Applied Use of Socio-Cultural Behavior Modeling and Simulation: An Emerging Challenge for C2

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Abstract

Command and Control (C2), especially in the uncertain environments associated with counter-insurgency, stability operations, and irregular warfare actions, require a knowledge and shared understanding of not only an elusive adversary, but the socio-cultural layer in which the adversary lives and enjoys a support structure. C2 in these situations must accommodate complexities and situations far different from classic force on force engagements. In this environment, C2 must take advantage of modeling tools that can elucidate the complex aspects of the environment and human interaction. To do this, users must be able to translate available data into the parameters and values of the models, generate and test hypotheses, and apply the model outputs in the command decision space. Ideally, commanders should have capabilities that support integrated planning, action, and assessment, such that they can select and rank order available actions based on their effectiveness across a landscape of plausible situations and outcomes. Moreover, these capabilities must be available not only for traditional military actions but also for non-kinetic actions and influence operations. There are many challenges associated with this vision of the applied use of models for C2. This paper will outline those challenges and discuss how they can be addressed. It will also outline the Human Social Culture Behavior (HSCB) Modeling Program of the Office of the Secretary of Defense, which exists to support the rapid transition of socio-cultural behavior computational models to acquisition programs of record.

Introduction

The Department of Defense (DoD) has gone beyond its traditional role, and capabilities, in large force-on-force scenarios. Current and future operations demand the capability to understand the social and cultural terrain and the various dimensions of human behavior within these terrains. The 2006 Quadrennial Defense Review and DoD Directive 3000.05 (on Military Support for Stability, Security, Transition and Reconstruction Operations) articulate the need for these non-traditional capabilities:

> *…preventing state or non-state actors from acquiring or using WMD [weapons of mass destruction] highlights the need for the following types of capabilities:… language skills and cultural awareness to understand better the intentions and motivations of potential adversaries and to speed recovery efforts* (QDR, p.35)

> *Stability operations are a core U.S. military mission…given priority comparable to combat operations…. U.S. military forces shall be prepared to perform...stability operations tasks…Rebuild indigenous institutions…..bottom-up economic activity and constructing necessary infrastructure…* (DoDD 3000.05)

The application of human, social, cultural and behavioral capabilities spans all operational environments, as illustrated in Figure 1. For example, effective influence operations must craft messages that will have the appropriate clarity and resonance with a target audience; this requires a thorough analysis and subsequent understanding of the audience. Similarly, commanders, warfighters and others central to stability, security, transition and recovery (SSTR) operations will enjoy significantly greater success if they are prepared with a more complete and sophisticated understanding of the human terrain in which they must function; training and mission rehearsal should therefore incorporate information and data on that terrain.

While the services and other elements of the DoD are moving quickly to build socio-cultural behavior capability, the inherent complexities outstrip traditional approaches. Alberts & Hayes (2003) describe the complexity of the situations that decision makers are facing:

> *It is becoming increasingly clear that the complexity of the situations faced and the responses needed have outpaced not only decision theoretic approaches, but have also outpaced the ability of even the best of experts (super stars) to deal with the complexities involved. First, the sources of complexity are accelerating. These sources of complexity include the variety of events and entities that are connected, the density of the interactions, and the speed of interactions that make it difficult to relate a cause to an effect and almost impossible to predict cascading effects.*[1]

Figure 1. Operational environments for socio-cultural behavior capabilities

Computational modeling, including simulation techniques, offers some capability for dealing with this complexity. As Zacharias, et al., write regarding organizational modeling:

> *First, a simulation model of an organization, which includes its structure and agents, generates behavioral and performance data on the organization, which can be analyzed as if they were field data. These are frequently called virtual*

[1] Power to the Edge, pages 88-89.

experiments….Second, simulation models can be similar to mathematical models, but they are more complex and not amenable to closed-form solutions….Simulation models free one from the size and scale restrictions of lab experiments and from the limitations of field data, which necessarily are historical and limited to what did happen—not what could have happened.[2]

This ability to explore complex sets of variables and explore "what if" scenarios is an aspect of computational modeling and simulation that is of particular value to the warfighters and others involved in military missions or SSTR operations. In the area of influence operations for example, techniques could include instantiating pertinent conditions affecting the audience, its susceptibilities and vulnerabilities, and media habits in an agent based model. That model could then be iterated to conduct a virtual experiment and explore the effects of adjustments to the model parameters—including influence operations. This type of application of computational models enables the user to leverage large amounts of data and explore cause-effect relationships without the time and resource costs associated with laboratory experiments. Alternatively, results from the model's application can be used to design and refine lab or field experiments to make them more effective.

