2006 CCRTS

THE STATE OF THE ART AND THE STATE OF THE PRACTICE

Exchanging PMESII Data to Support the Effects-Based Approach

Topics

Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM), Joint Command and Control (JC2), Taxonomy

Authors

Daniel Snyder*
Booz Allen Hamilton
115 Lakeview Parkway
Suffolk, VA 23435
Snyder_Daniel@bah.com

Dr. Andreas Tolk
Virginia Modeling Analysis & Simulation Center
Old Dominion University
Norfolk, VA 23529
atolk@odu.edu

Point of Contact

Daniel Snyder*
USJFCOM J9 Directorate
115 Lakeview Parkway, Suite B
Suffolk, VA 23435
(757)-203-3245/ (757)-203-3198
Snyder_Daniel@bah.com

Exchanging PMESII Data to Support the Effects-Based Approach

Daniel Snyder*
Booz Allen Hamilton
115 Lakeview Parkway
Suffolk, VA 23435
Snyder_Daniel@bah.com

Dr. Andreas Tolk
Virginia Modeling Analysis & Simulation Center
Old Dominion University
Norfolk, VA 23529
atolk@odu.edu

Abstract

United States Joint Forces Command (USJFCOM) Experimentation Directorate (J9) models the political, military, economic, societal, information, and infrastructure (PMESII) aspects of populations to investigate Effects-Based Approach in coalition environments. Current JC2 systems evolved from the need to more efficiently and effectively exchange data among military organizations; however, forces must now interact with non-governmental organizations under the auspices of the effects-based approach. The universe of discourse that JC2 systems concern themselves is extending beyond what has traditionally been called the battle-space. The J9 uses an Agent-based Simulation (ABS) called Synthetic Environment for Analysis Simulation (SEAS) to model the non- military aspects of the battle-space. By investigating taxonomies for capturing SEAS generated data in JC3IEDM (Joint Consultation, Command and Control Information Exchange Data Model), developers may be able to extend JC2 systems to include an increased number of non-military data exchange requirements. Hence, by adapting the JC3IEDM to the effects-based approach may accelerate the development of future C4ISR capabilities towards covering a wider spectrum of threats and deployment scenarios. This paper will outline the reasons why ABS may be useful to evolve the JC3IDEM model, and may assist in defining what is meant by taxonomy in the context of web-enabled ABS.

Background

The United States Joint Forces Command (USJFCOM) Experimentation Directorate (J9) studies the effects-based approach by modeling 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]. Unfortunately, the virtual environments to support today's experiments use simulations chiefly focus on attrition and the causal effects associated with kinetic interactions. Allowing investigations into the non-attrition realms, agent-based simulations (ABS) provide the means to address a broader range of non-kinetic interactions in a virtual world environment. Accordingly,

the universe of discourse that Joint Command and Control (JC2) systems must address is extending beyond the traditionally military battle-space to nearly all aspects of our respective cultures.

Migration Away from Tradition

As warfighters migrate from traditional military decision making to an effects-based approach, assessment processes must also adapt by collecting on an expanded set of observable social and economic characteristics and traits of battle-space entities. Our simulations will expand to include measuring popular support to examine the impact of reducing an adversary's ability to easily hide or disguise actions, and become vulnerable to preventive actions or tagging for exploitation. Identifying and quantifying the results of expanded basic local services that provide local employment opportunities impact on the insurgent base of support [2]. The visible graphic and quantifiable tabular results available from constructive simulations provide warfighters a forecast into human behavior responses to the availability or non-availability of essential city services. These, non-kinetic actions must address more than the reduction of the causal relationship of civilian causalities to the kinetic destruction of infrastructure that attrition simulations can model. They must include the prerequisites cultural awareness and understanding of the impacts of a nation's actions [2] on the local populace in order to deny sanctuary to insurgent and terrorist cells. Non-kinetic ABS, in combination with attrition simulations can assist in defining new JC2 information exchange requirements (IERs). However, there are many other observable information flows, other than just essential city services, as populations respond to non-kinetic effects. By using simulations to generate new data types that support non-kinetic aspects of an effects-based approach, JC2 systems developers can use this data for improving their components to better serve the warfighter.

Establishing an Experimentation Venue

One of the major J9 experiments to investigate the effects-based approach is Multinational Experiment 4 (MNE4), MNE4's aim is to explore concepts and supporting staff processes and technologies within a coalition environment conducting Stability Operations (SO) with increasing levels of violence to assist the development of future organizations and tools at the operational level of command [3]. Due to MNE4's close ties to the effects-based approach and SO concepts, J9 uses an ABS called Synthetic Environment for Analysis and Simulation (SEAS) to model the non-kinetic activities. By investigating a taxonomy for capturing SEAS generated data under the object entity of the Joint Consultation, Command, and Control Information Exchange Data Model (JC3IEDM), developers are capable of extending JC2 systems to an increased number of non-military IERs. In turn, ABS provides insights as to how information concerning non-kinetic actions can facilitate planning and decision making for complex operations that include the use of non-kinetic actions. Therefore, this paper will outline ways that SEAS may be useful to evolve the taxonomy of JC3IEDM resulting in necessary extensions not yet part of the definition.

Linking JC2 to Operating Concepts

Stability Operations (SO) are a core United States military mission that the DoD shall be prepared to conduct and support, and be given comparable priority to combat operations [18]. SO are defined as the process of providing security, initial humanitarian assistance, limited governance, restoration of essential public services and any other reconstruction assistance needed to facilitate a transition to legitimate local civil governance [5]. SO are often required even after achieving a nation's political goals by achieving immediate and long-term goals. The immediate goals are to provide the local populace with security, restore essential services, and address humanitarian needs. The long-term goals are to help develop indigenous capabilities for securing essential services, a variable market economy, rule of law, democratic institutions, and a robust civil society [18]. In order for a nation to have a stronger influence within a foreign community, and to allow unobstructed SO to occur, the population's support for the adversaries must be diminished. Figure 1 depicts four steps of a recursive loop that military decisions must address in order to stop the reemergence of a crisis [5].

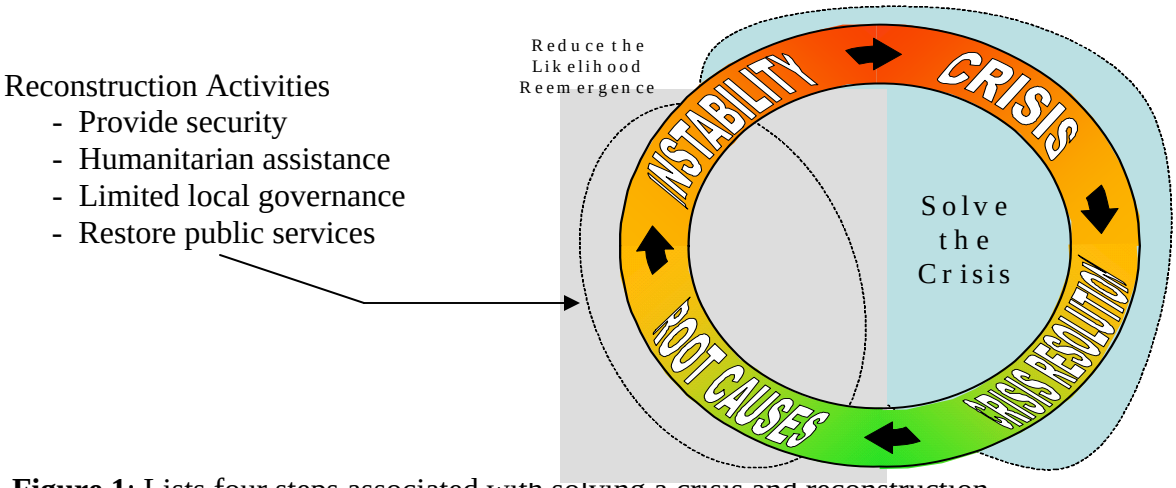

Figure 1: Lists four steps associated with solving a crisis and reconstruction activities which assist in breaking the recursive loop at the Root Causes [5] .

