Operational Environment Data Transformation for Army Training and Analytic Simulations

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ABSTRACT

Joint, Defense, and Army leaders have long recognized that in order to train and prepare tomorrow's leaders for operations exemplified by today's hybrid and asymmetric threats, that training must go beyond the typical force-on-force paradigm and include portrayal and interaction within a more complex training environment. Delivery of the Operational Environment (OE) is a responsibility of the Army's Training and Doctrine Command (TRADOC) G-2. A significant challenge also exists in transforming unstructured, text-based information in the form of country studies and subject matter expert assessments into coherent, quantifiable data that can be readily consumed by Army training and analytic simulations as well as those used by other Army Modeling and Simulation communities.

This paper will explore how the non-military data associated with the factors that define the OE—i.e., political, military, economic, social, information, infrastructure, physical environment, and time, or PMESII-PT—can be quantified across a set of variables and distributed to a range of training and analytic simulations. The key to this process is the proposed Operational Environment Dimensional Framework (OEDF) methodology for fusing and disseminating diverse data about the human and geographic terrain. The OEDF primarily employs the Cultural Orientations Framework developed by anthropologists Clyde Kluckhohn, Florence Kluckhohn, and Fred Strodtbeck. The OEDF methodology is also informed by research on Sacred Values. Finally, this paper will demonstrate how open-source PMESII-PT data about Iraq was processed using the OEDF methodology and ingested into the broad, cross-cutting Athena simulation.

ABOUT THE AUTHORS

Tony Cerri is the Data Transformation and Modeling and Simulation Lead for the TRADOC G2. He is responsible for the integration of technologies to facilitate Operational Environment replication. Previous assignments include leading the JS J7's Joint Operating Systems Environment, leading the Experiment Engineering Div for USJFCOM J9, and serving as M&S Branch Chief for USJFCOM J9. Tony is a graduate of the United States Military Academy. He earned master's degrees from Central Michigan University in Administration and from the Florida Institute of Technology in Management. His military awards include the Legion of Merit and the Bronze Star.

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INTRODUCTION

This paper will examine and demonstrate how open-source information can be methodically processed to inform the inputs of the Athena simulation as well as other simulations requiring non-military PxESII-PT data. There are varied and rich sources of open source data that have yet to be integrated into a single PxESII-PT framework. Academic studies of national and subnational cultures as well as subject matter expert assessments are readily available for many regions of the world. There are any number of survey instruments that capture cultural values and population sentiments. The Global Database of Events Language and Tone (GDELT) data mines news reports from all over the world and codes them according to political and social content. The question is, how does one collate or integrate all of these sources into a single, coherent, construct? To this end, the Operational Environment Dimensional Framework (OEDF) will be described. The process of selecting an information source, its decomposition, and fusion according to the OEDF will be discussed along with a practical example of how the OEDF can be used to enhance an Athena simulation database including the Iraqi civilian population. Finally, the future possibility of an OEDF data sharing system will be explored. First, the overall OEDF process and possible use cases are illustrated in Figure 1.

