Using the Multinational Experiment 4 (MNE4) Modeling and Simulation Federation to Support Joint Experimentation

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ABSTRACT

Multinational experimentation is a critical element of the United States Joint Forces Command's (USJFCOM) Experimentation Directorate (J9) joint concept development and experimentation program. The Multinational Experiment (MNE) series explores ways to achieve a coalition's political goals by influencing the behaviour of our adversaries by relying on the full weight of the coalition's collective national powers (diplomatic, information, military and economics actions). MNE4, conducted in February – March 2006, was one such experimentation venue that explored new ways to apply the various elements of the coalition's considerable influence, short of direct military conflict. MNE4 required an extensive international modeling and simulation (M&S) development effort with models provided by France, Germany and the United States. France provided the Application Logiciele InterArmees Nationale pour l'entainement Au Commandement d'un Engagement militaire (ALLIANCE). Germany provided the Joint Operations Army, Navy, Air Force (JOANA) simulation system. The United States provided the Joint Semi-Automated Forces (JSAF) and the Synthetic Environment for Analysis and Simulation (SEAS) systems. The resultant constructive environment rendered by MNE4's four simulation components supported the entire range of the effects-based approach to assist in the development of future processes, organizations and technologies. Many M&S challenges were addressed as three countries conducted a series of integration milestone and spiral development events to make their respective models

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interoperate. M&S components provided the constructive environment at the platform and unit levels, which were displayed via web-enabled Command, Control, Communications, and Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems. Several first time successes were necessary to make this international development effort a reality. The significance of this work stemmed from the on-going international cooperation needed to get the simulations to communicate and understand each other's interactions. As the M&S community better learns to work together, it will favorably influence the coordination and cooperation needed to advance other work associated with MNE5. In turn, the MNE5 federation will provide an enabling tool to revolutionize coalition military and inter-agency experimentation. MNE5 will seek to include representative participants from non-military organizations to explore how to integrate international capabilities across the spectrum of international security issues. This paper discusses the technical approach to create a sufficient M&S environment for MNE4, and how this development effort may be leveraged for MNE5.

1.0 BACKGROUND

The United States Joint Forces Command (USJFCOM) Experimentation Directorate (J9) conducts studies that require the modeling of population centers and their associated cultures. These studies support the warfighter's evolving need to plan and execute complex regional operations as interdependent joint forces involving non-Department of Defense (DoD) agencies and other nations while drawing upon global resources and considering global consequences [1] and USJFCOM's mission of development and integration of joint, interagency, and multinational capabilities to meet present and future operational needs.

Multinational Experiment 4 (MNE 4), conducted from February 27 to March 17, 2006 explored the uses of international power (diplomatic, information, military and economic) to influence the behavior of adversaries. The MNE4 participants – Australia, Canada, Finland, France, Germany, Sweden, the United Kingdom, the North Atlantic Treaty Organization (NATO) and the United States – used an effects based approach to operations (EBA), which included knowledge-base development and effects-based planning, execution, and assessment. MNE4 built on the experience of previous J9 experiments, especially MNE3, which included a multinational simulation federation.

The Modeling and Simulation (M&S) federation was a key enabler for MNE4. Four simulations joined together to create the MNE4 synthetic environment. The United States provided the constructive simulations Joint Semi-Automated Forces (JSAF) and Synthetic Environment for Analysis and Simulation (SEAS). Two other federation members included France's Application Logiciele InterArmees Nationale pour l'entainement Au Commandement d'un Engagement militaire (ALLIANCE) and Germany's Joint Operations Army, Navy, Air Force (JOANA). The Coalition Task Force (CTF) simulation federation signified a multinational leap-ahead in coordination and international cooperation. As the international M&S community better learns to work together, it will favorably influence and accelerate the coordination and cooperation needed for coalition experimentation and joint force transformation. This paper discusses MNE4 battlespace simulation and command and control (C2) information system stimulation.

2.0 A GLOBALLY DISTRIBUTED, TRULY INTERACTIVE MULTINATIONAL SIMULATION FEDERATION

The four MNE4 simulations interact via the High Level Architecture (HLA) protocol in a true coalition and globally distributed M&S federation. ALLIANCE, JOANA, and JSAF provided the kinetic synthetic battlespace while SEAS provided insights into local population "non-kinetic" responses to kinetic actions.