Pertaining to the root causes of instability, restoring public services is one means to reduce the likelihood of a reemergence of a crisis. To assist in breaking this loop, the integration of civilian and military efforts is key to successful SO [18]. Once the loop is broken, then the transition to a local civil governance is more likely. The effects-based approach calls this transition an "end state". Of these SO activities, restoring public services is the one that leans itself to modeling in simulation, and will be revisited below.

Evolving to support the future processes investigation of MNE4, the Effects-based Approach Concept of Operations (CONOPS) describes a method to combine military and other activities on influencing the overall behavior of actors in an operational environment [4]. The CONOPS groups kinetic and non-kinetic actions into four categories referred to as DIME: Diplomatic, Information, Military and Economic. The DIME are directed against an adversary's political and cultural underpinnings, as

well as used to leverage the perceived behaviors of key leaders and fighters in an effort to align such individuals with a nation's political aims. Pressure points categorize these underpinnings and are known as the Political, Military, Economic, Social, Information and Infrastructure (PMESII). The infrastructure and networks used by the civilian populations, which are also leveraged by the adversaries, can be directly impacted by applying DIME to specific pressure points. Applying DIME against the PMESII is what constitutes an action. The central idea to this approach is to execute courses of action to influence the behavior of the intended actors while minimizing any undesired outcomes or effects. The revolutionary aspect of this approach is that it focuses a combination of military and other activities on influencing the overall behavior of other actors. The resulting benefits of applying the effects-based approach to the expanding battle-space are that actions are explicitly linked to a set of "end states", coherently harmonized with those of other governmental organizations, and made truly adaptive within the course of their execution by effective assessment [4]. In other words, Effect-based approach provides a method for military decision to break the SO recursive loop cited above if the PMESII can be appropriately influenced.

Gaining a Shared Understanding

Simulating the characteristics and traits of battle-field entities is necessary to enable the stimulation of JC2 systems in training, experimentation, course of action analysis, and mission rehearsals. Simulations parse data into structured messages formats to emulate unit location and status reporting by stimulating the Common Operational Picture (COP). Web-enabled components of the Global Command and Control System (GCCS) allow remote international users situational awareness and situational understanding (SA/SU) of the operational environment without requiring them to have direct access to the GCCS software. Some of the proposed ways that the COP can be used during MNE4 include: visualization of self reporting unit and platform locations and detection reports called tracks, linking free text remarks to tracks for communicating intent and mission status, and user graphic to supplement the track information [6]. By extending the capabilities that typical JC2 possess, then these features enable simulations to emulate the exchange of meaningful non-kinetic information. For potential stimulation of the JC2 COP, the J9 uses human-in-the-loop (HITL) assisted constructive simulations to model military activities and ABS to model the behavior of civilian populations and the reactions of populations to military events [7]. As the ABS broadens the spectrum of information that can be used to stimulate the COP with non-kinetic activities, MNE4 operational planners can experiment with how this information can best be visualized to support decision making.

Cross walking JC3IEDM and Effects-based Definitions

JC3IEDM represents years of data modeling efforts under the administrative management of the Multilateral Interoperability Program (MIP), and supports

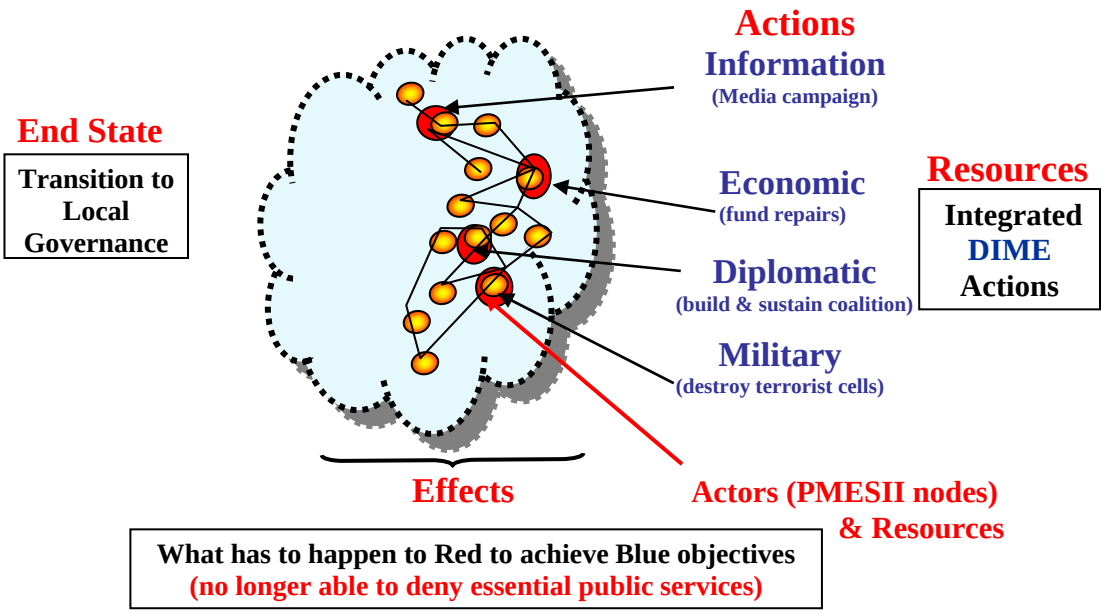

Figure 2: Depicts actors as gold circles and actions as red circles. The actions cause a state change for the actors that generates observable effects.

specifications that can represent many aspects of the effects-based approach. These representations are possible because JC3IEDM is the result of the merging of the Command and Control Information Exchange Data Model (C2IEDM) and the NATO Corporate Data Model (NCorpDM). While C2IEDM was initially developed for data management purposes, it was the MIP that adapted it for information exchange specifications [19]. The significance of the NCorpDM is that it was developed to cope with strategically and operationally important data. By merging these projects in 2004, the JC3IEDM now has the potential to become a truly robust information repository to support combined joint operations [8]. The past agreements reached under the Army Tactical Command and Control System (ATCCIS) and MIP programs are what make JC3IEDM interoperable in a multinational environment. It should be noted that JC3IEDM is not yet another data model. C2IEDM – and therefore JC3IEDM as the direct follow-on activity as well – has been designated to support the unambiguous definition of IERs in the operational domain. The contributions of data modeling experts, operational experts and users from more than 20 countries over more than 15 years ensure *technical maturity* and *operational applicability* based on mutual agreement and *multilateral consensus*. This makes the JCIEDM unique in the technical as well as the operational domain. Every recommendation alternative must be measured against these criteria and achievements. The potential importance of this work is recognized by the United States Army's endorsement of C2IEDM as the standard for information exchanges in Battle Command systems and Command and Control applications [21]. It is this legacy is what makes the JC3IEDM interesting for further investigations in regards to the effects-based approach.