OPERATIONAL ENVIRONMENT DIMENSIONAL FRAMEWORK

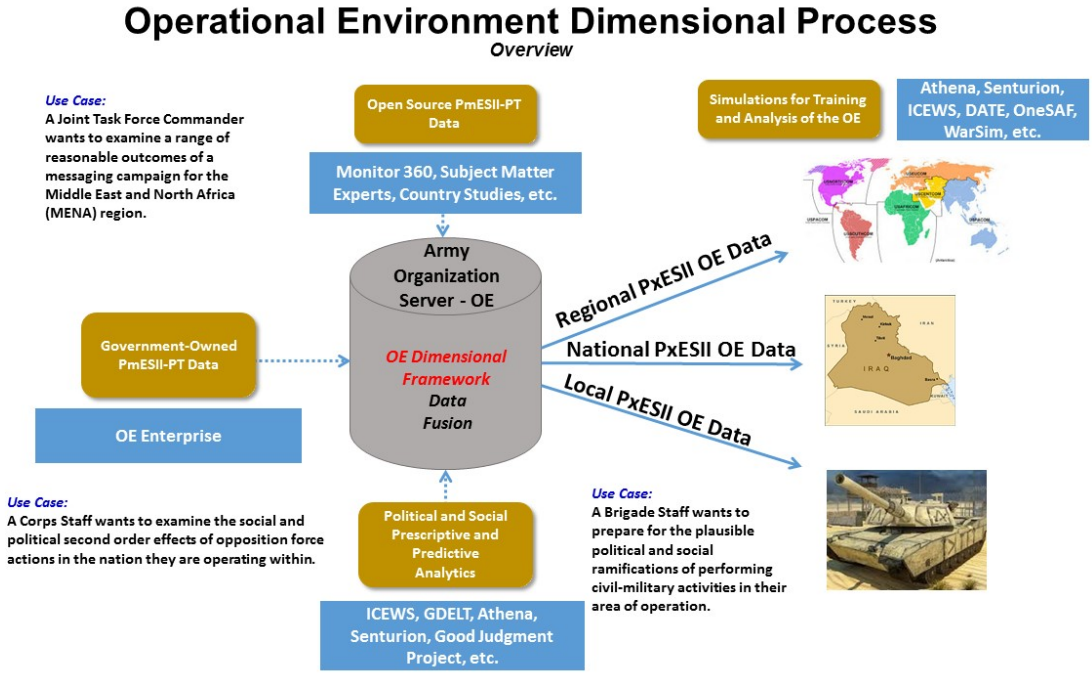

Figure 1. Overview of the OEDF Process

Army commanders and staffs describe the operational environment in terms of operational variables. These variables describe not only the military aspects of an operational environment, but the population dynamics within it. These descriptions occur across six interconnected operational variables: political, military, economic, social, information, and infrastructure—Army doctrine adds two more, namely, physical environment and time. All together, these operational variables are abbreviated using the acronym PMESII-PT. The OEDF is intended to ease and standardize the ingestion of non-military aspects of PMESII-PT (henceforth referred to as PxESII-PT) data into simulations. The operational variables relevant to the OEDF are listed below (Headquarters Department of the Army, 2008):

The **political** variable describes the distribution of responsibility and power at all levels of government, formal and informal. The **economic** variable consists of the general economic categories of an Area of Operations (AO), such as energy, raw materials, government development policy, distribution of labor and labor policies, income distribution, national food distribution, free market or socialist interface and functions, consumption patterns, external investment, taxation policy, port authorities, movement of goods, consumer issues, border controls, foreign trade, tariffs, and graft or corruption.

The **social** variable describes societies within an operational environment. A *society* is a population whose members are subject to the same political authority, occupy a common territory, have a common culture, and share a sense of identity. The **information** variable involves the collection, access, use, manipulation, rapid distribution, and reliance on data, media, and knowledge systems—both civilian and military—by the global and local communities.

The **infrastructure** variable includes the basic facilities, services, and installations needed for a community or society to function. The state of the infrastructure determines the resources required for reconstruction. Typical key infrastructure includes sewers, water, electrical, academic, trash, medical facilities, safety, and other considerations (also known as SWEAT-MSO). The **physical environment** variable is often the most noticeable aspect of an operational environment, since the terrain affects people, equipment, trafficability, visibility, and the employment of many weapons. **Time** affects all entities and relationships in the OE (obviously) and influences all decisions.