ALLIANCE, JOANA and JSAF used simulation bridges to send emulated message traffic to the Global Command and Control System (GCCS) server. All three kinetic simulation systems stimulated GCCS with Over-the-Horizon (OTH) Targeting Gold (OTG) position reports while JSAF's bridge, a Joint Live Virtual Constructive Data Translator (JLVCDT) prototype, also generated a real-time Link-16 data stream. A second simulation federation consisting of separate instances of JSAF and the JLVCDT provided the virtual battlespace for a simultaneous NATO Response Force (NRF) certification exercise. Figure 1 shows the simulation to C4I setup for MNE4.[1]

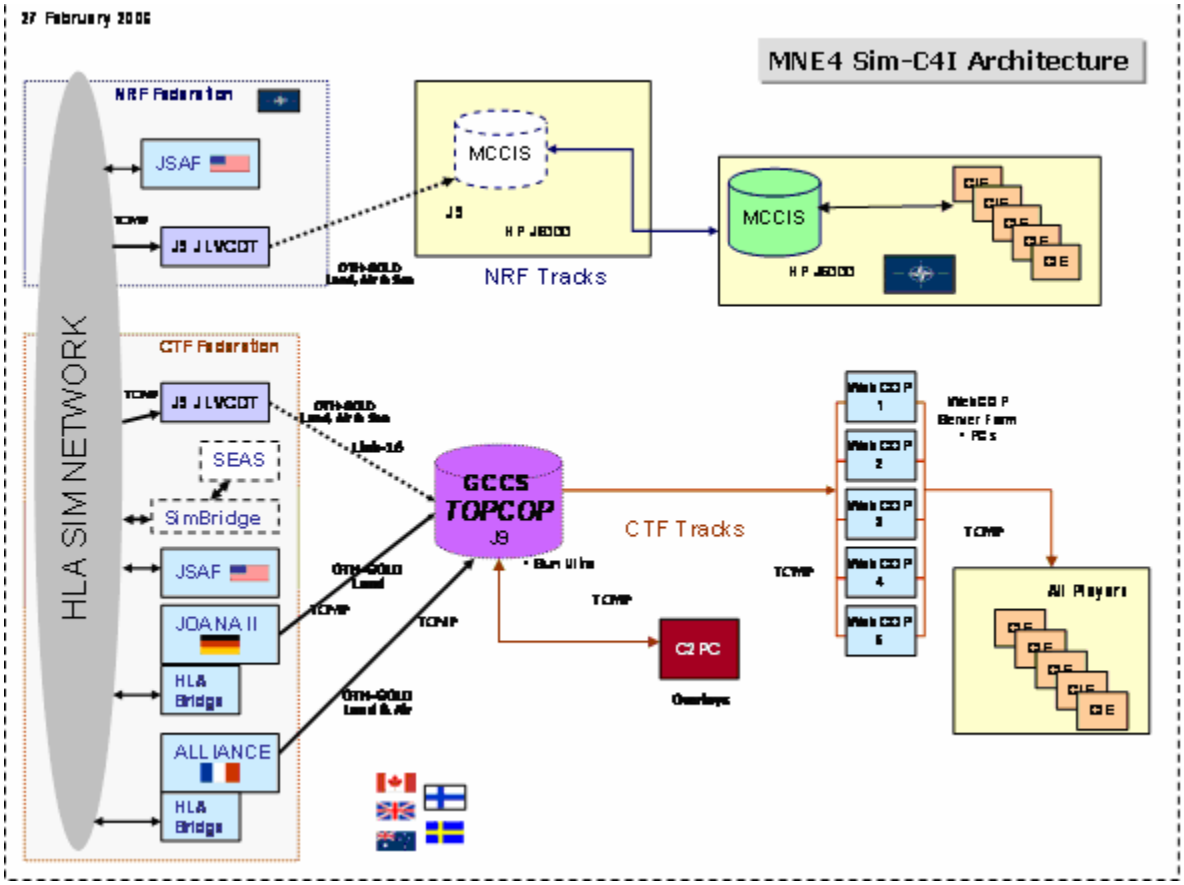

Figure 1: MNE4 Sim-C4I Architecture

2.1 JSAF

Joint Semi-Automated Forces (JSAF) is the primary M&S component used by the J9 to conduct experiments involving conventional combatant operations. JSAF represents military organizations at a granularity where fundamental processes of target identification and kinetic actions associated with inflicting damage against targets can be measured. Individual sensors and munitions are represented as distinct entities. The processes of acquiring and engaging entities in a synthetic environment are modeled as independent and explicit occurrences, enabling a quantified comparison of engagement protocols. The JSAF terrain file is constructed using real-world data provided by the U.S. National Geospatial-Intelligence Agency (NGA). The Compact Terrain Database is capable of scaling to representations of over a million buildings, and each building is

[1] A third simulation federation (not shown in Figure 1) was used for troubleshooting and software development.

uniquely identified, so emulated pedestrians and combat platforms can interact with the buildings based on pre-established behaviors [9]. Of more importance for non-kinetic modeling, buildings can be singled out, and mapped to corresponding Political Military Economic Societal Information Infrastructure (PMESII) functions which can interact with Agent Based Simulations (ABS) [7].