Within the JC3IEDM data specification, the entity is the basic concept. Different attributes among the 194 JC3IEDM entities allow them to be distinguishable, and only 15 entities are stand-alone structures that do not depend on other entities to be indistinguishable [8]. Table 1 depicts five key information concepts that are of fundamental importance to providing structure to such constructs as the JC3IEDM along with their corresponding definitions [19]. Two of these independent entities are the

Concept	Definition
OBJECT-ITEM	An individually identified object that has military significance. Examples are a specific person, a specific item of materiel, a specific geographic feature, a specific coordination measure, or a specific unit.
OBJECT-TYPE	An individually identified class of objects that has military significance. Examples are a type of person (e.g., by rank), a type of materiel (e.g., self-propelled howitzer), a type of facility (e.g., airfield), a type of feature (e.g., restricted fire area), or a type of organization (e.g., armored division).
CAPABILITY	The potential ability to do work, perform a function or mission, achieve an objective, or provide a service.
LOCATION	A specification of position and geometry with respect to a specified horizontal frame of reference and a vertical distance measured from a specified datum. Examples are point, sequence of points, polygonal line, circle, rectangle, ellipse, fan area, polygonal area, sphere, block of space, and cone. LOCATION specifies both location and dimensionality.
ACTION	An activity, or the occurrence of an activity, that may utilize resources and may be focused against an objective. Examples are operation order, operation plan, movement order, movement plan, fire order, fire plan, fire mission, close air support mission, logistics request, event (e.g., incoming unknown aircraft), or incident (e.g., enemy attack).

Table 1: Five Fundamental JC3IEDM Concepts [19]

object-type and object-item, and are central for the discussion of extending the JC3IEDM in support of an effects-based approach. The JC3IEDM defines objects such as physical things to include units, equipment, repositories, personnel, facilities, geographic features, and non-physical things such as control graphics. The specification defines generic objects as types, and specific instances of an object-type as items. Correlating this to the effects-based approach, actors and resources are objects depicting military and civilian

organizations that have the capability to influence a change in PMESII objects' state. In turn, the JC3IEDM has the extensibility to support the exchanges of non-kinetic information [19]. Further, the JC3IEDM defines actions as the processes where some resources carry out a series of assigned actions to affect some number of object items or object-types at some specified time. Finally, the JC3IEDM defines an action-effect as the perceived effectiveness of specific actions against specific battle-space object items or object-types.

The State of the Art of Simulations

Joint Semi-Automated Forces (JSAF) is the primary modeling and simulation (M&S) component used by the USJFCOM 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 can be represented as distinct entities. Additionally, the processes of acquiring and engaging entities in the virtual environment are modeled as independent and explicit occurrences, enabling a quantified comparison of engagement protocols. The virtual, urban terrain used by JSAF is constructed using real-world data. The Compact Terrain Database (CTDB) is capable of scaling to representations of over a million buildings, and each building is uniquely identified so that 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 a corresponding PMESII functions which can interact with ABS [7].

JSAF Integrated Components

Integrated with JSAF are many federated sub-components that assist with kinetic and non-kinetic cultural modeling of the battle-space. CultureSim models pedestrian, 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 battle-space 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 the different service collection platforms. Finally, these rendered crowd differences are based on different appearance bit settings associated with the objects enumerations that are sent over the run-time infrastructure (RTI) of the High Level Architecture (HLA).

The Different Types of SEAS

Synthetic Environment for Analysis and Simulation (SEAS) is an ABS used by USJFCOM J9 to model the behavior and the emergent cultural of population centers. 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 behavior of actors at various levels of abstraction [10]. SEAS assists to correlate tactical combat actions and non-kinetic behavior 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 mimic the interactions between civilian individuals and military forces. It listens for explosions in vicinity of the PMESII coded buildings and cues CultureSim to render either angry or curious crowds. SEAS-VIS simultaneously captures the perceived behavior 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 accurately captures population behavior in an urban setting by simultaneously handling diverse models at multiple temporal and spatial granularities [7].

Coupling JSAF with SEAS via the society of simulations approach makes it possible to represent a full cycle of military decisions and civilian reactions in regards 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 the effects-based approach, kinetic actions can instantiate themselves within minutes, but resulting second and third order effects on the population's demeanor can take days to surface. For example, the action to close a bridge achieves the first-order effect, which stops all traffic, including resupply convoys, to an overcrowded refugee camp. This leads to second-order effect of unrest and frustration in the camps. Then this leads to the third-order effect of losing the support of key religious and political leaders, due to adverse media coverage, to squelch ensuing demonstrations and riots in a nearby urban setting. The following scenario illustrates the correlation between military decisions and civilian behavior using JSAF and the two types of SEAS. While this specific JSAF and SEAS interaction to was not used in MNE4, it does address a capability that may be more extensively used in future experiments.

An Illustrative Scenario

The scenario's settling is in a fictitious country within one of many complex urban environments. The urban environment is constructed with PMESII coded buildings as mentioned above. For the purposes of illustration, the region is divided and designated as a Left and Right side. Initially, all the people are neutral with regard to the foreign security forces and any opposing forces seeking to destabilize the local government. The foreign security forces are referred to as Blue Forces. Opposing forces are referred to as Red Forces. Bomb detonations that cause collateral damage to building structures result

in reactions by nearby civilians. Well-being of the people is influenced by the state of the economy and the perception of the cause for the detonations. The populace assumes detonations and repairs to be actions of the Blue Forces. How the virtual populace reacts to the destruction of a PMESII coded infrastructure depends on the building's relationship to the local citizens which is established by SEAS-VIS. Every detonation is assumed by the population on the Right side to be the result of deliberate Blue Force action against their people. Due to the destruction, the Right side becomes generally anti-Blue and pro-Red as any new explosion on the Right Side elicits an angry response. Figure 3(a) shows a SEAS-VIS view of the overall state of well-being across the Right side of the city, and the location of the explosion against a power generation plant highlighted in the green circle. The general hostile mood of the region is depicted by the red shaded area. Figure 3b shows a Modstealth view of the angry crowd that formed due to the destruction of the building. JSAF reflects the agitated state of the population by entities displaying protest signs. Of note, the M&S generated red shaded area can be displayed on the JC2 by leveraging the user graphics feature. Also, the constructive sensors modeled in the M&S can differentiate between angry and curious crowds, and populate textual information linked to icons visible in the JC2.