These variables succinctly describe the non-military aspects of the OE, and most information covered by these variables can flow seamlessly into any simulation that can accommodate them. For example, urban population, labor force participation rate, unemployment, the number of people with access to television, and the time when certain TV broadcasts (information operations) occur can be modeled in the Athena simulation in a straightforward fashion. However, certain human socio-cultural behavioral variables require further decomposition. In order to provide this higher level of resolution, the OEDF applies the Value Orientations Theory of Clyde Kluckhohn, Florence Kluckhohn, and Fred Strodtbeck. Value Orientations Theory focuses on capturing the cultural orientations of people to others in their group or society, their relationship to the wider world, as well as their relationship to time (Hills, 2002). When Value Orientations Theory is integrated with communications and physical environment considerations, a robust range of dimensions are accounted for. Finally, this set of dimensions uses the PxESII-PT variables of Political and Social as categories. For each applicable PxESII-PT category, the following OEDF dimensions would apply (Bhagat & Steers, 2009; Francesco & Gold, 1998):

- **Relationship to People:** Beliefs in the society regarding the preferred and generally accepted as legitimate form of social structures.
- **Relationship to Environment:** Beliefs in the society regarding the need or responsibility of individuals or groups to attempt to control nature (including people).
- **Evaluation of Human Nature:** Beliefs in the society about whether basic human nature is good, mixed, or evil.
- **Human Activity:** Beliefs in the society regarding appropriate human goals.
- **Time:** The extent to which individuals and groups in the society allow a past, present, or future orientation to influence their actions and decisions.

We have added two additional dimensions:

- **Communications:** The nature of the relationship between civilians or political entities and the media space, including print, TV, radio, mobile telephony, and the Internet.

- **Terrain:** The location-based information regarding private or public assets, including infrastructure. This dimension also defines the political boundaries of the AO and relationships between any smaller areas within it.

Further, OEDF categories permit recursion. For example, the Political category can describe the broad culture of governance in the AO as well as a single political actor (e.g., Government of Iraq, Ministry of Interior). The same applies to the Social category whereby the general civilian socio-cultural terrain of an area can be quantified as well as the values of a specific subculture (e.g., Albu Salih tribe).

The dimensions of the OEDF can be divided into enumerated, qualitative, settings along a continuum as well as a numerical scale for increased resolution. For example, the enumerated elements of the Relationship to People dimension are below, along a continuum from one position to its opposite (Hills, 2002):

- **Individualistic:** Emphasis on the individual or individual families within the group who make decisions independently from others.
- **Collectivist:** Emphasis on consensus within the extended group of equals.
- **Hierarchical:** Emphasis on hierarchical principles and deferring to higher authority or authorities within the group.

The numeric scale can also be aligned with the enumerated elements. For example, if one uses a seven point scale, 1-2 maps to Individualistic, 3-5 corresponds to Collectivist, and 6-7 into the Hierarchical range.

Sacred Values

Anthropologist Scott Atran has identified some values people hold as immutable and non-negotiable. Sacred values are "are moral imperatives that seem to drive behavior independently of any concrete material goal" (Atran & Axelrod, 2008; also Sheikh, Ginges, Coman, & Atran, 2012). If such a value can be identified in an existing culture, it can also be emphasized in the OEDF by first identifying the appropriate dimension(s), then selecting the correct numeric value. A summary of all OEDF dimensions and scales is below.

Dimension	**Enumerated Scale**						
Relationship to People	Individualistic		Collectivist			Hierarchical	
Relationship to Environment	Mastery		Harmony			Subjugation	
Evaluation of Human Nature	Good		Mixed			Evil	
Human Activity	Doing		Thinking			Being	
Time	Past		Present			Future	
Communications	Extensive		Moderate			Isolated	
Dimension	**Numeric Scale**						
Numeric Scale	1	2	3	4	5	6	7
Dimension	**Sacred Value Scale**						
Sacred Value Scale	1		4			7	

Figure 2. OEDF Dimensions with Enumerated Elements, Numeric Scale, and Sacred Values

The OEDF would allow the fusion of PxESII-PT data from multiple sources into a single quantifiable construct describing a region. If there are conflicts between what the data sources are describing, then the pedigree of the source should be used to resolve the conflict. Alternately, contradictory OEDF profiles of an AO could be stored separately and used to compare and contrast outlier perspectives. Once stored, the quantified OEDF OE profiles could be distributed to a range of simulations as needed. Perhaps one key leader engagement training simulation would make use of an OEDF profile for a local governing council. The same profile could be used to inform the cooperation level set between an agent and Blue or Red forces in a One Semi-Automated Force (OneSAF) or WARSIM scenario.