2.2 Integrated Components Augment JSAF's Capabilities

Integrated with JSAF are many federated sub-components that assist with kinetic and non-kinetic cultural modeling of the battle-space. CultureSim efficiently models large numbers of pedestrians, civilian vehicle traffic, and crowds. Dynamic Terrain Simulation (DTsim) models collateral damage and building repairs that can trigger a change in the well-being of the local populace. ModStealth provides a three dimensional view of the battlespace to include CultureSim and JSAF PMESII coded buildings. Additionally, ModStealth displays either angry or curious CultureSim rendered crowds, which can be detected by virtual sensors representing different service collection platforms. Rendered crowd differences are based on different appearance bit settings associated with the object enumerations sent over the HLA run-time infrastructure (RTI).

2.3 SEAS Modelled the Population's Behaviour and Cultural Attitudes

SEAS is an ABS that models the behaviour and the emergent cultural attitudes of population centres. Artificial agents create a fully functioning synthetic infrastructure and corresponding relationships, economies, societies, nations, and organizations that mirror the real world actors [7]. The SEAS environment describes the background, and the contextual structure of the domain for which the synthetic environment is developed. Additionally, SEAS contains the geography and the physical details of the space such as the road networks, the structures, traffic patterns and pedestrian dispersion. Within this environment, agents communicate, sense and interact to mimic the behaviour of actors at various levels of abstraction [10]. SEAS assists with the correlation between tactical combat actions and non-kinetic behaviour by employing two types of simulations: Near Real-Time (SEAS-NRT), and Virtual International System (SEAS-VIS). SEAS-NRT advances time at sufficient granularity to address the interactions between civilian individuals and military forces. It listens for kinetic simulation interactions, such as explosions, in the vicinity of the PMESII coded buildings and cues CultureSim to render either angry or curious crowds. SEAS-VIS simultaneously captures the perceived behaviour of the population on a larger scale, and establishes the context, which in this case influences the opinion of organizations, citizens and leaders in regards to the support of coalition forces, the local governance and adversarial activities. SEAS-VIS does this by modeling the intra and inter-nation dynamics of national PMESII to include expectations, goals and desires for well being. Thus SEAS captures population behaviour in an urban setting by simultaneously handling diverse models at multiple temporal and spatial granularities [7].

Coupling JSAF with SEAS makes it possible to represent a full cycle of military decisions and civilian reactions in regard to modeling the restoration of essential city services [7]. This modeling includes the improved relations between friendly forces and a foreign culture, which has a direct influence on the civilian reactions. These reactions are the response the populace has to local events based on actions against different types of infrastructure representing the PMESII. The challenge in coupling diverse models such as JSAF, SEAS-NRT and SEAS-VIS is their respective perception of different temporal and spatial granularities [7]. With respect to modeling EBA, kinetic actions can instantiate themselves within minutes, but resulting second and third order effects on the population's demeanour can take days to surface.

By organizing SEAS generated data under the object entity of the Joint Consultation, Command, and Control Information Exchange Data Model (JC3IEDM), developers may be able to extend C2 systems to include increased non-military data and Crisis Response Operations (CRO) information exchange requirements (IERs). In turn, ABS may have a significant role in providing insights as to how information can better

facilitate decision making by modeling non-kinetic complexities. Therefore, SEAS may be useful in evolving the JC3IEDM model taxonomy.

2.4 Multinational Partner Models Fulfilled MNE4 Requirements

JSAF and SEAS did not simulate all of the units, behaviours and interactions needed to adequately model the complex multinational MNE4 scenario. The MNE4 scenario included requirements for peace support operations (PSO) units including: civilian and military convoys, Internal Displaced Persons (IDP) camps, checkpoints, blockades, terrorist incidents, United Nations (UN) and civilian flights, and a variety of other PSO units and operations. The scenario also called for national military units from the participating countries. To achieve the MNE4 M&S goals, the simulation federation also relied on M&S expertise provided by the ALLIANCE and JOANA development teams. Among the four simulations, scenario simulation responsibilities were divided among the federation members to take advantage of the respective strengths of the individual simulations and to distribute the processing load. Units from countries providing simulations were typically, but not always, simulated by that country's simulation system.

2.4.1 ALLIANCE

A portion of ALLIANCE's capability, France's simulation component of MNE4, was used to model the kinetic effects of indirect fire units and fixed wing aircraft. ALLIANCE simulated land units and aircraft entities, including entities capable of intelligence, surveillance, and reconnaissance, up to 600 missions. Land units are published as aggregate entities and aircraft are published at the entity level. Aircraft are equipped with Identification Friend or Foe (IFF). In MNE4, ALLIANCE simulated French ground units and French, German, civilian and United Nation aircraft.