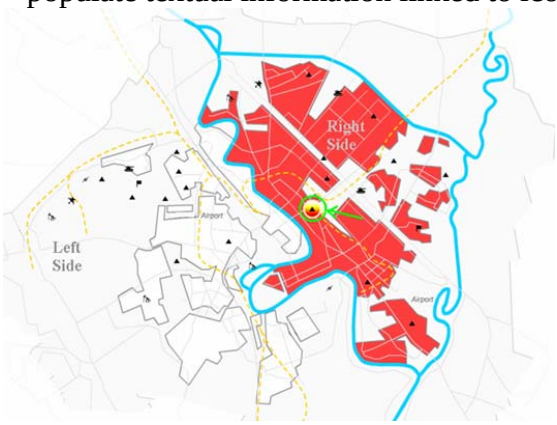

Figure 3a: Explosion on hostile side of the city at a power generation plant [7].

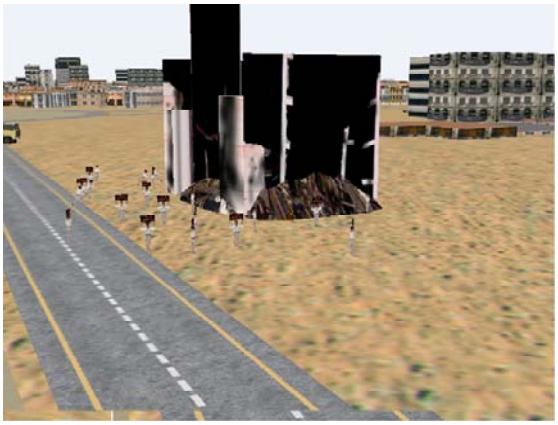

Figure 3b: Angry crowd with signs [7].

On the Left side every detonation is assumed by the population to be the result of insurgent activities, and that the Blue Forces are taking reasonable measures to secure the region. Due to the destruction, the Left side remains generally pro- Blue and anti-Red. Any new explosion on the Left side elicits a curious response. Figure 4(a) shows the SEAS-VIS view of the overall well-being across the Left side of the city, and the location of the explosion against an oil refinery highlighted in the red circle. The general curious well-being of the region is depicted by the lack of red shaping. Figure 4b shows a ModStealth view of a curious crowd that formed to watch the repair of the damaged refinery, and the DTsim repair team is visible as vehicles in the lower left corner. ModStealth reflects the curious state of the population by entities not displaying

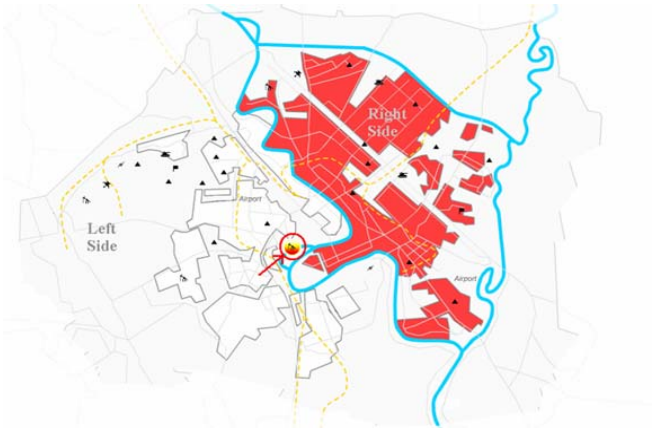

Figure 4a: Explosion on calm side of the city at an oil refinery [7].

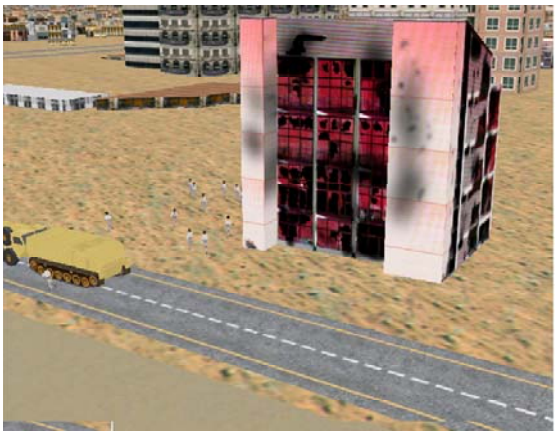

Figure 4b: Curious crowd without signs [7].

protest signs will appear on the ModStealth visualization. Of note, if the region's well-being transitions to hostile from calm, then this can be depicted on the JC2 by leveraging the native user graphics features and used to populate the remarks fields associated with an JC2 icon. This is because the constructive sensor modeling of JC2 systems can differentiate between angry and curious crowds.

Addressing the JC3IEDM Taxonomy

The JC3IEDM is an evolving data specification to enable information exchanges among national command and control systems, and this specification summarizes the information requirements under the five major topic areas. Associated with the potential measure of effectiveness of a nation's progress towards a higher degree of stability are seven criterion items called normality indicators, which address aspects of the environment such as the economic, social, political and media context [20]. Some of these normality indicators relate to the JC3IEDM topic area of Environment Conditions Civil with the associated information categories of political, cultural and economic[8]. Within this topic area, there are several related IERs known as the Peacetime Support Operations that later evolved into the Crisis Response Operations (CRO). This set of requirements was created from the information exchange needs to coordinate and integrate the joint use of lethal and non-lethal assets, which extended earlier terrestrial-centric versions of the JC3IEDM [8]. The CRO serves as a method for consumers and producers of JC2 IERs to organize JC3IEDM information such that others may reused the respective content in ways beyond what was originally intended. Leading references on the subject define this type of organization as a taxonomy. A taxonomy consists of a tree classification for an established set of objects usually starting at a single classification that relates together all other objects, within the tree, via some relationship or dependency [11]. Moving away from the single classification increases the objects' deaggregation or decomposition. Based on the identified need for CRO, the object-type can be considered the root node for extending the JC3IDEM from a kinetic to a non-kinetic realm. This is

because the object sends actions that result in a change to receiving objects' status and is stored in the action-event. Since each CRO IER is supported by corresponding operational level message types, then these IERs serve as a method to exchange information on non-kinetic objects. As depicted in figure 5, there are object-types and item object subtypes which can be extended to support non-kinetic activities; namely, feature, organization and person. In the next section, it will be shown how the selected subtypes can be related to the previously mentioned illustrative scenario and CRO IERs.

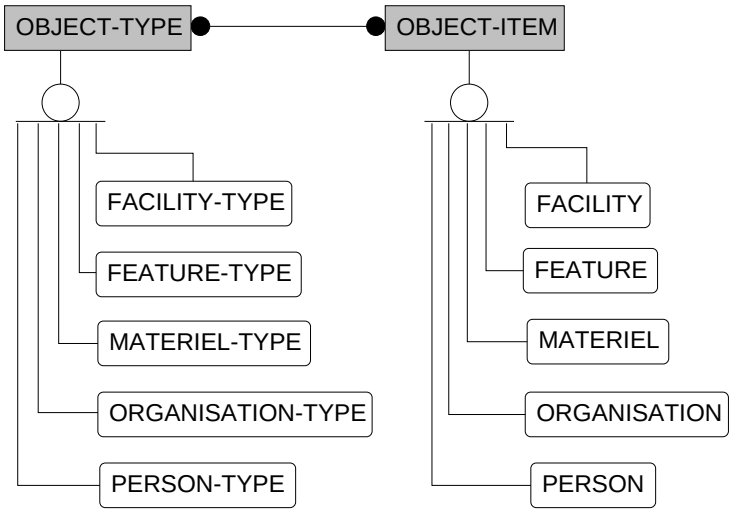

Figure 5: JC3IEDM Object-Type specification with EBO extendable subtypes [8].

