C2SIM Systems and in Use/Coalitions Assembled

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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 describes the current state of practice of C2SIM with regard to client systems, server systems, ancillary software, and overall Coalitions: systems constructed from such systems.

1.0 INTRODUCTION

This paper was prepared to support a session in the NATO Modelling and Simulation Group Lecture Series in Command and Control – Simulation Interoperability (C2SIM). The session describes the current state of practice in C2SIM [28]. Topics include the various C2 and Simulation system clients; the server systems; ancillary software used. Also included are the C2SIM Coalitions that have been assembled: systems of systems, assembled from these various software instances.

2.0 C2SIM SERVERS

Four servers are in use today. Three of them, the VMASC CBMS and the FKIE Server, input and store whole XML document without parsing them. This is fast but it's not capable of translating since the server does not pull out individual data values (a process called "parsing") so it can't reassemble them into a translated document.

The WISE/SBML server, built by GMU on Saab's commercial information sharing platform (WISE), works by parsing which means it can translate. It is the one used by MSG-085 to support the final demonstration.

2.1 CBMS Server

The CBMS server was developed by Virginia Modeling, Analysis and Simulation Center for the previous Joint Coalition Warfighting organization. It was built on commercial Web technology which allows supporting very high message rates and was made available to selected government and national groups [8]. Figure 1 shows the architecture of CBMS.

Here is a description from the CBMS System Description Document, description CBMS subscription as shown in the figure:

The Subscription package uses the Atmosphere framework to open persistent connections to clients, filtering requests, and broadcasting responses. When an XML file is posted to the server, a database location called "temp" is created and the XML file is added to that temporary location. When a request is filtered and it is determined it needs to be broadcast to a subscriber, the XML is retrieved from the temporary location. A response is created with the XML as its payload, and it is sent to all interested subscribers.

CBMS supports several additional capabilities, in addition to the three core server functions:

- Namespaces
- Semantic validation using ontology
- Schema validation
- Filtering data for general queries and subscription Topics
- Logging
- SOAP and REST
- Serving MSDL
- Government open source (Open Technology Development)

Functions of JCW were taken over by US Joint Staff J-7 – interested parties should contact them for more information.

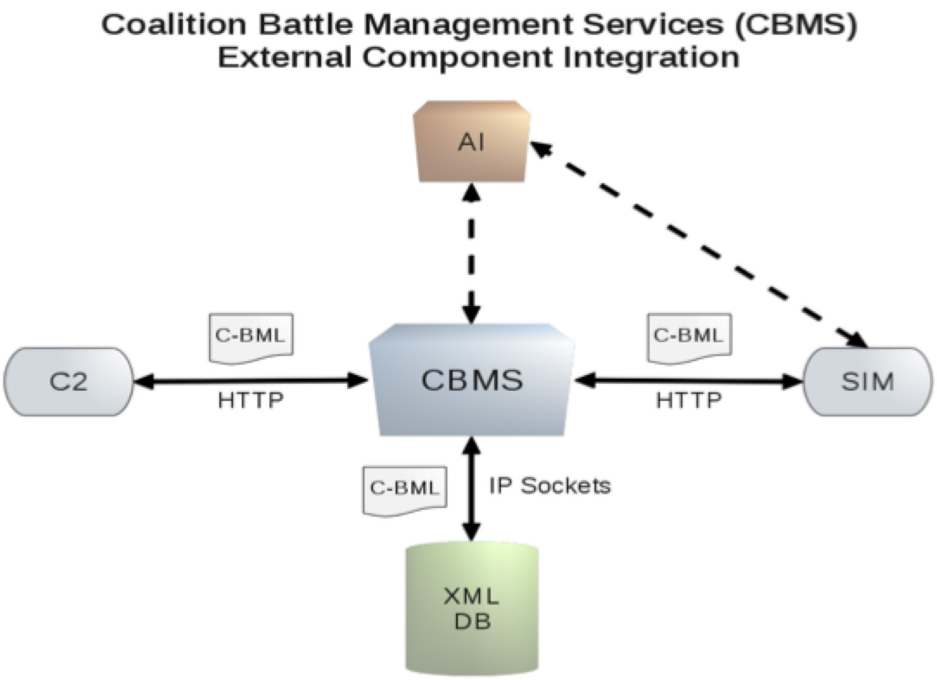

Figure 1: CBMS Architecture.

2.2 FKIE Server

For MSG-048, GMU built an open-source BML server using open-source XML technologies. In the tradition of open source, our collaborators at the German lab Fraunhofer FKIE have built their own server, starting from the GMU implementation but eliminating it parsing function. Thus it is a document-style server so it can't perform schema translation.

FKIE's sponsor, the German Bundeswehr, allows them to make the executable (not source code) of this server available under bilateral agreements with France, Denmark, Netherlands, and Spain [10]. Additional capabilities of the FKIE BML server are:

- Distributed operation
- Namespaces
- Filtering for distribution by Topic
- Logging
- SOAP and RESTful interfaces

2.3 Ellipse Server

The newest server in the community is Ellipse, developed b AIRBUS for France, to support their Joint Staff program. It has a number of features to support enhanced connectivity among systems. One of these is to function as a document-style BML server. So far, only an enhanced MSG-048 schema called IBML09+ is supported. Ellipse will be available in executable (not source) code under bilateral agreements with France.

Additional capabilities of the Ellipse server are:

- Distributed operation
- Namespaces
- Filtering for distribution by Topic
- JMS, SOAP and RESTful interfaces

2.4 WISE-SBML Server

The Widely Integrated Systems Environment (WISE) is a Saab commercial product, which provides high-performance facilities for system interconnection. The SBML part of WISE-SBML was built by GMU and is available as open source. It gives WISE a BML Web service interface using REST and STOMP protocols. Saab has interest in productizing this. The WISE platform is a Saab commercial product, but they make it available at no cost for development.