2.4.2 JOANA

JOANA is a German simulation component that models kinetic effects of ground combat and support operations. JOANA simulates jointness and service interoperability in the areas of C2, PSO, reconnaissance, combat, integrated air defence, logistics and strategic movement. The JOANA-PSO component provides the capability to investigate how PSO units interact in the synthetic environment with military and civilian entities. JOANA-PSO was developed to represent peace-enforcing and peace-keeping operations within a civil-military environment including elements of asymmetric operations, like weapon caches and prison camps, mass graves, drug cultivation and transportation, terror assaults, blockades and checkpoints [14]. In MNE4, JOANA modelled camps (refugee and Internal Displaced Persons (IDP)), resupply convoys for those camps, civilian convoys, Afghan National Army (ANA) convoys and patrols, and German national ground forces.

Putting together these four complementary simulation components provided J9 the capability to simulate the scenario's complexity to include humanitarian relief, movement of intelligence or surveillance assets, and the execution of small scale combat interactions. The information exchanges among these four simulations sufficient enough to display a near real time common operating picture (COP) was transformational [21] . In addition to their participation in the simulation federation, JOANA and SEAS also performed an EBA planning function (Course of Action Analysis wargaming) outside of the battlespace execution support.

2.5 Building the COP

Critical to MNE4 success and the joint experimentation process is the development, implementation and management of the Joint COP architecture. The term "TOPCOP" refers to the actual GCCS-J server that hosts

the primary COP node for the CTF Commander. The COP serves as the central command and control situational awareness capability for the CTF Commander while providing the principle data feed to the MNE4 Web-based COP client systems. MNE4 was the first joint experiment to use GCCSv4.0.1. The COP is the integrated capability to receive, correlate, and display a Common Tactical Picture (CTP), including planning applications and theater-generated overlays and or projections for instance, battle plans, and force position projections. Overlays and projections may include location of friendly, hostile, and neutral units, assets, and reference points. The CTP is the data linked system that shares tactical data at all levels for an operation, from the squadron up. The system enables all involved units to have access to needed information [20].

The CTF Commander, CTF components, service components, and logistics and supporting units share the same common dataset throughout the area of operations. The COP provides these elements and other coalition supporting forces with a common battlespace awareness of the location of enemy and friendly forces and other relevant data points such as operational overlays and certain neutral entities such as IDP camps and civilian convoys. The MNE4 TOPCOP is a fusion of battlespace pictures from coalition forces producing a centralized operational database for distribution to C2 nodes in the MNE4 player and exercise control cells.

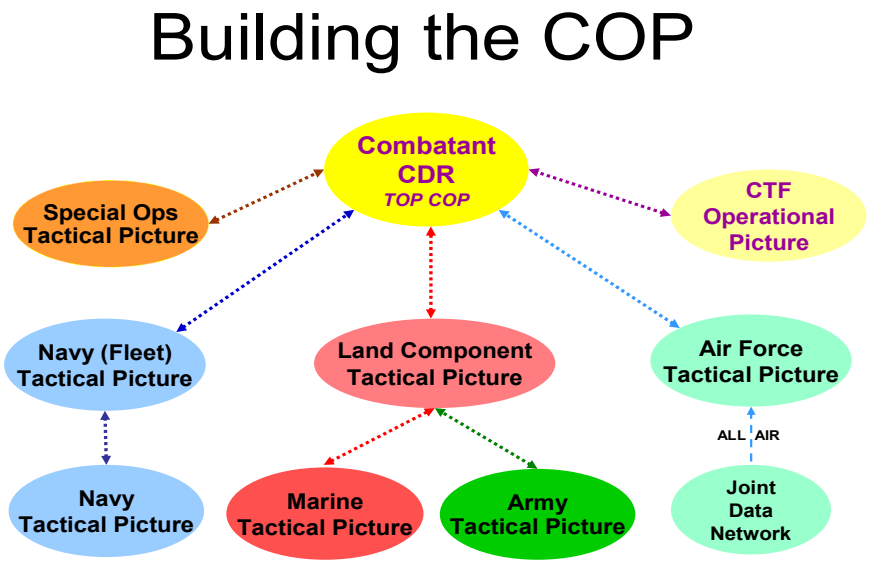

Figure 2: Building the COP [20]

2.5.1 Translating JSAF Data to C4I Information

The JLVCDT prototype converts JSAF simulation information to real-world C2 information system message formats. In MNE4, the JLVCDT produced two types of C2 messages: OTG and Tactical Data Information Link – Joint (TADIL-J) J-series messages. TADIL-J is also known as Link-16.