Relating Leader Influence to JC3IEDM

Simulations can emulate CRO IERs for stimulating the COP, but not all simulation data can be displayed. Establishing a taxonomy associated with camps, personnel identification, and refugees & displaced persons can support SA/SU. The first object subtype that leans to capturing simulation generated data is person-type. JSAF represents the kinetic simulation aspects of the battle-space by rendering crowds that display well-being as either anger or curiosity as a result of attacks against the region's PMESII represented by specially coded buildings. Given the person-type represents regional, ethics and demographic characteristics of populations, then the JC3IEDM can relate these characteristics with a virtual crowd, at a virtual location, and at a specific time. Since these crowds' respective moods can be visualized on the COP, then the region's general state of well-being can be inferred. Given the item instance of the person entity represents personnel holding military or civilian significance like key leaders [8], then the JC3IEDM has the capability to relate these characteristics and traits of leaders that can potentially influence the mood of the populace.

SEAS represents the non-kinetic military and civilian personnel as key leaders as shown in the glyph graph in figure 6 [12]. Returning to the illustrative scenario mentioned above for context, the x and y axis represent the relative support for Blue and

Red. The circles' movement in regards to the respective axis represents the leaders' reaction to kinetic actions in JSAF and non-kinetic actions inputted via SEAS [12]. The history of the leaders' movement is shown by migration of the circles using connecting lines and redrawn circles. These histories depict the leaders' change of position over discrete time jumps of one week intervals. In turn, regional well-being, as inferred by the crowds display of mood, can be displayed on the COP. This can be done by defining regions using national JC2's user graphics, such as the red shaped area bonded by the rivers in figure 3b. Thus, displays of well-being information can technically be displayed on the COP.

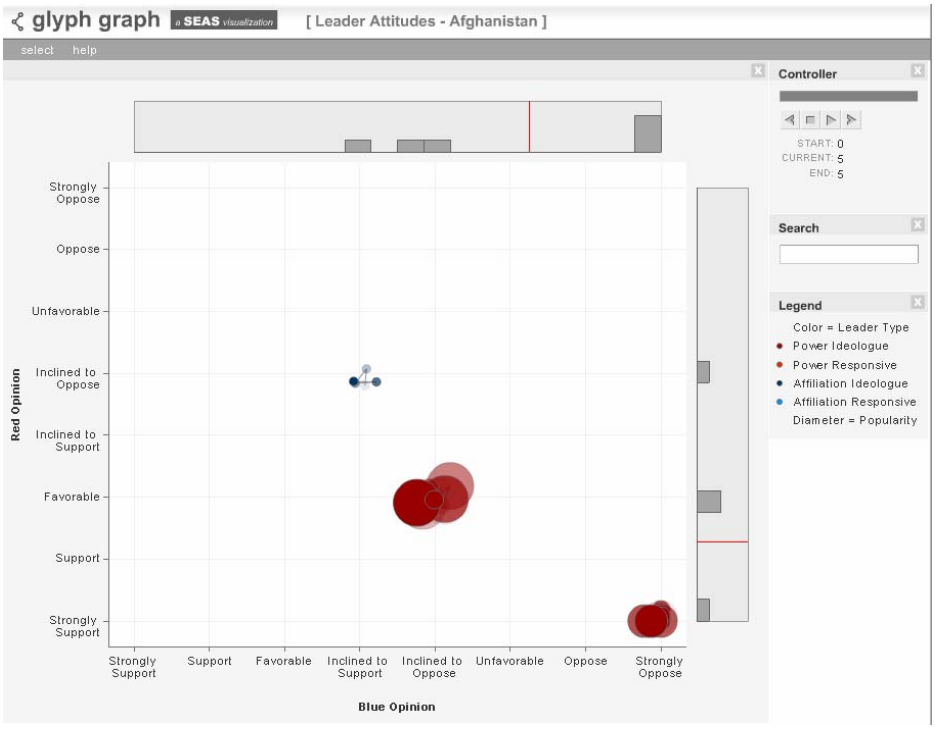

Figure 6: Circles represent regional leaders by leadership styles with the size of the circle representing the leaders' popularity. This graphic cannot be reprinted or used in anyway without the written permission of Simulex [12].

While the glyph graph data that SEAS generates does not easily translate to a COP display, it does have a direct correlation to the personnel identification CRO IER. The capability of regional leaders to cause or inhibit the formation of crowd formations at different locations, such as the urban environment as depicted in the illustrative scenario, can be captured. This information can be extended in the JC3IEDM by adding an attribute under the person item of the object entity. This information can be useful as it provides a means to exchange a perceived level of leader influence that can affect conditions that cause crowds to form. This information is useful because crowd formations, by their very nature, can obstruct the movement of military formations and hence have the potential to hinder military activities. Additionally, these same regional

leaders can make decisions that affect the economic posture of the region, and hence the region's stability. Figure 7 illustrates how this proposed taxonomy may look in regards to the person item.

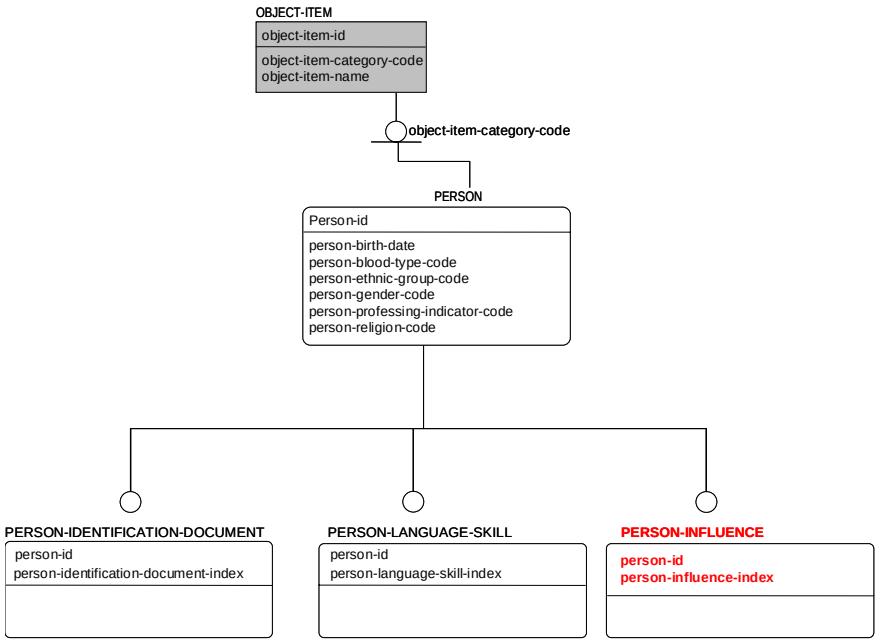

Figure 7: Red highlighted block adds a political influence entity [8].