WISE-SBML is notable for having high performance even when translating. Its other features are:

- Namespaces
- Schema validation
- Filtering data for subscription topics
- Logging/replay
- Distributed operation
- Over 10x performance of original SBML
- SBML Schema translation

- Multithreading
- REST input
- STOMP output
- Aggregating and serving MSDL

2.5 Server Logging and Replay

As presented in the paper on C2SIM Infrastructure, some advanced BML server functions are:

- Logging inputs, with time stamps, for review
- Replaying the log to recreate the effect of the input stream
- Working with one or more other servers to distribute load (this can, for example, reduce overall network traffic)

Now let's consider what can and can't be done using replay in C2SIM today. The recorded server log is a useful tool for after-action review. Using a client that can read the log and emit messages matching its content, the server sends all the messages again. They can then be displayed on participating C2 systems. I'll run a demo replay of the MGS-085 Final Demonstration from Fort Leavenworth while I talk about this.

In principle, replay of the server log can be used to "rewind" an exercise or experiment to some point after its start and run again from there. This could be very useful in a training environment. However, there are some issues that have kept this from happening:

- In order to return the systems to some intermediate state, it is necessary to play the log from the beginning up to the chosen restart time; this needs a high performance server
- The C2 systems and particularly the simulation systems must be able to restore their internal state, either form the server's message stream or from internal storage. While some simulation systems do have a capability to restart at an intermediate time, we don't know of any that have arranged to synchronize that capability with a server.

2.6 Distributed Server Systems

The other advanced capability we will consider is distributed server operation [30]. Figure 2 shows an example of two servers cooperating in MSG-085 final demonstration:

- The FKIE server supported French and German C2 and simulation clients.
- The WISE-SBML server supported US and UK clients and translated among the three schemas used by different clients in the demo.

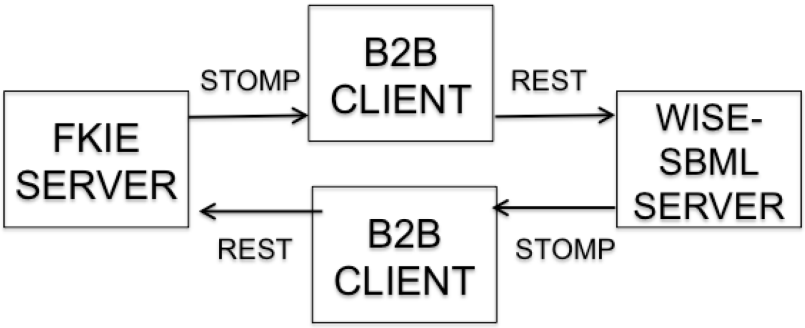

Figure 2: Simple Distributed Server Architecture.

Figure 3 shows a more complex distributed system of interoperating servers. One server relays messages between two others. This configuration, known as a "tree," is necessary to avoid looping messages back through the servers after they have been delivered to the clients once.

The potential benefits of the distributed server system are to reduce network traffic and distribute server load. However, neither of these is guaranteed. The distributed system-of-systems must be designed properly in order to achieve either or both of these.

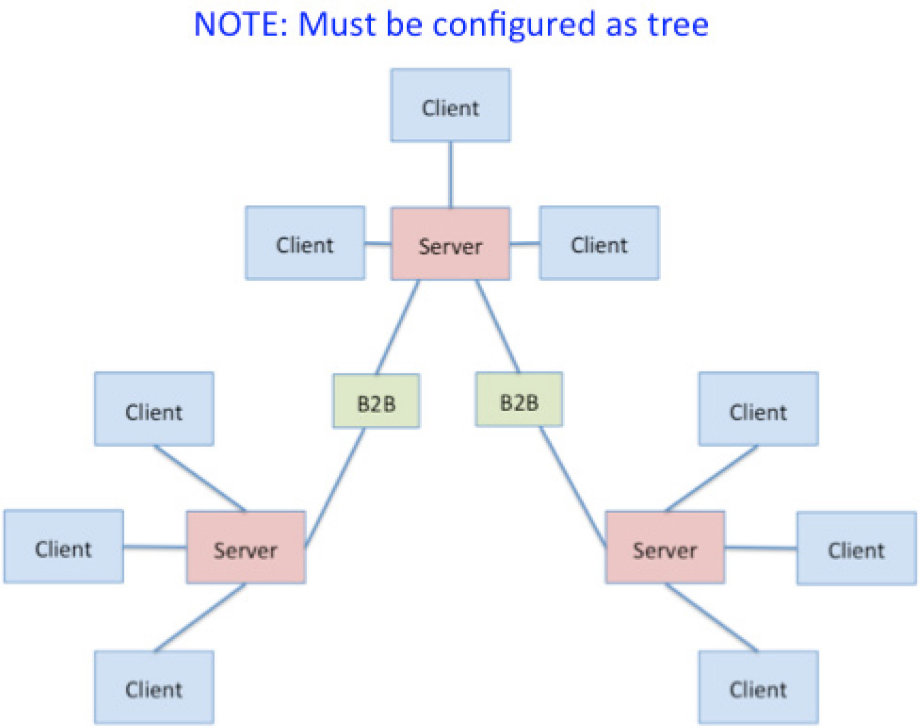

Figure 3: More Complex Distributed Server Architecture.

Figure 4 shows a demonstration of distributed BML servers, including the GMU/Saab server in Virginia, the FKIE server in Germany, and the Ellipse server in Orlando, Florida.