Models are, by definition, incomplete. They are a formal abstraction of reality. This is especially true for socio-cultural behavior models, considering the complexities with which they are dealing. In order to be developmentally tractable they invariably leave out some factors or some interactions among factors that impact behavior. Still, even if they are incomplete, the models using social science frameworks are our best synthesis of the data at hand into a usable form. Without such models, people cannot deal with the degree and character of complexities noted by Alberts and Hayes. This paper will address the challenges associated with bringing socio-cultural behavior models into operational usage, and outline the Human Social Culture Behavior (HSCB) Modeling Program of the Office of the Secretary of Defense. The HSCB Program is focused on meeting those challenges and the rapid transition of socio-cultural behavior computational models to acquisition programs of record.

The Technical Challenges

The Challenge of Leveraging Modeling & Simulation for HSCB

The Need for Underwriting

Where C2 involves socio-cultural behavior considerations it must accommodate complexities and situations far different from classic force on force engagements. In this environment, C2 must take advantage of exploratory modeling tools that can elucidate the complex aspects of the environment and human interaction.

There is no potential shortage of of modeling and simulation (M&S) applications that might be useful for understanding socio-cultural behavior. Journals such as the *Journal of Computational & Mathematical Organizational Theory*[3] and the *Journal of Artificial Societies and Social Simulation*[4], along with textbooks such as Gilbert (2005) contain relevant studies. There are even entire academic programs, such as the Computational Social Science program at George

[2] Zacharias, MacMillan and Van Hemel, page 137.
[3] http://www.springerlink.com/content/102865/
[4] http://jasss.soc.surrey.ac.uk/

Mason University[5]. The problem is not in trying to create M&S tools to use within the socio-cultural behavior context; rather, the problem is in understanding which M&S tools are actually useful and when. Understanding how best to use these M&S tools is a challenge, as these techniques can vary widely in their complexity and granularity, ranging from macro-level modeling of complex systems through meso-level social network analysis and agent-based modeling, to micro-level approaches such as cognitive and rational choice models. How complex is complex enough? How simple is simple enough? Unfortunately there is no single or right answer. Each M&S application within the socio-cultural behavior realm will be unique to some extent; thus, requiring unique levels of complexity and simplicity; not to mention verification, validation, and accreditation.

It may seem oxymoronic to discuss unique levels of complexity and simplicity within the same application but within the socio-cultural behavior context it is not. As well articulated by a recent National Research Council study (Zacharias 2008), it is a rare case when a single model will be sufficient to tackle to entire question posed within an socio-cultural behavior context. Socio-cultural behavior questions often require the use of many different M&S tools. This could range from a loose coupling of a conceptual model informing data gathering that is then used to create a regression equation, to very tightly coupled large-scale model federation with immense interconnectivity. These various M&S tools may be of different resolutions and levels of verisimilitude; some models may be very high resolution, while other parts are much lower resolution. This is compounded when the socio-cultural behavior tools are to be integrated with, or used in conjunction with, a command and control system. Here, M&S tools can be used, at a minimum, for training individuals on socio-cultural behavior background information for an area of interest, as an immersive environment in which to learn how to use a culturally enhanced C2 system, as a way to explore the dynamics of a human system and thus gain awareness of the mission focus of a C2 system, and as a part of a C2 planning system used for course of action (COA) development and analysis.

Given this variety, the only way to authoritatively assess the usefulness of the whole M&S conglomeration is to understand each component model. Once each component is understood, then one can begin to understand the whole and, thereby, make a decision as to its usefulness for addressing the socio-cultural behavior related questions at hand. This understanding is required if the government is to rely regularly upon the M&S tool(s) and their results. Without this authoritative assessment, government users will not have the confidence in socio-cultural behavior tools to make them a regular part of their decision-making process. Therefore, we must establish a routine principled way to authoritatively assess these models.