Building on Exchanges Associated with Leader Influence

Building on the object entities in the JC3IEDM, the following areas can be extended to support a specification of leader influence. First, the data specification of the entity action-context links together parent entities in order to state enabling, constraining or otherwise relevant conditions on an action [8]. This entity can be a means to exchange the level of influence and the inclination leaders' possess either to incite or squelch demonstrations or riots. In many cases, this influence has a direct relationship to the ethnic background and the professed religion of the key leader. Attributes captured in the person item specification can easily be modelled in SEAS-VIS. Second, there is the ability to link together two instances of object-item which is the object-item-association. This specification is defined as a relationship of using an object-item as the subject with another object-item as the object of the first object-item [8]. This relationship can capture the dependency between the glyph graph depicted of a national level leader and an organization rendered in JSAF as a crowd. Next this crowd formation can be identified under the organization-group to provide indictors that the group was morphing into a demonstration or riot due to the leaders influence and the mood of the region.

Further building on the object entities, the object-type can be associated with organization-group to capture observable crowd characteristics of curiosity or volatility via the establishment specification. Establishment associates for given instances of object-types a number of instances of other object types as its constituent elements [8]. Thus groups comprising internal displaced and refugee camps or urban centers can use the establishment specification to capture demographically different types of people. Useful in keeping track of the demographics in a camp is the counting specification, which is a reference to asset of characteristics that can identify a distinct collection of objects [8]. JC3IEDM examples of how camp residents can leverage this counting structure include delineating by infectious diseases, nationality, age group, and gender. Also, the specification of affiliation defines the country, nationality, ethnic group, functional group, exercise group, or religion to which membership or allegiance may be ascribed [8]. Additionally, a specification of object-item-status can capture the perceived condition of an object-item as determined by an associated reporting organization [8]. This specification can report on a perceived drop in a group's well-being as a direct relationship to availability of supplies like medical, food and water. Finally expendable classes of supply can be captured in the consumable-material-type specification. Thus a combination of the above mentioned object-type specifications can capture simulation generated data that models different types of population groups and their perceived well-being.

Reporting Methods to Include the User Graphics Attribute

As demonstrated in the illustrative scenario, simulations can generate visual cues to emulate battle-field assessments of the progress of actions to achieve that desired end state. Many of these effects-based assessments can be transmitted via the reporting-data and its subtypes specification that captures temporal status updates and the reporting source information [8]. However, the observed well-being of a region is not easily transmitted via the reporting-data specification. In turn, another method to display perceived well-being is the user graphics attributes as described in the feature-type specification. The feature-type represents administrative, political, and/or tactical constraints to be taken into account during military operations that can occur around civilian populations [8]. Extending the CRO IERs for EBO, user graphics can draw polygonal regions highlighting areas of varying degrees of public opinion for supporting coalition forces, adversaries and /or the local civilian governance. User graphic features, such as lines and overlays with differentiating color shaded regions, can capture simulation generated data associated with population groups and organization. Since the intent of the control-feature specification is to define administratively objects created by military authorities and controlling or affecting the activities of military formations, then a logic place to insert well-being into the object taxonomy is under this feature subcategory. This proposed change in the taxonomy is depicted in figure 6.

Of note, a related element under control-feature is the route specification which defines the prescribe course to be travelled from a specific point of origin to a specific destination [8]. While the subtype of facility can capture the road characteristics of the routes of interest, the route specification can specify critical locations. The importance here is that when a crowd forms along a road, then it is of more significance because the crowd can deny the road to military and non-governmental activities associated with SO. Hence, the JC3IEDM extension of a well-being specification probably should be associated with the route specification as opposed to the road characteristic specification.

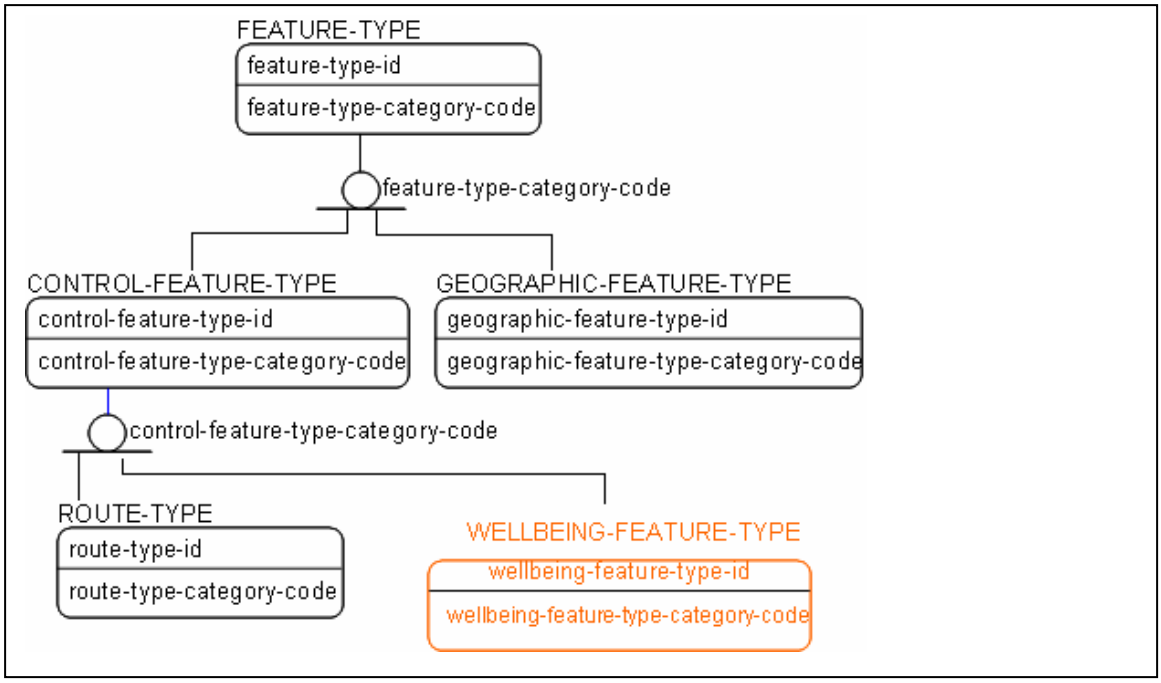

Figure 6: Adding Well-Being to the Feature-Type allows user graphics and overlays to capture regions of interest [8].