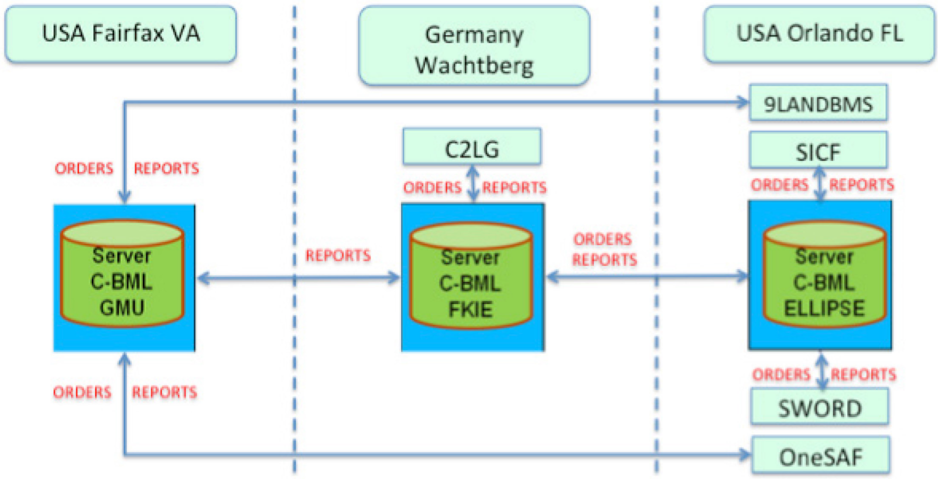

Figure 4: I/ITSEC 2014 Distributed Server Demonstration.

3.0 ANCILLARY SOFTWARE: SYSTEM COORDINATION

As described in the C2SIM Infrastructure lecture, another useful capability to assemble and operate a large C2SIM is a coordination mechanism. We discovered during MSG-048 that coordinating start/stop and involvement of multiple C2 and simulation programs is challenging. Therefore we built a webpage as a way to show participants the state of each system in the coalition [19]. It provides for a "master controller" who tells all systems to start. We also automated the interface, by adding a Web service client that can start/stop/pause the simulation.

Figure 5 shows a screen shot of such a webpage. All clients are either stopped or in setup here. The master controller has told all systems to initialize. They do this by reading the MSDL scenario file.

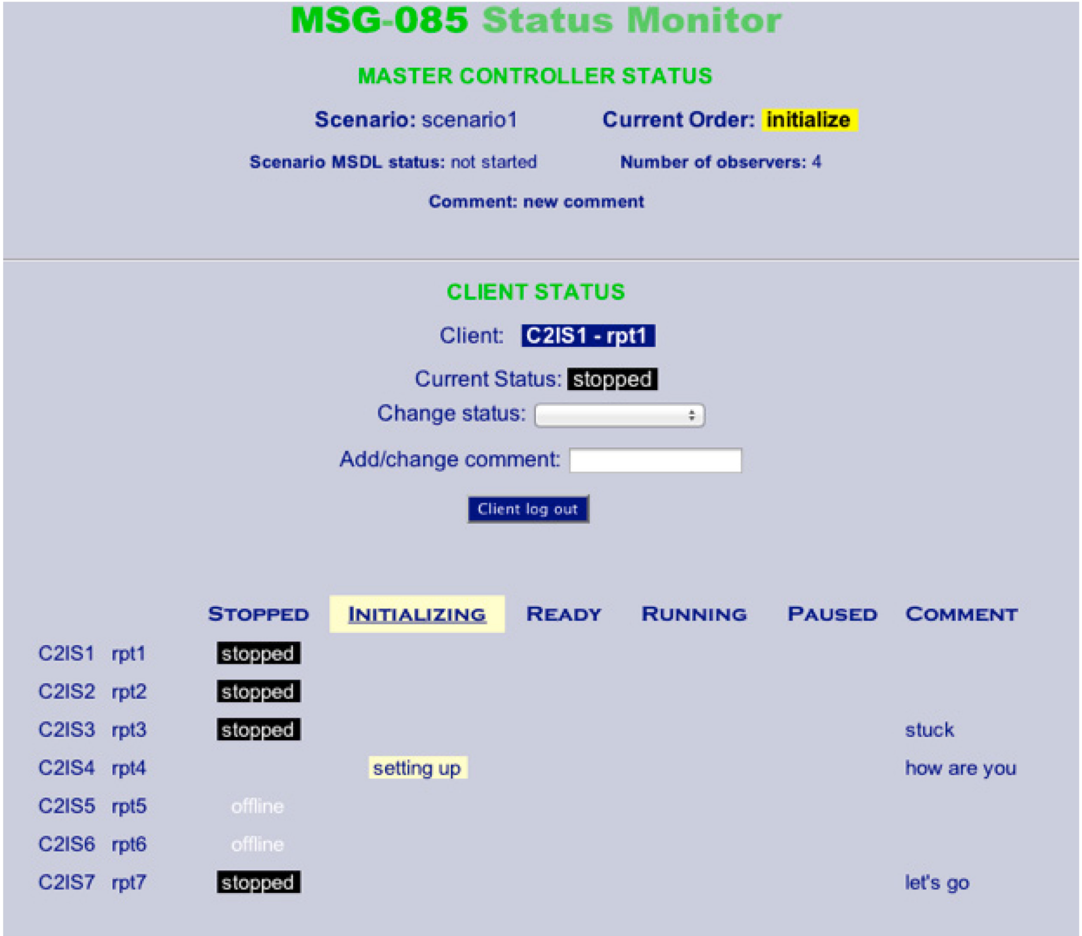

Figure 5: BML Coalition Status Monitor Webpage.

4.0 COALITIONS ASSEMBLED

This section introduces the list of Coalitions using the C2SIM standards-based Coalitions that have been assembled to date. These C2SIM Coalitions include those that were developed as part of the NATO MSG-048, German French COMELEC experiments, and MSG-085 demonstrations and final activities.

4.1 MSG-048

The NATO Modelling & Simulation Group 048 (MSG-048) conducted a Technical Activity (TA) from 2006 to 2009 that involved an assessment of the concept of Coalition Battle Management Language (CBML). MSG-048 included participation from Canada, Denmark, France, Germany, Great Britain, NC3A, the Netherlands, Norway, Spain, Turkey and the United States.