Such assessment of these models is nontrivial. By their nature they require a multidisciplinary perspective, usually a social scientist(s) articulating theories and gathering relevant data and a computer scientist(s) creating the M&S tool. Other disciplines may be involved also, such as statistics, artificial intelligence, and data mining/machine learning. This diversity of information, tools, and techniques required to create a socio-cultural behavior tool necessitates a particular structure to its documentation and presentation.

Most aspects of the documentation are quite typical including, inter alia, user and technical documentation discussing application programming interfaces, data requirements, hardware requirements, and other necessary software. However, what is most important is a plain language model formulation. It is this plain language formulation that will allow other domain experts to

[5] http://socialcomplexity.gmu.edu/

be involved with a review of the socio-cultural behavior M&S tool. This formulation must include, at a minimum, three parts:

1. Descriptions of all theories that underlie the model,
2. Descriptions of all modeling techniques used in the model, and
3. An explanation of why the chosen modeling techniques are appropriate to use with the theories that underlie the model.

A formulation that includes the above three parts will allow an independent review of the socio-cultural behavior model to occur; one that can include not just computer scientists verifying the code base, but also domain experts that can review the theories that shaped the computer code. In this way, the government can truly gain an appreciation for the socio-cultural behavior tool and how best to use it within the context of a C2 system. Changing critical data, uses and contexts present a particular challenge for these types of models. In these fluid environments the socio-cultural experts who are familiar with the available models will be especially important as they will be able to 'scope' the areas where the underlying socio-cultural theories are valid and relevant. Furthermore, extensive sensitivity analysis and "model breaking" will be important within these dynamic C2 environments. Sensitivity and model breaking will allow the tool users to understand where the model works, where it does not, and how the model fails.

Assessment of Socio-Cultural Models

In most cases, model documentation should include some aspect of verification, validation (V&V), and, potentially, accreditation (VV&A). Moreover, with the aforementioned formulation the government will be in a very good position to make an accreditation determination. There are many very good treatments of traditional VV&A (Hartley 1997; the Defense Modeling and Simulation Office[6]). However, traditional V&V is extremely difficult with respect to socio-cultural behavior models. There are many reasons for this, including lack of availability of data, theory, and measurement precision, among others. Does this mean that rigorous V&V is not possible for socio-cultural behavior M&S? In the strictest, traditional sense, yes. However, appropriate *technical assessment* can be done with a different assessment framework that will be briefly outlined below. A more complete treatment can be found in Barry, et al.(2009) and Johnson, et al. (2007).

For technical assessment (and potentially accreditation) of socio-cultural behavior M&S tools there are two frameworks of particular utility: the Framework of Empirical Relevance (FER) and the Model Docking Framework (MDF)[7]. Generally speaking, the FER relates to the focus of the model and the MDF applies to how a model relates to a reference dataset. The FER and MDF offer ways to think about what a model does and how well it relates to some sort of referent. Articulated for agent-based models, both the FER and MDF could be used in analogous ways to think about other types of models, such as game theoretic or systems dynamics.

[6] www.dmso.mil
[7] See Axtell (2005) and Axtell (1996), respectively.

There are four levels in Axtell's FER:

- Level 0: individual level qualitative correspondence between the model and the data
- Level 1: macro level qualitative correspondence between the model and the data
- Level 2: macro level quantitative correspondence between the model and the data
- Level 3: macro and micro level correspondence between the model and the data

While the FER framework discusses qualitative versus quantitative correspondence between the model and the data at specific levels of resolution, one can use the MDF to add specificity to those distinctions. The MDF defines three levels of correspondence between model generated data and a reference data set, be it from another model or from a "real-world" dataset. Axtell, et al. (1996) lists three levels of correspondence:

- Identity: the model and the referent are identical
- Distributional: the model and the referent are statistically indistinguishable
- Relational: the model and the referent behave similarly, increases to input "X" produces a similar directional change in output

These two frameworks and the intended use of the socio-cultural behavior M&S tool can be used to spell out the necessary level of rigor for the technical assessment. This will be illustrated via examples below.