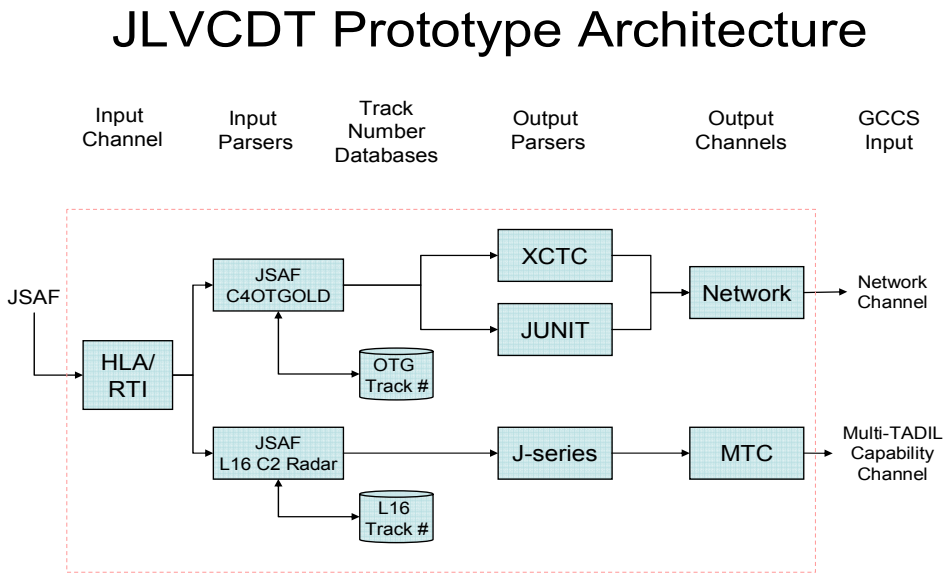

Figure 3: JLVCDT Prototype Architecture

The JLVCDT OTG reporting task passively listens to the JSAF command and control message (C4OTGold) infrastructure and produces the information in OTG message format. OTG messages provide a standardized method for transmitting selected data between C4ISR systems and are designed to be human readable. JSAF publishes C4OTGold messages based on individual entity or unit task frame self-reporting configuration settings. The data under a JSAF entity's Reporting Tab controls how vehicles or units are reported into C2 Systems and how it is perceived to be reported (based on the simulation/C4I configuration). The JLVCDT sends the properly formatted OTG messages to the GCCS network communications channel. Ground tracks are reported using Joint Unit (JUNIT) reports. Sea and air tracks are reported using Contact Reports (CTC).

The JLVCDT Link reporting capability produces a Mil-Std-6016c J-series bit oriented data stream. JLVCDT data comes from a JSAF entity configured as a Link-16 C2 platform – typically an E-2 Hawkeye or E-3 Airborne Warning and Control System (AWACS) aircraft model. The JSAF C2 platform reports precise participant location information (PPLI) (J2.x message data) for entities configured to participate in the Link-16 network. The C2 platform reports track information (J3.x message data) for other entities detected by the platform's radar model. The JLVCDT prototype formats the message data into Mil-Std-6016c J-series messages and sends the messages to the GCCS Multi TADIL Capability (MTC) communications channel.

2.5.2 Track Management

Track management was performed at the TOPCOP GCCS server to correlate the various tracks produced by the simulation federation. Once in GCCS, track information is then shared out via a web-enabled GCCS segment called WebCOP [6]. Added to the architecture, Command and Control Personnel Computer (C2PC) provide a capability to manually draw overlays and share user graphics.

Air picture management relied heavily on IFF models in JSAF and ALLIANCE. JSAF published link tracks for all aircraft detected by the JSAF C2 aircraft radar model. Air tracks were also published to GCCS as platform tracks by JSAF and ALLIANCE because commander intent was contained in OTG formatted remarks (RMKS) fields and because ALLIANCE does not produce J-series messages. To facilitate GCCS track correlation and enhance experiment realism, the Mode 2 IFF codes were uniquely populated for aircraft in accordance with the Air tasking Order (ATO).