The 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. BML-enabled C2 systems were provided by Canada, France, Netherlands, Norway, UK, and USA. BML-enabled simulations were provided by Canada, France, Spain, UK, and USA. Supporting software was provided by Germany (C2LG GUI) and USA (SBML server). The event was conducted in collaboration with active and retired military personnel from several of the participating (NATO) nations. Several of them played an active role in the exercises that comprised the experimentation event.

A scenario, called "Operation Troy," was built by the SMEs that participated in MSG-048. These SMEs acted as the Brigade Staff that sent out the order to their subordinates. The exercise area was the Caspian Sea region used in earlier demonstrations. This allowed reuse of components that were prepared in 2007 and 2008. The Multinational Brigade consisted of French and Norwegian battalions and a US ground reconnaissance element, with UK air component and a Canadian UAV company.

The Mission given to the Brigade was to maneuver rapidly from an attack position along Phase Line Denver to seize objectives LION and TIGER, destroy Enemy forces in zone, and secure objectives along the international border to enable establishment of Caspian Federation (CF) regional military stability. Figure 6 shows a French Course of action.

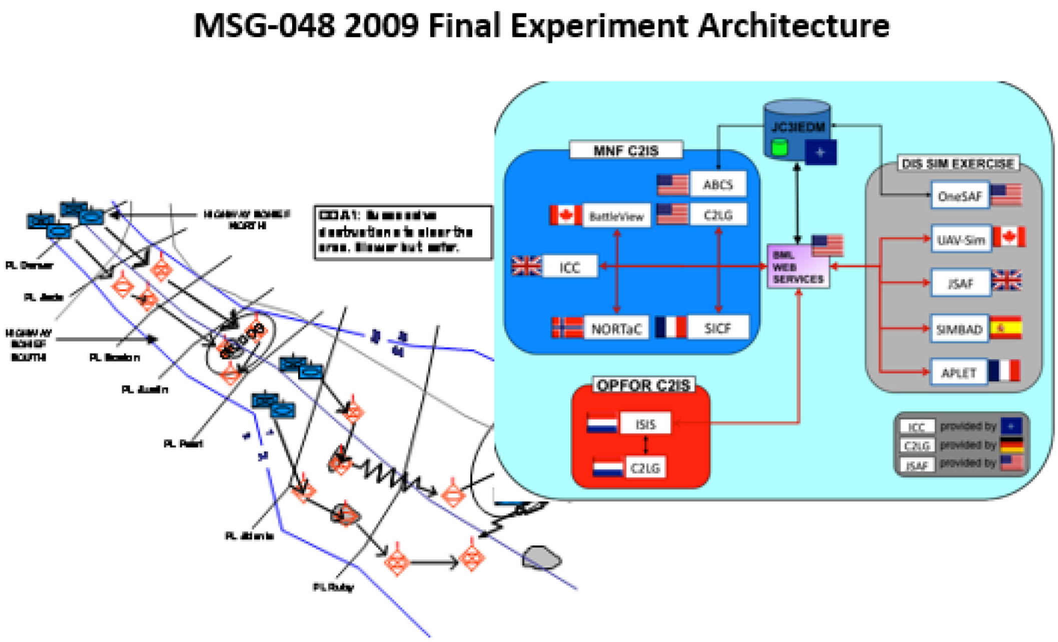

Figure 6: MSG-048 French Course of Actions [13].

By the end of the experimentation period, interoperability was achieved, many of the experimentation goals were met, and much was learned about how BML would need to be supported in MSG-085. Considering the complexity of the system of systems assembled (as reflected in the variety of subsystems described above) and that an entirely new paradigm was implemented, the fact that the MSG-048 final experimentation ended with all subsystems demonstrating interoperation was a significant accomplishment.

As a "proof of principle," the process followed was successful and showed that the technologies used, and the overall BML concept, would provide a sound basis for future work. This was confirmed by the participating SMEs, who were not part of the MSG-048 development team and therefore were able to view the results objectively.

Evidence that others also were convinced can be seen in the fact that MSG-048 received the NATO Scientific Achievement Award in 2013.

4.2 MSG-085 Initialization Coalition Demonstration (ITEC 2011)

As presented in the C2SIM Client perspective brief and shown in Figure 7 this MSDL-initialization focused Coalition was developed as part of MSG-085 and was demonstrated during ITEC 2011 in Cologne Germany [21].