DATA SOURCES

The OEDF could be fed by a range of data sources. These include the CIA World Factbook, country studies, subject matter expert (SME) assessments, as well as data from other simulations. Each source would require an appropriate transformation matrix. The World Values Survey (WVS) is an example of one such source, a database of global beliefs and values collected from almost 100 countries. In the Demonstration section of this paper, a transformation methodology for WVS data will be described. In Figure 3 one can see an example of a cultural map of World Values Survey data.

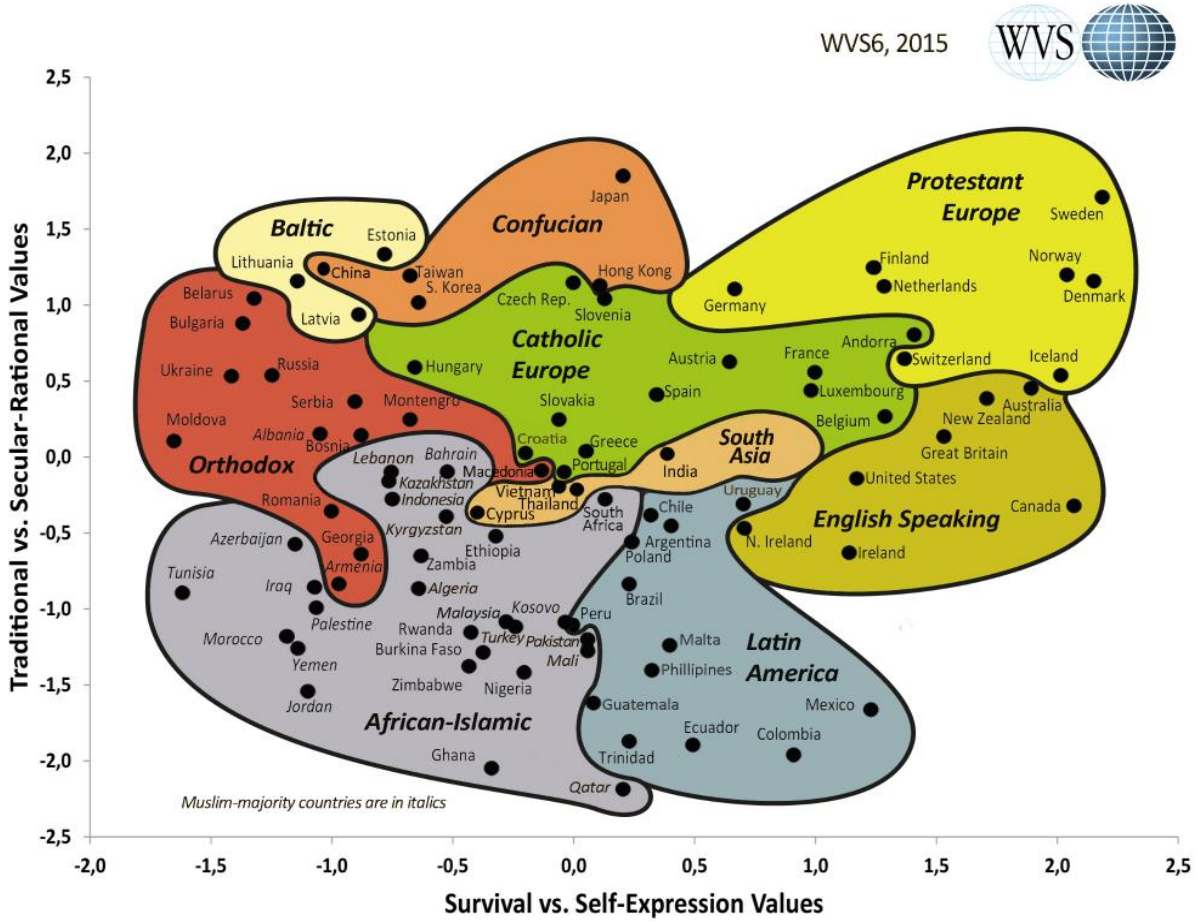

Figure 3. World Values Survey Wave 6 Data

SIMULATIONS

A number of simulations could receive OEDF PxESII-PT profiles, among them the PMESII decision support tool, Athena. The Athena capability supports a decision maker by providing both a framework to better understand complex PMESII-based problems and a simulation for anticipating the long-term consequences of engagement choices across the totality of the operational environment.