Multinational Federation

Four constructive simulations support MNE4's aim by providing the virtual environment. Besides the previously mentioned kinetic JSAF and non-kinetic SEAS, two other kinetic federation members include France's Application Logiciele InterArmees Nationale pour l'entainement Au Commandement d'un Engagement militare (ALLIANCE) and Germany's Joint Operations Army, Navy, Air Force (JOANA). In this architecture the simulations interact via the HLA protocol. Additionally, ALLIANCE, JOANA and JSAF use bridges to send emulated message traffic to the GCCS server. All three kinetic simulations stimulate GCCS with OTH-Gold (Over-the-Horizon Targeting

Gold) position reports while JSAF's bridge, the JLVCDT (Joint Live Virtual Constructive Data Translator) also generates TADIL-J (Tactical Digital Information

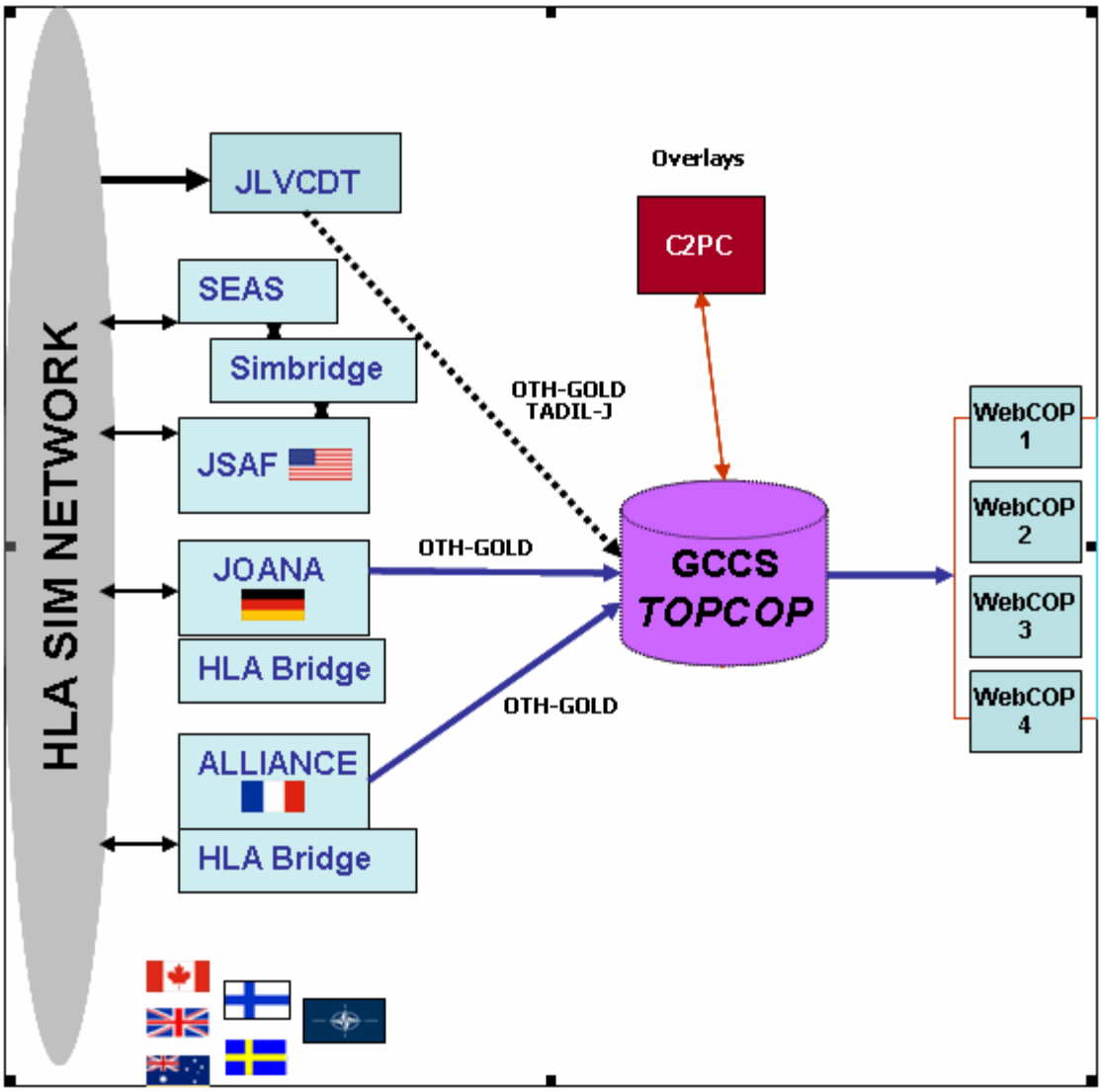

Figure 7: MNE4 simulation to JC2 architecture shown, the additional flags at the lower left of the figure represent the other participating nations that will leverage the M&S Federation.

Links – Joint) detections in the form of contact reports. Track management occurs to correlate the various tracks at the GCCS server called TOPCOP. Once in GCCS, track information is then shared out via a web-enabled GCCS segment called WebCOP [6]. Added to the architecture, C2PC (Command and Control Personnel Computer) provides a capability to manually draw overlays and sharing user graphics. Figure 7 depicts the simulation to JC2 architecture.

Exchanging Attributes for Commander's Intent

Addressing the MNE4 Federation strengths, each of the kinetic simulations have the capability of sending position reports to the GCCS server. Additionally, these simulations can also send free text message 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 via the JC2. 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 free text Remarks (RMKS) fields within OTH-Gold Contact Reports and JUNIT (Joint Unit) messages. When the WebCOP operator accesses the information window associated with a given track, the RMKS become viewable [6]. ALLIANCE and JOANA have a similar capability to report commander's intent via their respective bridges to GCCS. If operators manually highlight the regions of interest based on SEAS outputs, then C2PC user graphics can share-out 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 JC2 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.

Future Work

Influence on Other Experiment Venues

The JC3IEDM has the potential to influence another J9 experiment, which is the multi-year Urban Resolve (UR) 2015. For this experiment, the JC2 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 demeanor as done in MNE4. Additionally, there are over fifteen M&S components envisioned to assist in generating the attributes sufficient to drive the JC2 to include JSAF and SEAS. While it can be assumed that some of these traits and observables will correspond to the CRO ICEs of the JC3IEDM, there is the potential that many will not map to any of the ICEs. Further, many of the M&S attributes will be needed to assist in determining the demographic makeup of demonstrations, and help analysts characterize the individuals engaged in hostile actions other than direct combat[12]. Example areas which can assist in defining new and different JC3IEDM IERs 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. In addition, the JC3IEDM is evaluated as

the basis for the international studies on a Coalition Battle Management Language (C-BML). Standardization efforts are conducted under the Simulation Interoperability Standards Organization (SISO) and NATO's M&S Group initiated technical activity (MSG-048) to evaluate the applicability of such concepts and ideas for the participating nations [14]. The technical maturity of this approach, in particular when combined with web-based standards, such as web services, is commercially recognized [15].

After MNE4 there will be a MNE5, and 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 one area of interest. JOANA has the refugee camp representation which has corresponding attributes that display the frustration level of the refugee camp populations based on resupply convoy activities [16]. 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. SEAS's 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 demeanor of demonstrations or riots, in distant urban areas based on the influence of the regional leaders' opinion of the coalition occupation. How this can play out in simulation is the following. First, a camp has a critical supply shortage, and a resupply convoys arrives without the supplies to satisfy the need. This results in a negative opinion of the camps population's mood, which can be displayed in the remarks fields of WebCOP, and generated by the JOANA C2 stimulation capability as remarks fields in OTH-Gold messages. This leverages refugee camps CRO IERs as mentioned above by generating additional attributes that can be displayed in one of many manners on the JC2. Further, there are some specific OTH-Gold message sets that are designed to provide amplifying information to describe personnel, refugees, prisoners of war and engagement status. Work in GCCS to use more of the attributes of the OTH-Gold message specification would be an example of how simulation may assist in identifying new IERs for JC2.