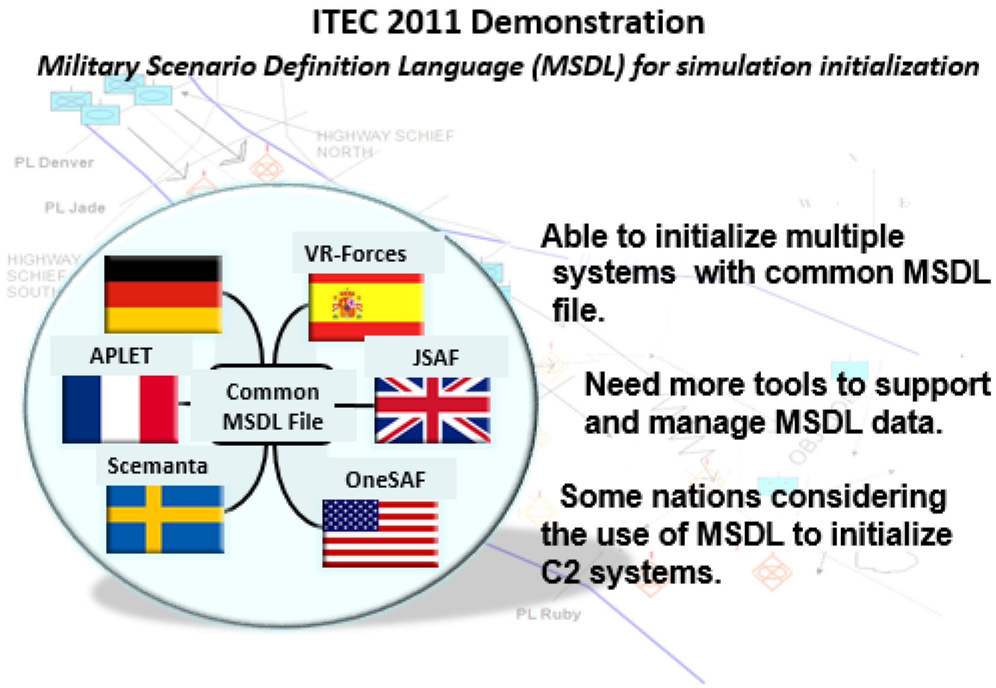

Figure 7: ITEC 2011 Demonstration [21].

This effort made a number of significant achievements to start the MSG-085 activity [21]:

1. It validated the concept that the MSDL standard could be used to merge coalition initialization inputs and support consistent initialization across a coalition simulation federation. Initial coalition participants included members from DEU, ESP, FRA, GBR, and the USA;
2. It established an engineering process and rhythm for coalition collaboration using MSDL and C-BML technologies within the MSG-085 organization; and
3. It provided lessons learned back to MSG-085 participants in the use of MSDL technologies in support of both simulation and C2 initialization.

4.3 MSG-085 Initialization Coalition Demonstration (COMELEC)

Concurrent with MSG-085 activities a German and French experimentation focused Coalition was developed and demonstration in December 2011 under the umbrella of the "Commission Electronique et Optronique – sous-comité 9" (COMELEC / SC9) cooperation in Ottobrunn, Germany.[32]

In general, the COMELEC C2/Simulation group's goal was to promote the common use of national simulations in addressing both interoperability between different simulations and currently between C2IS and simulations. In general, the main focus of the COMELEC is to provide the German-French Brigade with new M&S capabilities. In particular, the 2011 efforts focused on the following topics [32]:

- Enhancement of the task synchronization between French and German units, by using BML;

- Enhancement of smoothness to generate C2 orders and for simulation to execute tasks with more automation, by using BML;
- Enhancement of reports to address logistics (equipment and ammunitions), by using BML;
- Improvement of C2 systems and simulations initialization consistency, by using the MSDL standard and leveraging it to manage logistics aspects.

As shown in Figure 8 the experimentation demonstrated that MSDL and BML can easily be adjusted so that they work together to automate the use of simulations for use-cases like command post training, after action analysis, and decision support.

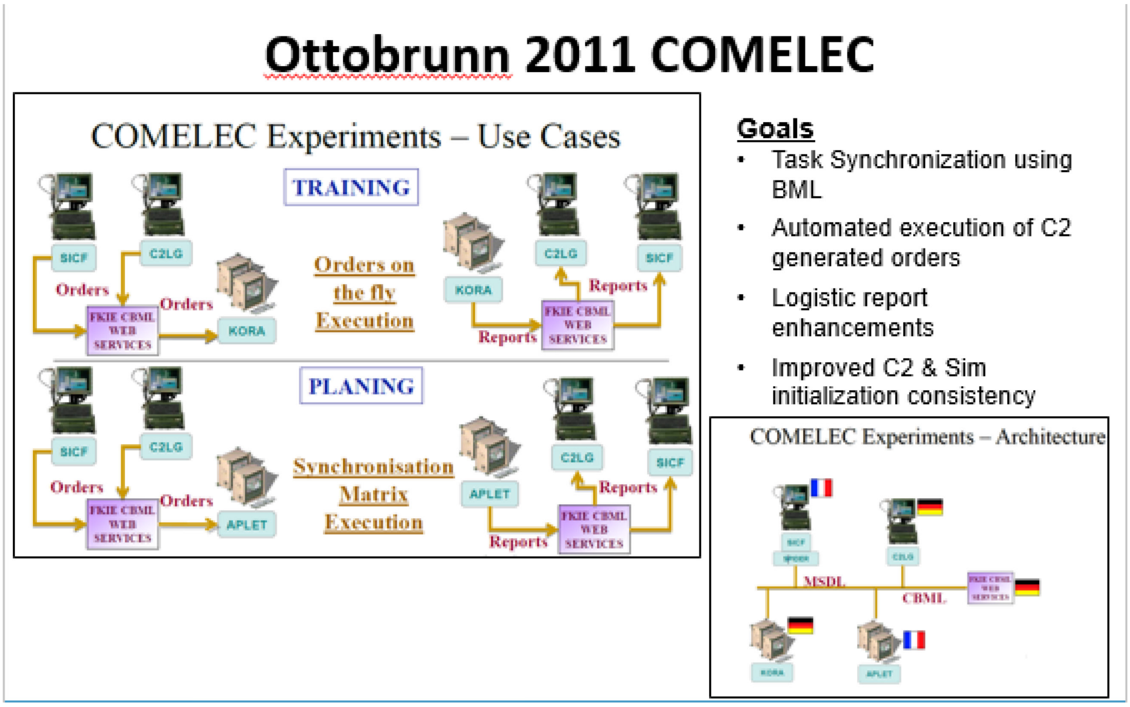

Figure 8: 2011 COMELEC [32].

The major aspect that enables this is that both MSDL and BML are defined by XML schemata that can be easily adapted with new data elements or with slight adjustment of existing data elements in the respective schema.