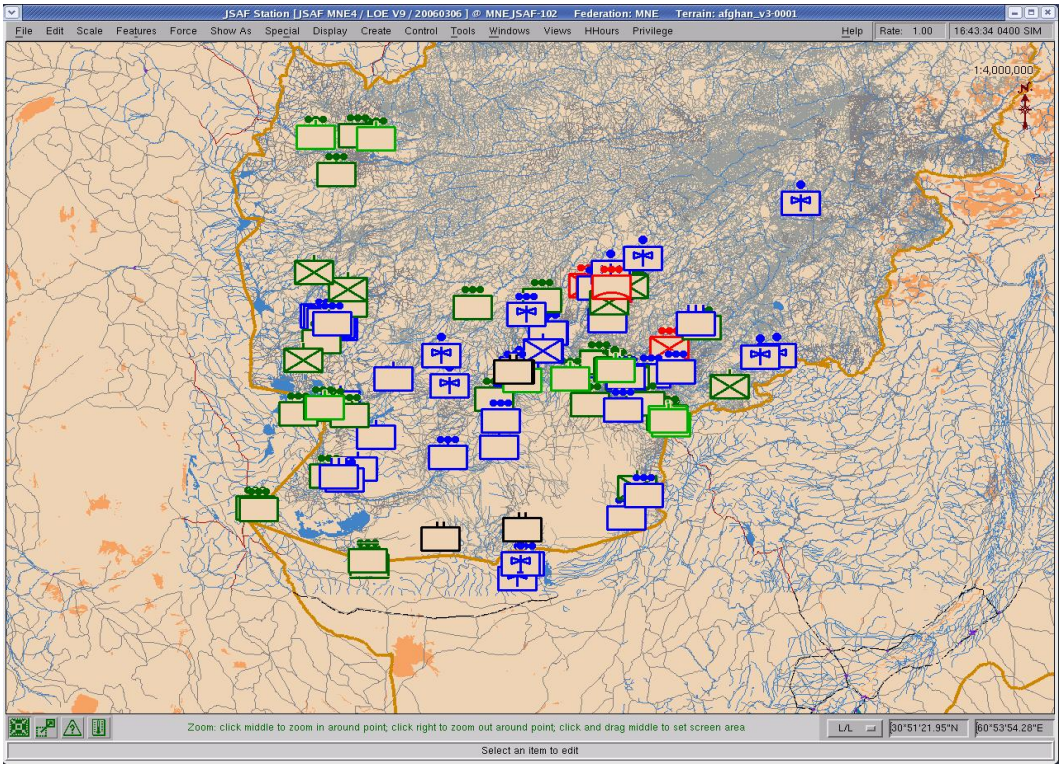

Figure 4: Federation units as viewed on the JSAF PVD

Figure 4 shows aggregated federation simulation unit icons as viewed on the JSAF PVD. JSAF was configured to show ALLIANCE ground units as black icons and JOANA ground units as dark green icons to make it easy for the simulation operators to determine which simulation system modelled the units. Figure 5 shows the COP as displayed on WebCOP.