Athena is an open-source, scalable, single-user, laptop-based simulation, and enables the analysis of second- and third-order effects upon noncombatant groups—and those groups' possible responses—in order to discern potential outcomes from political, military, economic and social interventions. Athena allows leaders and analysts to understand the intended and unintended consequences of their proposed actions through a simulation process that

incorporates social science "universals" into course-of-action analysis and campaign planning. It enables the examination of interdependent political, economic, security/military, and information dynamics, as well as the anticipation of emergent actors, factions, and powerbases, and compares and contrasts multiple courses of action.

The Athena Simulation has been used since 2011 to conduct studies and analysis in support of the Joint Staff, various Combatant Commanders (COCOMs)—to include Central Command (CENTCOM), Strategic Command (STRATCOM) and Africa Command (AFRICOM)—and the Defense Threat Reduction Agency (DTRA). In addition, Athena has supported experimentation events to include Unified Quest 2014 and 2016. Beyond its utilization in support of studies and analysis, the simulation has been deployed with an Athena Support Team on real-world operations. The first was in support of CENTCOM for the purpose of examining the Syrian refugee crisis and its potential regional impacts. The second was in support of Special Operations Command Central (SOCCENT). The Athena Support Team (AST) utilized the simulation and supporting research efforts to help inform commanders and staffs as they sought a better understanding of the motivations and philosophy of the ISIL phenomenon. Additional ASTs have supported US Army Forces, US Central Command (ARCENT) operations during Operation Inherent Resolve.

Athena's Belief System

Athena's belief system can be linked to OEDF dimensional values. Every civilian group and political entity (actor) has a belief system composed of statements of the ideas and issues that are important to the group or actor, along with how important they are and how the group or actor feels about those who disagree with it. The group's belief system is the source of the group's identity and the basis for its relations with all other groups. An actor's belief system may indeed reflect the actor's deeply held beliefs, or it may be a construct intended to garner support from the civilians (Duquette & Hanks, 2014). As a part of the transformation demonstration, three belief topics corresponding to the enumerated settings of the Relationship to People OEDF dimension were added to the Iraqi civilian groups within an existing Athena database. A belief system consists of an entity's beliefs about one or more topics. A topic is some value, principle, or issue about which there is some disagreement. In Pakistan, for example, Islam is a significant fault line between the Pakistani citizens and the United States. Topics are chosen by the analyst; there is no default set. A belief is described by two values, the entity's position for or against the topic of interest and the entity's emphasis on agreement or disagreement with that position. The former indicates how much the entity cares, and the latter determines how it feels about those who agree or disagree. The position and emphasis are entered qualitatively. With respect to position, the entity may be Passionately For, Strongly For, Weakly For, Ambivalent, Weakly Against, Strongly Against, or Passionately Against (Duquette & Hanks, 2014). The entity may put its emphasis on agreement or disagreement as follows: Agreement Strong, Agreement, Neither, Disagreement, Disagreement Strong, and Disagreement Extreme. If the emphasis is on agreement, the entity will tend to have a higher affinity with those entities with whom it agrees on this topic, while to some extent disregarding disagreements. If the emphasis is on disagreement, the entity will tend to have a lower affinity with those with whom it disagrees on this topic, while to some extent disregarding agreements (Duquette & Hanks, 2014).

Given the belief systems of two entities, A and B, Athena computes the affinity of A with B, and of B with A. The affinity is a number from -1.0 to +1.0 that indicates whether A supports or opposes the same things as B. Note that affinity need not be symmetric. All horizontal and vertical relationships in Athena are ultimately based on affinities, and hence on belief systems (Duquette & Hanks, 2014).