4.4 MSG-085 Distributed Coalition Training Development and Demonstrations (I/ITSEC 2011)

These demonstrations were developed and performed prior to and in support of I/ITSEC 2011 and extended the ITEC 2011 demonstration described above. The event focused on scenario initialization including pre-planned orders provided in C-BML format and referenced within the MSDL file. This demonstration also included MSDL/BML servers using different information exchange infrastructures while encouraging a maximum participation from the MSG-085 nations. The use case providing the basis for the demonstration was Distributed Coalition Training. The demonstration event included three demonstrations based on three different vignettes: [21]

1) Air/Ground Reconnaissance as shown in Figure 9;

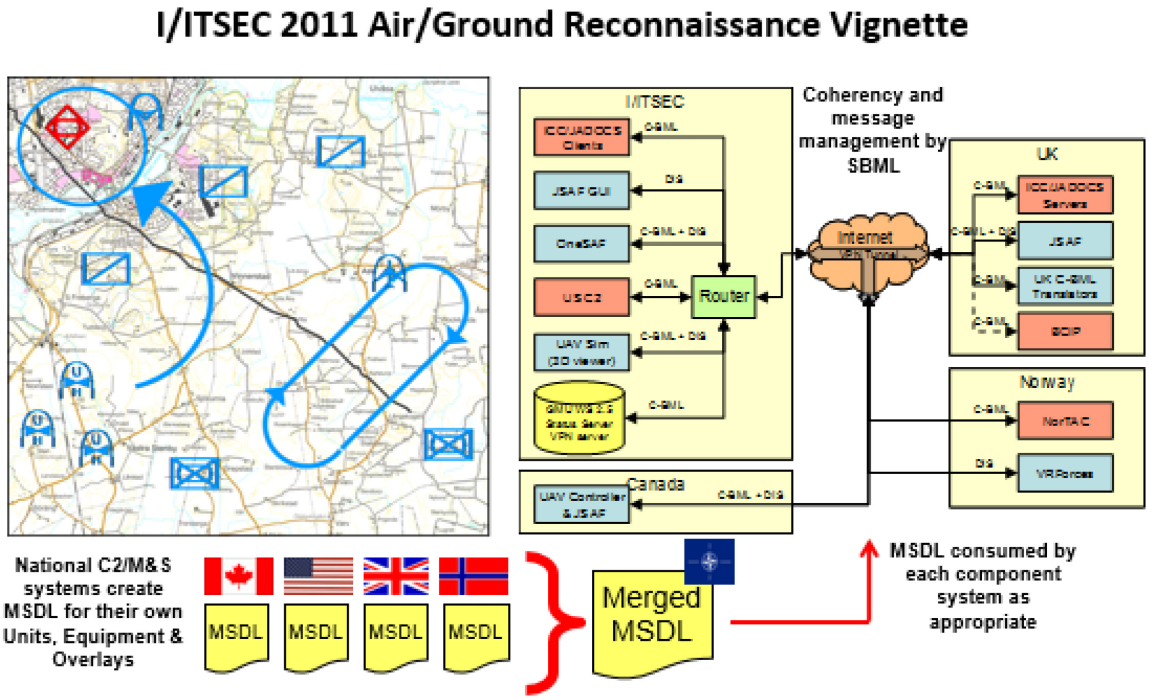

Figure 9: Air/Ground Reconnaissance Vignette.

2) Combined Operations and Logistics as shown in Figure 10; and

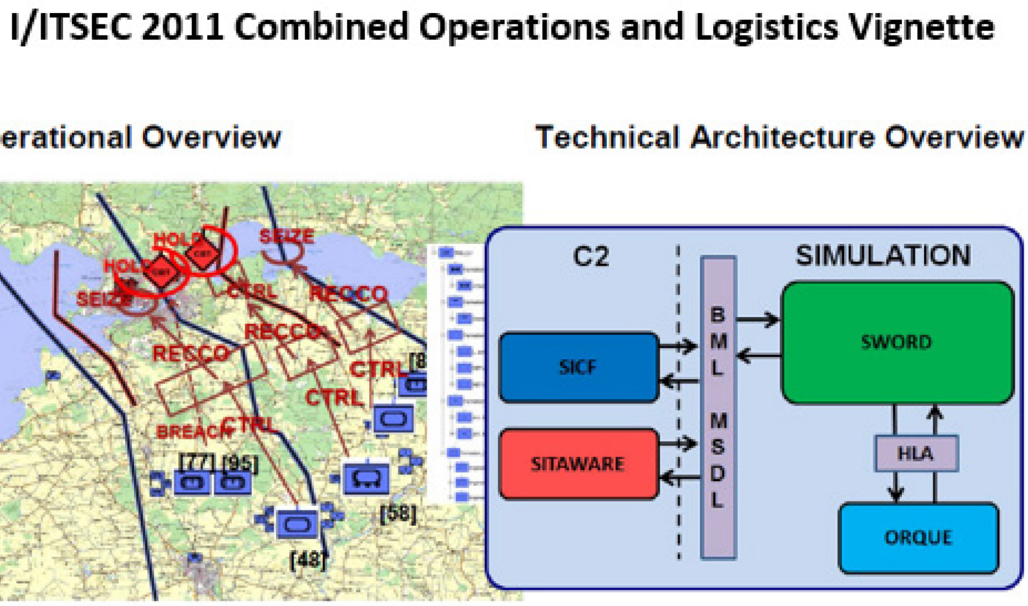

FIGURE 5-4 : COMBINED OPERATIONS AND LOGISTICS VIGNETTE AND ARCHITECTURE

Figure 10: Combined Operations and Logistics Vignette.

3) Ground Manoeuvre as shown in Figure 11.