If the tool is to be used for what-if analysis at a strategic level to gain an understanding regarding what might be a better COA, as opposed to determine the optimal COA, or the exact impact of a COA, then likely the level of technical assessment for the tool is relational at the Level 0 or perhaps Level 1 FER. If, however, one is going to use the M&S tool at a tactical level to understand the exact impact of a COA, then the level of rigor used for technical assessment must be higher. In this case, one will need at a minimum distributional equivalence at Level 2 FER. At the extreme, if one is going to use a socio-cultural behavior M&S tool for determining individual reactions, behavior, or importance then the rigor of V&V necessary will be very high. This use of the tool would require distributional (ideally identity) equivalence at FER level 3.

However, there are inherent irreducible uncertainties in socio-cultural behavior models that limit their FER correspondence to Level 0/1 and their MDF correspondence to Relational. These uncertainties stem from the limits of the applicable domain and range of current social science theories themselves. There is nothing like a unified theory in any single social science that addresses the complete domain of human social cultural behavior, let alone one that all the different social sciences would accept. Even within their limited domains, the range of variance in behavior that any social science theory can account for is relatively small. Moreover, the translation of real-world data into model parameters and values is also an uncertain and ultimately a subjective process.

Given these low levels of quantitative and qualitative correspondence, these models cannot be used for predictive purposes in the same way a projectile trajectory model is used. However, they can be used to bound the space of plausible future behaviors of a simuland under various courses of action or policies. Used in this *exploratory* way (Bankes, 1993), these models can help identify the most robust policy or operational plan for a landscape of plausible futures. This is described in more detail below.

The Challenges of Translating from Model Results to Human Decision Space

Seeking Robust Decision Making.

An *optimal* plan is one that maximizes expected return on investment. Under deep uncertainty (Lempert et. al. 2006) such as that posed by socio-cultural behavior models, optimal strategies lose their prescriptive value if they are sensitive to the modeling uncertainties. That is, selecting an optimal strategy is problematic when there are multiple plausible futures. Consider a very simple example.

Suppose the optimal infantry line of approach to a target is down a gully under dry conditions, but under heavy rains, a different line would be optimal. If your weather model predicts dry and wet conditions with equal probability, then which will be the optimal line? One could expend a lot of effort trying to improve the modeling of the weather in order to determine the answer. Alternatively, Chandresekaran (2005) and Chandresekaran & Goldman (2007) note that for course of action planning under deep uncertainty one can shift from seeking optimality to seeking robustness. In other words, one could look for the most robust line of approach that would likely be successful whether or not it rains.

Lempert, et al. (2006) describes a general simulation-based method for identifying robust strategies, a method they call robust decision making (RDM). Using our simple example, one would translate different lines of approach into the parameters of a model. Then for each line, one could explicitly systematically manipulate the other uncertainties of the model (e.g. weather). The model would be executed for each combination of line of approach and set of uncertainties to determine which line performs relatively well across the range of the plausible futures that the model projects. This approach can also identify vulnerabilities of these lines of approach, showing under what plausible circumstance each does poorly. In turn, this can suggest new lines of approach to try to better hedge against these vulnerabilities. Ultimately, this enables decision makers to characterize the trade-offs involved in their decision space of different lines of approach.

The general approach of seeking robust strategies has been a common business practice (Schwartz, 1996). However, the power of computer modeling enables extending this approach far beyond human-generated strategic scenarios or the traditional three courses of action of the military decision-making process. Figure 2 illustrates the results of the application of this approach in a strategic assessment of lines of operation in Sudan using the S3DM systems dynamic model of violent dissident recruitment[8]. Each course of action that is listed along the vertical axis of the graph was translated into parameter values in the model. Uncertainty around each of these endogenous variables was estimated and systematically varied across multiple executions of the model. In addition, other exogenous variables that would not be under the control of a course of action, but would likely interact with it (like the rain in our simple example), were also systematically varied across these multiple executions of the model. The result was a hyperspace of combinations of different endogenous and exogenous variable values, which can be considered a hyperspace of plausible future situations. Each of these situations can then be evaluated in terms of how much regret (in this case, how many violent dissidents are recruited) is generated by that situation. When the regret of each situation is mapped against each course of action, we get a two-dimensional projection that allows us to compare robustness in the

[8] Choucri, et. al., 2006.

users' decision space, as illustrated in Figure 2. For each option, the distribution of regret is illustrated as a box plot[9].