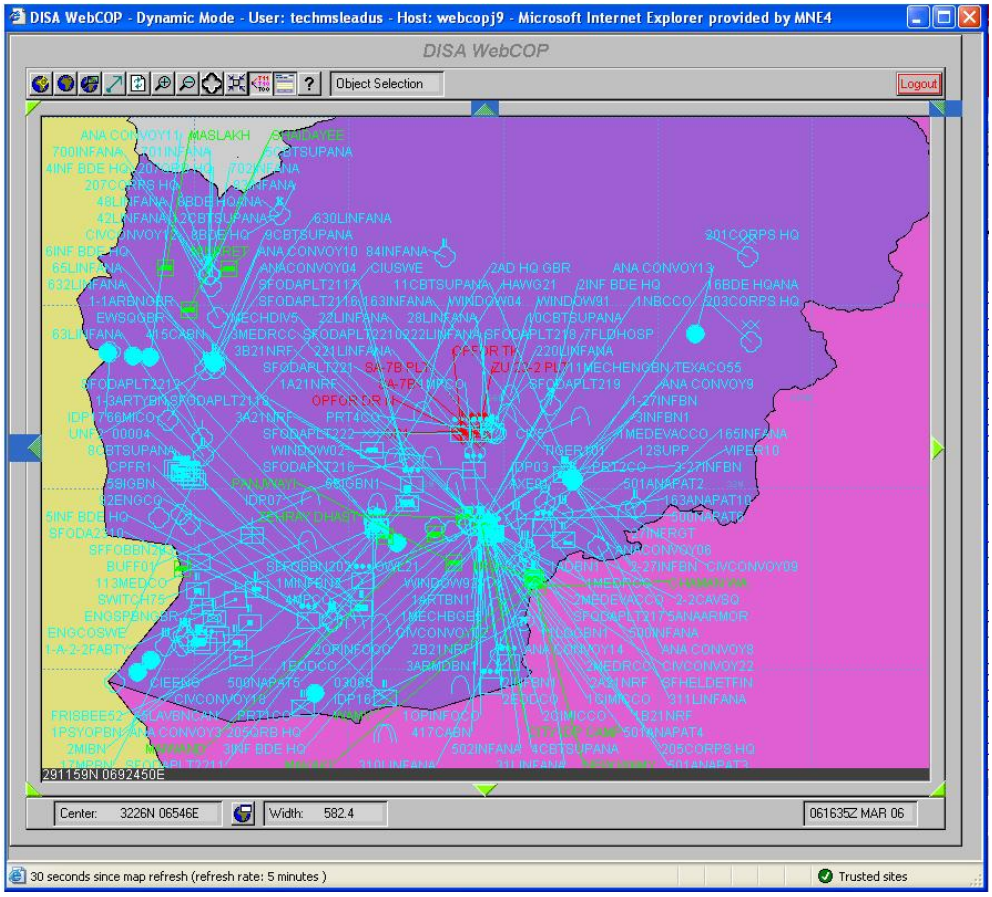

Figure 5: Common Operational Picture via WebCOP

2.5.3 Exchanging Attributes for Commander's Intent

In addition to the capability of sending position reports to the GCCS server, JSAF, JOANA, and ALLIANCE can send free text messages associated with the reporting features of the respective simulation entities. The JSAF operator performs this feature by filling out the mission attribute option in the Task Frame Editor on the Plan View Display (PVD) when creating or retasking a JSAF entity or unit. These free text messages are a means to communicate commander's intent to the COP and are contained in an OTG message remarks (RMKS) field. Once the JSAF order is given for the respective simulation entity to execute its assigned mission, the free text messages are passed through the JLVCDT, and then viewable as a RMKS field in an OTG message. When the WebCOP operator accesses the information window associated with a given track, the RMKS become viewable as free text within the track's attributes [6]. ALLIANCE and JOANA have a similar capability to report commander's intent via their respective simulation bridges to GCCS. If operators manually highlight the regions of interest based on SEAS outputs, then C2PC user graphics can share non-kinetic information through GCCS in a similar manner using a web browser. In turn, MNE4 participants can directly access the non-kinetic information, and associate the respective information to explicit tracks. By stimulating the COP in the manner just mentioned, then it is possible to exchange simulation data that describes a method for communication commander's intent via a simulation stimulation of the COP.

2.5.4 Representing Internal Displaced Persons in the COP

MNE4 required a method to convey IDP camp information in the COP. Platform tracks were created in the COP using JUNIT OTG messages. REFUG is a legitimate platform field entry for refugee in the JUNIT message. The JSAF operator populated the JUNIT message remarks lines with additional information about the health, welfare and status of the IDP camp.

2.6 Combined Federated Battle Laboratories Network

MNE4 participants used a tunnel via Combined Federated Battle Laboratories Network (CFBL Net) to facilitate the experiment. Numerous multinational partners use the CFBL net throughout the year. A variety of distributed services are available on this network including real-time and asynchronous collaboration, effects-based planning, knowledge base development, and various types of data analysis. In order to secure the MNE4 network traffic TACLANE and FASTLANE encryption devises were used at the various sites with end-points established in Canada, France, Germany, Great Britain, Istanbul (NATO), and the United States. The MNE4 network enclave topology and size throughout is described in Figure 6.