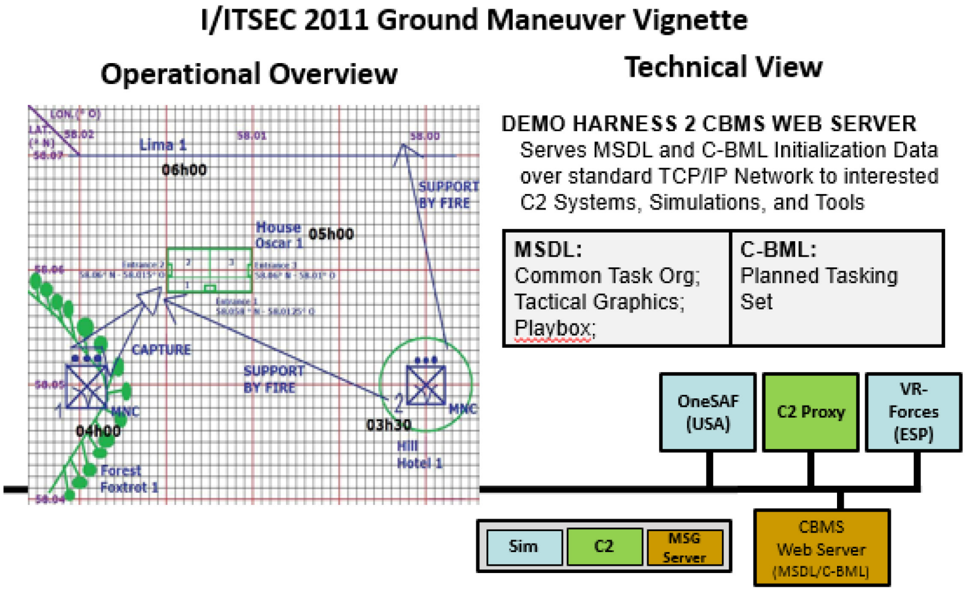

Figure 11: Ground Maneuver Vignette.

The demonstrations leveraged both MSDL and C-BML for scenario initialization and execution. Multiple "Capability Harnesses" were provided to support the Nations" requirements for exchanging information among C2 system, simulation and tools for scenario initialization and execution. Demo Harness 1 was based on the GMU Scripted Server Infrastructure and Demo Harness 2 utilized the Coalition Battle Management Service (CBMS) infrastructure provided by the US Joint and Coalition Warfighting (JCW). [21]

The goals of the demonstration event were the following:

1. There is a need to be able to initialize heterogeneous C2 and simulation systems in a coherent and systematic manner. MSDL can contribute to accomplishing this. This is the subject of continuing work and includes suggested extensions and amendments to both SISO C-BML and MSDL standards, using lessons learned during the MSG-085 Programme of Work.
2. It is important to be able to conduct experimentation, and ultimately operational planning and training, using systems that are not co-located but distributed, potentially across several nations. In principle, it should not matter whether systems are co-located, but in practice coordination is more difficult so processes and tools are required to coordinate and facilitate distributed activities.
3. To this end, during the demonstration, C-BML systems were connected from nodes in Norway, Great Britain and the USA. Real Command Post Training activities involve more than combat-related tasks. Therefore, the addition of logistics reports allowed for a more realistic capability that added realism to the training environment.

In addition to the results recorded from ITEC 2011 several positive conclusions were drawn from the vignette development and demonstration focused activities. The conclusions include:

1. Two independently developed MSDL/C-BML messaging infrastructures were successfully used to service initialization/re-initialization and order-based message traffic to a variety of C2 and simulation clients;
2. The MSDL transmittal file was successfully extended with logistics and C-BML related data; and

3. The use of MSDL/C-BML within the simulation and C2 initialization process led to shorter scenario preparation times than previous experience without the MSDL technology.

Many C2 orders provided to the simulations in C-BML format would have required additional artificial intelligence within the simulations to execute them with minimal import and transformation of the order set.

4.5 MSG-085 Distributed Combined Operation Coalitions (I/ITSEC 2012)

In early 2012, MSG-085 formed a number of Common Interest Groups (CIGs): Technical Infrastructure; Maritime Operations; Land Operations; Joint Mission Planning and Autonomous Air Operations. Each group comprising operational and technical specialists from across the MSG whose principal aim was to study requirements, use cases and identify solutions relating to the use of C-BML and MSDL in these domains. The CIG organization was orthogonal to MSG-085's original division into Operational, Technical, and Management SubGroups. An important aim of all the CIGs has been to work towards developing supporting knowledge and complementary skills, which were used in MSG-085"s final experimentation programme and contributed to the groups body of results and findings [21].

The goals of the demonstration event were the following:

- To illustrate how it is possible to initialize heterogeneous C2 and simulation systems in a coherent and systematic manner.
- To show the potential for conducting operational planning and training, using systems that are not co-located but distributed, potentially across several nations.
- To demonstrate the added realism of Command Post Training activities by including more than combat-related tasks. Therefore, the addition of logistics reports allowed for a more realistic training environment.
- To show how the C2SIM interoperability technologies developed by the nations can be utilized across several domains, including land operations and also air operations that involved the use of operational Air Coordination Order (ACO) and Air Tasking Order (ATO).

4.6 MSG-085 Distributed Combined Operation Coalitions for Mission Planning (I/ITSEC 2013)

MSG-085 held a series of demonstrations, with a core event architecture as depicted in Figure 12, highlighting the benefits of the latest technologies for C2SIM interoperability to the Warfighter. Battalion and Brigade level Joint and Combined Mission Planning demonstrations were given at the NATO booth. These demonstrations illustrated how the C2SIM technologies could be used to perform mission planning in a more effective, collaborative fashion [21].