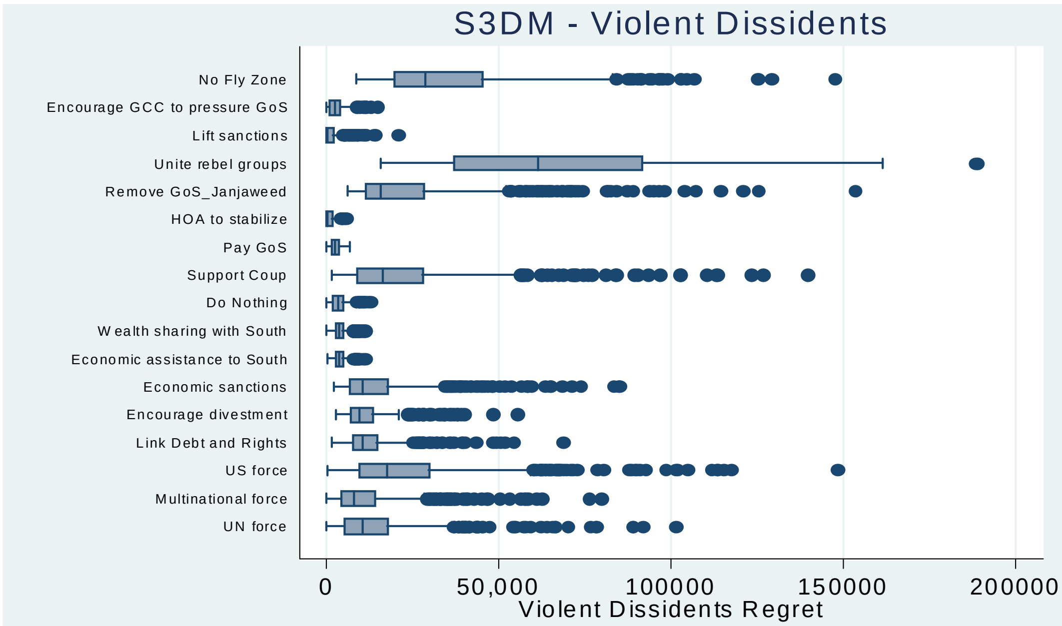

Figure 2: 2-D projection that maps hyperspace of possible future situations into COA decision space

In doing so, we can see that the option of "uniting the rebel groups" is apparently both the least optimal and the least robust. It has the highest median regret (the vertical line inside the gray box). Moreover, it has a wider range of results that are sensitive to the interaction between the course of action and the endogenous variables in the model. Finally, under the best situation (the left-hand end of the box plot), it results in more violent dissidents than even the median of some other options. On the other hand, "doing nothing", having the "North fairly share wealth with the South", and "providing economic assistance to the South" are all fairly robust lines of operation. Although the plot shows that each of these options can result in zero violent dissidents being recruited, it cannot be inferred that these outcomes occur under the same situations. However, this situation information could be gotten from the details of the model executions. That information might suggest that the low-regret outcomes of one of these options actually occurs under conditions that a commander can help make more likely to occur with additional preparatory actions. Such preparatory actions could be translated into the model and new round of model-executions done.