DEMONSTRATION

This section provides an end-to-end demonstration of how PxESII-PT data can be translated into OEDF dimensions, then ingested into the Athena simulation. There are four steps to this overall process.

Step 1: Area of Interest

The first step is to select the area of interest. For this example, the nation is Iraq. The limits of investigation are the overall cultural orientation of the general population of that nation.

Step 2: PxESII-PT Data Sources

Next, the open source data feeds need to be chosen. While there are any number of country studies or reports that could be drawn upon, this example uses the World Values Survey Wave 6 (2010-2014) and approved TRADOC unclassified sources and expertise.

Step 3: PxESII-PT Translation to OEDF

Responses to questions from the World Values Survey Wave 6 (2010-2014) (World Values Survey Association, 2015) could be translated to the OEDF Relationship to People dimension based on a factor analysis of responses, a range of mean scores, or a percentage of affirmative answers such as:

- 0%-40% = zero points
- 41%-70% = one point
- 71%-100% = two points

A diagram of the overall OEDF data transformation process demonstration is below.

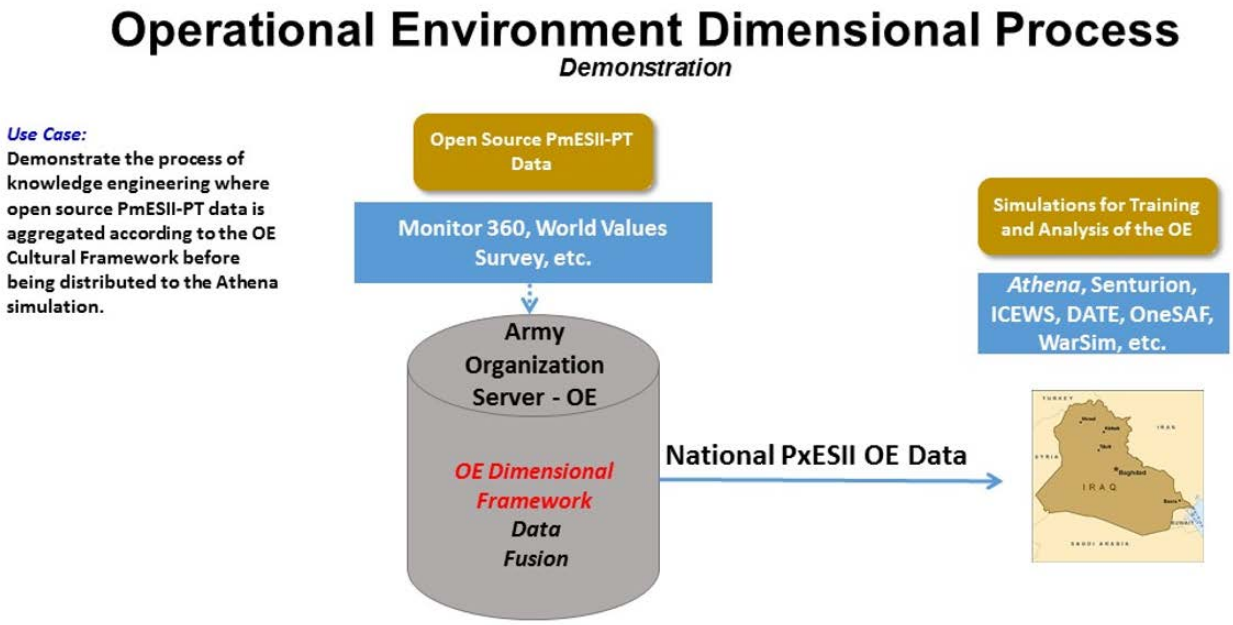

Figure 4. The OE Dimensional Process

One selected WVS question was: "It is important to this person to do something for the good of society." 66.5% of Iraqis answered "Very Much Like Me" or "Like Me." Thus, one point was logged along the Relationship to People dimension. The total number of points came to five, which scores the general Iraqi population as highly Collectivistic on the Relationship to People numeric scale. Thus, in Figure 5, one can see the mapping of Collectivism to a numeric scale. One or two points maps to Individualistic dimension, three to five points corresponds to Collectivist, and six or seven points maps to the Hierarchical range.