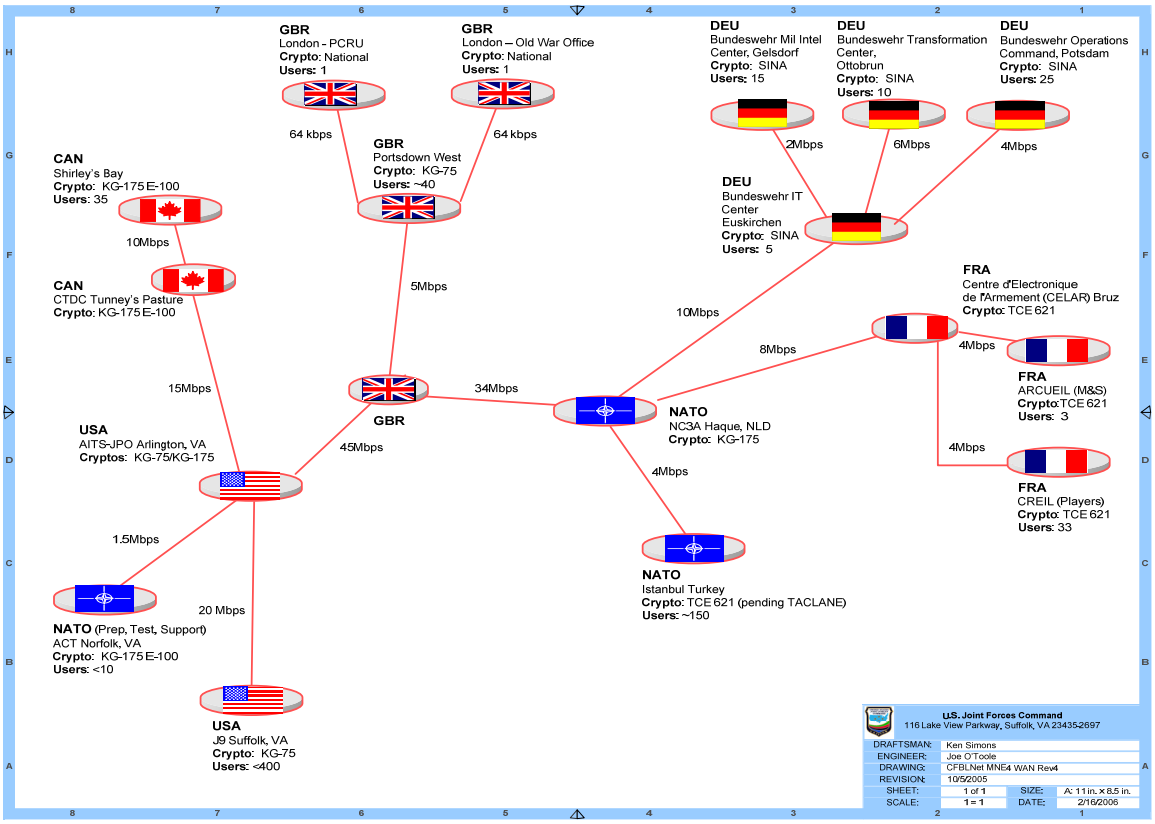

Figure 6: MNE4 Network Topology

3.0 FUTURE WORK

3.1 MNE5

The international federation will continue to build on the strength that the member simulations bring to the environment. For example, JOANA's capability to internally interact between non-kinetic and kinetic objects is an area of interest. JOANA has the IDP camp representation with corresponding attributes that display the IDP camp population frustration level based on resupply convoy activities [14]. A SEAS-JOANA coupling can allow regional leaders to be influenced by the media's reporting of the perceived camp frustration level based on shortages of medical supplies, food and water. Basically, the perceived shortages can become traits and observables to trigger a response in the camps' population to cause the population to become frustrated. The SEAS media models can then spread the influence of these disturbances to other regional areas which can be reported using a variation of the control-feature specification mentioned above. An example of this implementation is that JSAF can generate crowds, with the demeanour of demonstrations or riots, in distant urban areas based on the influence of the regional leaders' opinion of the coalition occupation. The following sentences explain how this can play out in simulation. First, a camp has a critical supply shortage, and a resupply convoy arrives without the supplies to satisfy the need. This results in a negative mood within the camp's population, which can be generated by the JOANA C2 stimulation capability as remarks fields in OTG messages, and displayed in the remarks associated with COP tracks. This leverages refugee camps CRO IERs as mentioned above by generating additional attributes that can be displayed in one of many manners on the COP. Further, there are specific OTG message sets that are designed to provide amplifying information to describe internal displaced persons, refugees, prisoners of war and engagement status. Work in GCCS and other C2 information systems to use more of the attributes of the OTG message specification would be an example of how simulation may assist in identifying new IERs for command and control.

3.2 Influences on Other Experiment Venues

The work completed in MNE4 influenced M&S implementations in another J9 experiment, the multi-year Urban Resolve (UR) 2015. For this experiment, the C2 architecture is one of the key variables for investigating futuristic concepts involving complex urban terrains. This year's theme of isolate and control will necessitate an evolution of the M&S to generate additional traits and observables beyond the visual cueing of a crowd's demeanour as done in MNE4. Additionally, there are over twenty M&S components envisioned to assist in generating the attributes sufficient to drive the C2 information systems to include JSAF SEAS, FAARS (Future After Action Review System) and Tactical Simulation (TACSIM). These four components model and allow the display of the perceived level of well-being, support for blue and arousal levels of the neighbourhoods pertaining to the UR2015 country of interest [24]. Additionally, the other UR2015 M&S systems generate attributes needed to assist in determining the demographic makeup of the groups of people necessary for the analysts to characterize the individuals engaged in hostile actions other than direct combat [12]. Other examples of areas where the UR2015 M&S assisted in defining emerging IERs between the M&S and C2 include: improvised explosive device (IED) supply chain analysis, relating the insurgent population to the number of human generated intelligent reports, and the impact of leaders on the general public mood. Thus, the IERs that will be generated from UR2015 can potentially be the basis for the next generations of CRO IERs.

4.0 CONCLUSION

There exists an opportunity to further evolve the M&S and C2 environments in support of MNE5. The time is right for the MNE5 M&S community to start imagining and developing those capabilities which can be achieved in the up-coming months. A logical starting point is to start by expanding the PMESII modeling efforts associated in MNE4. Additionally, national PMESII modeling efforts, such as with the UR2015 federation and the PSO in the JOANA simulation, could be adapted to what was accomplished by the MNE4 M&S federation. The rationale for expanding the PMESII modeling effort stems from MNE5 interest in Unified Action (UA). Since UA can be defined as a synergistic application of the instruments of multinational power, to include the actions of non-military as well as military forces, MNE5 scenario may facilitate investigations in UA beyond what was conducted for MNE4. MNE5 will likely be set in an economically disadvantaged and politically unstable region, to enable realistic non-military involvement requiring interagency efforts to create a secure, politically stable, economically sound environment [25]. Therefore, as we better model the PMESII indicators in M&S, then these indicators may provide us insights for better representations of otherwise unobserved indicators via our C2 systems. Ideally, this further evolution of the C2, enabled by the M&S, may help us learn how better to avoid crises involving combat engagements in the future, by addressing security, political and economic issues, before the conditions for a military crisis develop.

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