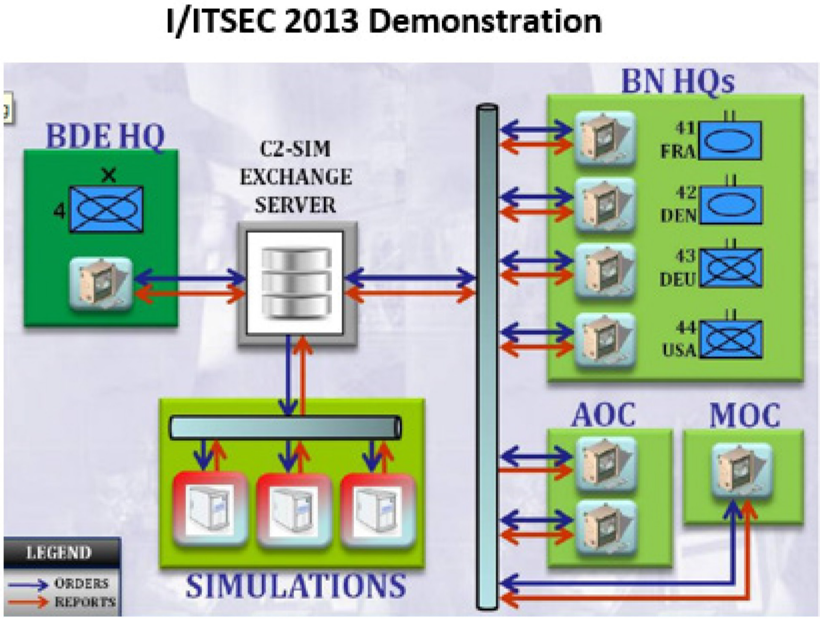

Figure 12: Final Demonstration Event Architecture.

The goals of the demonstrations were:

1. To show illustrate how C2SIM interoperability solutions also can lead to new ways of performing military activities such as joint and combined mission planning; and
2. To present a new approach for specifying, building, evolving and sharing C2SIM interoperability solutions using an engineering process.

4.7 MSG-085 Final Demonstration Series for Mission Planning (Ft Leavenworth, Kansas)

MSG-085 presented a final demonstration, using the event architecture shown in Figure 13, featuring military operational use of C2 systems interoperating with combat simulations on 12 Dec 2013. The demonstration was hosted by the Mission Command Battle Laboratory (MCBL) at Fort Leavenworth, Kansas, and featured six national non-US C2 systems and five national simulations, supported by servers from two different nations, linked into a single system of systems. Standards used were the Military Scenario Definition Language (MSDL), Coalition Battle Management Language (C-BML), along with elements of the JC3IEDM [21].

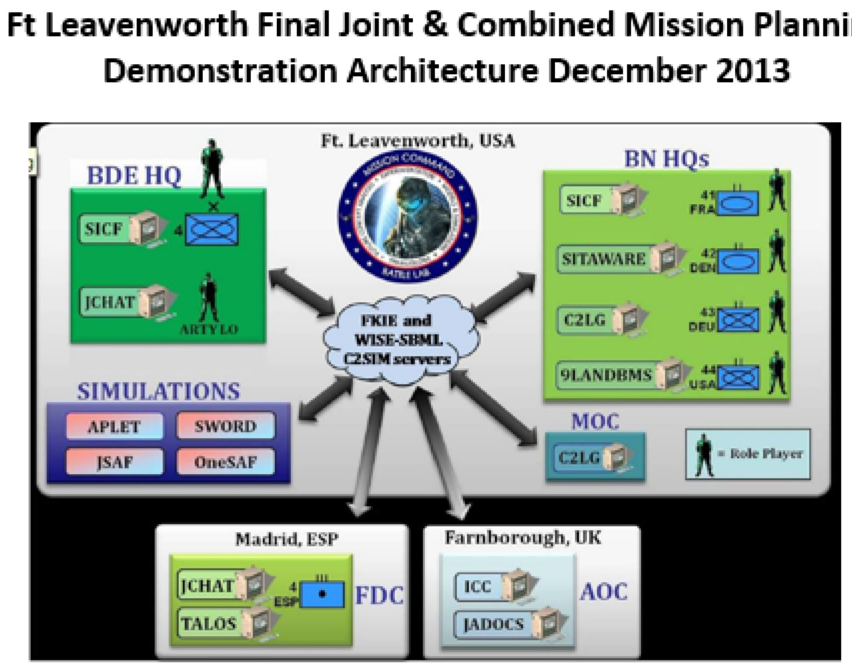

Figure 13: Final Demonstration Event Architecture.

The operational focus of the demonstration was joint and combined mission planning, operating in a breakthrough parallel, collaborative mode across brigade and battalion echelons of a multinational coalition force. Personnel and systems from nine nations (23 personnel) participated at Leavenworth while personnel from the United Kingdom and Spain participated from their home locations via Internet links. Military SMEs provided by the MCBL played roles of brigade and battalion commanders and contributed a critique of the operational employment that was highly positive and also offered avenues for future improvement [21].

The demonstration was well attended by US and international military and supporting civilian personnel, who offered mainly positive comment and also recommendations to improve operational utility, for example the need to resolve security issues before deployment. The senior military attendee was Brigadier General Thomas S. James, Director of the US Army Mission Command Center of Excellence, who stated very positively that the category of systems demonstrated by MSG-085should have an important role in supporting a wide range of future military operations by the US and its coalition partners [21].

The main purpose of the demonstration was to show how C2SIM interoperation technologies can be used to facilitate collaborative distributed planning. In particular, the goal of the demonstration was to show that these technologies can contribute to increased collaboration among brigade and battalion commanders during COA development [21].

The main results of the demonstration can be summarized with respect to the following achievements [21]:

- *Network sophistication*: The MSG-085 network included two remote participants and operated with two linked servers and three schemata (C-BML Full, while available on the WISE-SBML server, was not used by any of the systems). This models the sort of operation expected in operational BML use.
- *Setup process*: The MSG-085 systems came together smoothly. There were a few problems; mostly things “just worked”.

- *Audience impression*: The Final Demonstration audience got the message "We have an exciting new capability and it works very well to improve some unmet needs of coalition C2, using interoperable simulations."

In short, MSG-085 succeeded in achieving the main demonstration goal: proving the concept that C2SIM in the form of MSDL and C-BML is ready to be tested in real coalition operations.

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