Dimension	**Enumerated Scale**						
Relationship to People	Individualistic		Collectivist			Hierarchical	
Dimension	**Numeric Scale**						
Numeric Scale	1	2	3	4	**5**	6	7

Figure 5. OEDF Relationship to People Dimension Mapping to Scales

Step 4: OEDF Dissemination and Translation to Athena

Once we have a numeric entry on the OEDF Relationship to People dimension, it can be translated into an Athena belief system setting. Three belief topics (Individualistic, Collectivist, Hierarchical) were added to the Athena database to accommodate this enhanced modeling of the Iraqi population through OEDF dimensions. The Athena database used in the OEDF demonstration had its belief system modified, adding three additional belief topics to accommodate the OEDF dimensions: Individualistic, Collectivist, and Hierarchical. One can see the list of belief topics in Athena below in Figure 6.

Topic	Affinity?	Title
T01	Yes	Zionist Scourge
T02	Yes	Agents of the West
T03	Yes	Stabilizing Secularists
T04	Yes	Alawite Survival
T05	Yes	Iran Defends the Muslim Middle East
T06	Yes	Stability first
T07	Yes	Restoring the Kurdish Homeland
T08	Yes	Iraqi Nationalism
T09	Yes	Restoring the Caliphate Immediately
T10	Yes	Violent Sunni Jihad
T11	Yes	Shiite Heretics
T12	Yes	Fear of Retribution
T13	Yes	Arab Sunni Reintegration
T14	Yes	Federalized Iraq
T15	Yes	Individualistic
T16	Yes	Collectivist
T17	Yes	Hierarchical

Figure 6. Belief Topics in the OEDF Athena database

OEDF dimensions were then mapped to a range of Athena belief position and emphasis settings. The strongly Collectivist point on the numerical scale was converted into a position of Weakly Against the Individualistic belief topic, Passionately For the Collectivistic belief topic, and Weakly For the Hierarchical belief topic. If any sacred values were to be associated with enumerated elements (Individualistic, Collectivist, or Hierarchical), then the Athena emphasis setting for the corresponding belief topic would be set to Disagreement Extreme, which would dramatically drive down the civilian affinity with any others who disagree with its position setting on these topics.

OEDF Relationship to People Dimension/ Athena Belief Topic	**Athena Belief Positions and Emphasis Settings**						
Individualistic	Passionately For	Strongly For	Weakly For	Ambivalent	**Weakly Against**	Strongly Against	Passionately Against
Collectivist	Passionately Against	Strongly Against	Weakly For	Strongly For	**Passionately For**	Ambivalent	Ambivalent
Hierarchical	Passionately Against	Strongly Against	Weakly Against	Ambivalent	**Weakly For**	Strongly For	Passionately For
Dimension							
Sacred Value Scale	Disagreement Extreme		Disagreement Extreme			Disagreement Extreme	

Figure 7. OEDF Relationship to People Dimension Mapping to Athena Belief Settings

Figure 8 shows the OEDF modified input to Athena and some of the interrelated modeling areas within the simulation as well as the resulting outputs they generate. When the OEDF Relationship to People enhanced belief settings were given to Iraqi civilian groups in Athena, there was, in general, a slight decrease in polarization along existing fault lines. Moderate Sunni Arabs became closer in affinity with moderate Shia, while the relationship distance between extremists and moderates was generally unchanged.

