	Joint Warrior Individual Training and Education
LCC	Land Component Command
MSDL	Military Scenario Definition Language
NFFI	NATO Friendly Force Identification
NIRIS	Networked Interoperable Real-time Information Services
NL-CST	Netherlands Command and Staff Trainer
ORET	Operational Running Estimate
RAP	Recognised Air Picture
SCL	Standard Conventional Load
SIMCI	Simulation to Mission Command Interoperability
USMTF	US Message Transmission Format
VOIP	Voice Over IP