Feeds to the Multinational Knowledge Base

As described in the CONOPS, the Multinational Knowledge Base (MNKB) stores the knowledge required to inform Effects-based planning tools as well as the information exchanges necessary for the integration of National JC2 systems for the real-time execution of the effects-based approach. Fundamental to this approach is the need to capture SA/SU, and store it for timely retrieval via some appropriate data mining technique. While the JC3IEDM models only a subset of the universe of discourse covered by the MNKB, it can still serve as a unifying information structure for the MIP member nations [8]. In turn, the JC3IEDM has the potential to influence development work beyond discoveries made in MNE4. Outside the scope of this paper are the extensions of

the C-BML that may serve in the future as an unambiguous language as a means to automate command and control information [19]. By combining the capabilities of the JC3IEDM and C-BML, the resultant may actually evolve into the MKB of the future.

As a continuation of the media thread, a recent J9 initiative is Sentient World Simulation (SWS) which is a proposed means to dynamically update knowledge bases such as the MNKB [17]. By blending together several technologies, the system will canvas the world's media and JC2 sources to capture cultural information of interest. The belief is that SWS will precipitate the exchange of more PMESII data among JC2 systems; hence, causing an evolution in JC2 systems. In turn, SWS will become the catalyst for changes not only the JC3IEDM data models, but the knowledge base, which supports the effects-based approach. Additionally, evolving these data models can also assist in accelerating the integration of effects-based approach with Coalition partners

Conclusion

In summary, this paper has outlines ways that SEAS may be useful to evolve the taxonomy of the JC3IEDM model to further the advancement of JC2 IERs. Beginning with a discussion of the SO operating concept in the context of the effects-based approach and establishing a framework in MNE4, the concepts illustrate the intended use of leading M&S technologies to determine IERs requirements for future JC2 systems. It examine an extension of the JC3IEDM object entity to tie commander's intent to accessible tracks in a web-enabled JC2 environment, and to assist in visualizing regions that non-kinetic effects are occurring.

In turn, it can be argued that there are two types of data that needs to be captured and exchanged to allow the warfighter to advance his/her ability to prosecute the art of modern warfare. The first is the traditional kinetic objective data type, which can be easily measure traditional kinetic actions and effects. Examples include the numbers and sizes of the battle-field observable objects. The second is more difficult to define as it is more subjective in nature. Spawning from the non-kinetic actions and effects that are associated with the effects-based approach, each effect has an associated hypothesis that has to be confirmed or denied through the observation of battle-field indicators. Additionally, these indicators are currently not support by current day national JC2 systems, but more importantly will need M&S to help identify and prioritize what they are.

Therefore, as pointed out by the proposed future work, not only can M&S assist in evolving IERs for the future of JC2, but the attributes that are played out in the constructive environment may also assist developers in evolving the effects-based knowledge base. As the battle-space extends beyond the traditional universe of discourse, the JC2 users will demand greater SA/SU that must be distributed to locations from the battle-field to the varied offices that reflect the warfighter's interagency support.

Therefore, this demands a closer relationship between M&S and JC2 also takes us closer to a realization of the Global Information Grid.

REFERENCES

[1] Command and Control Joint Integrating Concept Version 0.99, Department of Defense, 15 July 2005

[2] Chiarelli, P.W., and Michaelis, P.R., "Winning the Peace The Requirements for Full-Spectrum Operation", Military Review, July – August 2005.

[3] Walker, Karen, "Future Thinking Battle Planners are Joining Forces to Explore Concepts through Simulation", C4ISR Simulation, November – December 2005.

[4] Effects-Based Approach to Multinational Operations Concept of Operations (CONOPS) with Implementing Procedures Version 0.85, United States Joint Forces Command, Joint Experimentation Directorate, 10 November 2005.

[5] Stability Operations Joint Operating Concept, Department of Defense, September 2004.

[6] Global Command and Control System (GCCS) User's Manual for Web Services Version 4.10.5.x, Defense Information Systems Agency, 15 April 2005.

[7] Chaturvedi, Snyder, Foong, Armstrong; "Bridging Kinetic and Non-Kinetic Interactions over Time and Space Continua". In *Interservic/Industry Training, Simulation, and Education Conference (I/ITSEC 2005).* Paper No. 2123.

[8] Multilateral Interoperability Program, "The Joint C3 Information Exchange Data Model (JC3IEDM Main)", Edition 0.75, 16 May 2005.

[9] Ceranowicz, A., and Torpey, M. (2004). "Adapting to Urban Warfare". In *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC 2004).* Paper No. 1554.

[10] Chaturvedi, Dehncke, Snyder (2004). Simulating Non-Kinetic Aspects of Warfare. In *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC 2004).* Paper No. 1700.

[11] Turnitsa, C. and Tolk, A., "Ontology of the C2IEDM – Further studies to enable Semantic Interoperability," Fall Simulation Interoperability Workshop 2005, Paper 05F-SIW-084, Orlando, Florida, September 2005.

[12] Floor demonstration at *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC 2005),* Simulex, Incorporated.

[13] Postma, M., “Urban Resolve – 2015, A JFCOM Experiment with Service, Interagency and Multi-National participation”, presentation, Suffolk, Virginia, 14 December 2005.

[14] Sudnikovich, W.P., Pullen, J.M., Kleiner, M.S. and Carey, S.A. (2004), *Extensible Battle Management Language as a Transformation Enabler*, SIMULATION, Vol. 80, pp. 669-680.

[15] Tolk, A., Diallo, S.Y., “Model-Based Data Engineering for Web Services”, IEEE Internet Computing, Vol. 9, Nr. 4, 2005.

[16] Erlenbruch,T., Horstkotte, A., “EBO Decision Support with the German Simulation System JOANA in Multinational Experiment 4”, Version 0.50, Bundeswehr Transformation Center, Germany, November 2005.

[17] Cerri, A., Chaturvedi, A., “Sentient World Simulation”, Version 1.1, paper, Distributed during panel discussions at *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC 2005),* 1 December 2005.

[18] Department of DirectiveNumber 3000.05 November 28, 2005 Subj: “Military Support for Stability, Security, Transition, and Reconstruction (SSTR) Operations”.

[19] Andreas Tolk: “ Moving towards a Lingua Franca for M&S and C3I- Developments concerning the C2IEDM” In *2004 Euro Simulation Interoperability Workshop Edinburgh, Scotland,* June 2004.

[20] DoD Command and Control Research Program, “Code of Best Practice for C2 Assessment” , www.dodccrp, Reprint July 2004.

[21] U.S. Department of the Army Memorandum, “Command and Control Information Exchange Data Model”, 28 September 2005.