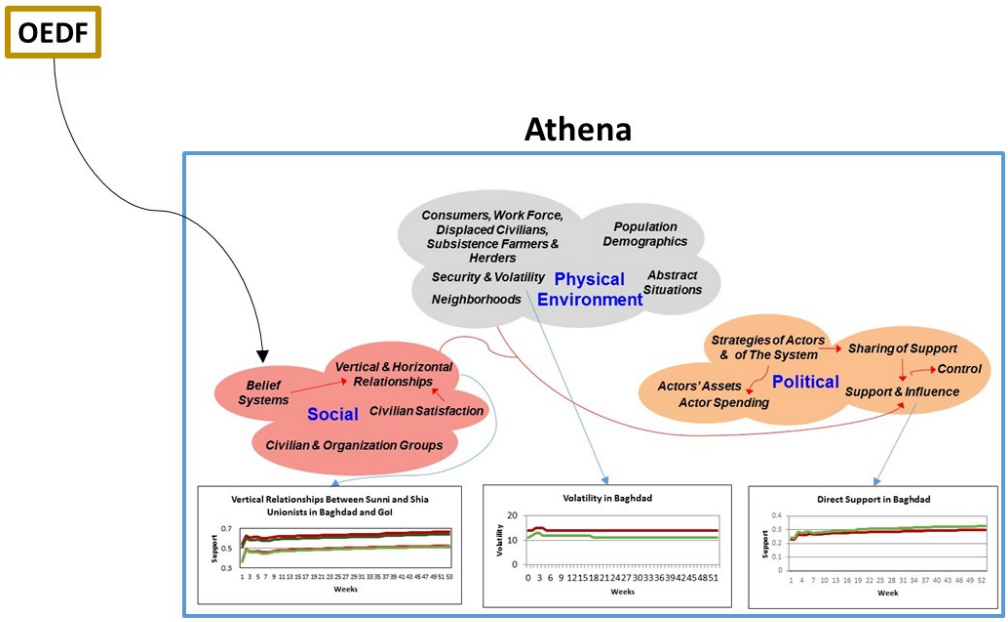

Figure 8. Excerpt of Athena modeling area interactions and inputs from OEDF

Within Athena, Volatility is a number between zero and 100 and is essentially a friends versus enemies calculation for a neighborhood. The higher the Volatility, the greater the antagonism between groups present there. With the OEDF enhanced beliefs and the increased simulated commonality of belief, Volatility decreases slightly (represented by the green line in Figure 8). In Athena, Direct Support is a variable measuring each civilian groups' level of support for all the actors in their neighborhood. In the OEDF enhanced simulation run, Direct Support for the Government of Iraqi increased slightly (again, the green line in Figure 8), signifying an overall increase in shared set of beliefs by the civilian population. However, before using any of these new settings, the new relationships would have to be validated by subject matter experts.

SUMMARY AND CONCLUSION

This paper demonstrates that it is possible to transform survey data, through the OEDF, into inputs that can be ingested by a cross-cutting PMESII-PT simulation like Athena. An OEDF-enabled simulation could be used to analyze or train commanders how to best plan for a complex operational environment. With inputs more diverse and authoritative than the World Values Survey, perhaps a richer and more representative operational environment could be simulated. A more ambitious study or experiment would have to be conducted to see how extensible the OEDF is to other simulations and data sources.

The way ahead for the OEDF is to search for interested stakeholders and make the methodology compliant with the Army Information Infrastructure (AIA). A first step in this process would identify authoritative data sources and use cases. During this phase use cases would establish the applications of the OEDF and prevent any duplication of effort (Office of the Army, 2013). The second part of the process would generate one or more data schemas describing how authoritative datasets would be formatted and transformed by the OEDF framework. In this phase the OEDF would also be made compatible with all data-receiving simulations. It is critical that subject matter expert evaluation of synthesized PxESII-PT data be integrated into the OEDF process. Simultaneously, legal considerations would be resolved—Data Owners would have to agree to data use and web service accessibility standards (Office of the Army, 2013). The third phase would codify how the OEDF service would exchange information with any other existing Army systems, accounting for factors such as interoperability and mediation (Office of the Army, 2013). It should be said that there is no technical reason why the OEDF service could not be extended to include other branches of the United States Armed Forces or international partners.

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