The process described above highlights using the models for translating between a situation space (the input to the models) and the decision space (the outcomes of the models) where alternatives are compared. Hall, et al. (2007) describes this distinction, and ongoing work (Klein, et al., 2009; Drury, et al., 2009) illustrates how this distinction provides a new perspective on

[9] The box portion of the plot indicates the inter-quartile range (IQR) – the distance from the lower first quartile below the median (indicated by the line within the box) to the upper first quartile above the median. The dots represent any outlier values that are more than 1.5 x IQR above or below the box. "Whiskers" connect the box to the largest and smallest values outside the IQR box that are not outliers.

establishing "sufficient fidelity" for an operational user's purpose. Considered from this perspective one could measure the sufficiency of fidelity or detail in terms of its impact on the decision space. Does it change the order of the decision options in terms of robustness (or optimality)? Does it change distance between options on a robustness scale? Does it change the conditions for low or high regret? Klein and Drury are working on developing general methods or principles for determining how much model-fidelity can be reduced to satisfy given decision spaces. In this way, models may be made more feasible for more tactical usage: by removing needless fidelity the models will execute faster, be more easily developed and more easily maintained.

Integrating Across Multiple Socio-Cultural Behavior Models.

There does not yet exist a unified theory of human social cultural behavior. Thus, one must integrate findings from many different models into a structure where a rational basis to understand factors influencing or driving social-cultural problems can be objectively and analytically examined. Social science models represent many different issues on many different scales. For example, one model might forecast the growth rate in a country's number of dissidents; another might forecast the probability of civil war; another might forecast the development of societal conflict under differing levels of criminal activity.

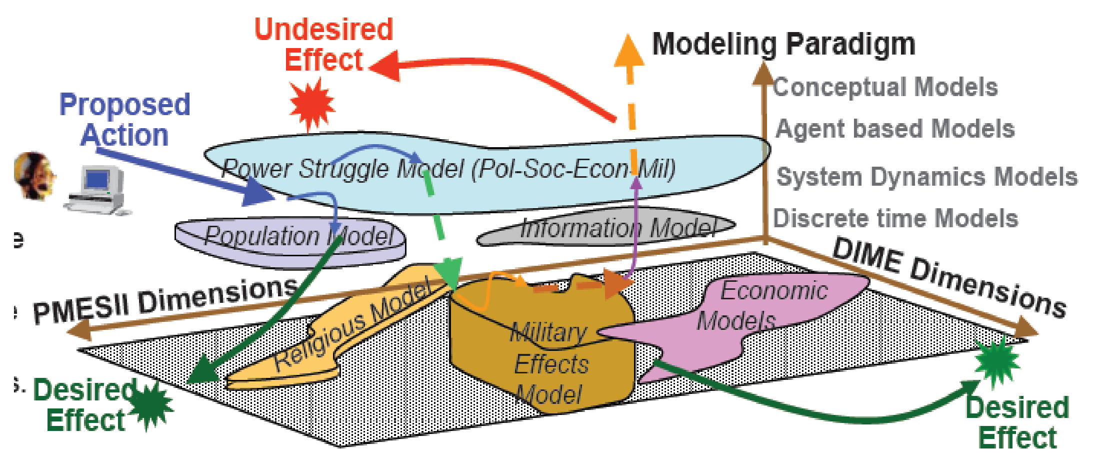

Figure 3 Human socio-cultural behavior problem space

Figure 3 illustrates the interrelationship between multiple models at multiple levels of abstraction. If their interactions are studied and their effects integrated into the decision space then an increasingly holistic understanding of a country, environment, or condition can emerge - one that otherwise might be unseen. With this, improved understandings of social situations are possible, as well as responses to specific policy actions. This is the challenge in social science and in social science modeling; that is, how to translate and integrate disparate model outputs, and their interactions, into human decision space. How can this challenge be addressed?

Suppose we have three variables X_1, X_2 and X_3 as shown in Figure 4. Observe each variable is expressed in a different unit. The horizontal scale for X_1 is qualitative. It has an ordinal preference ordering. The horizontal scales for X_2 and X_3 are quantitative. They each have a cardinal preference ordering. Each vertical scale in Figure 4 represents the variable's measure of "goodness" over the level it achieves along the horizontal axes. A value of one on the vertical axis is associated with a decision maker's judgment of the "best" or "most preferred" outcome of X_i. A value of zero on the vertical axis is associated with a decision maker's judgment of the "worst" or "least preferred" outcome of X_i. In the military analytic communities, the horizontal and vertical axes of these functions are called measures of performance and measures of effectiveness, respectively.

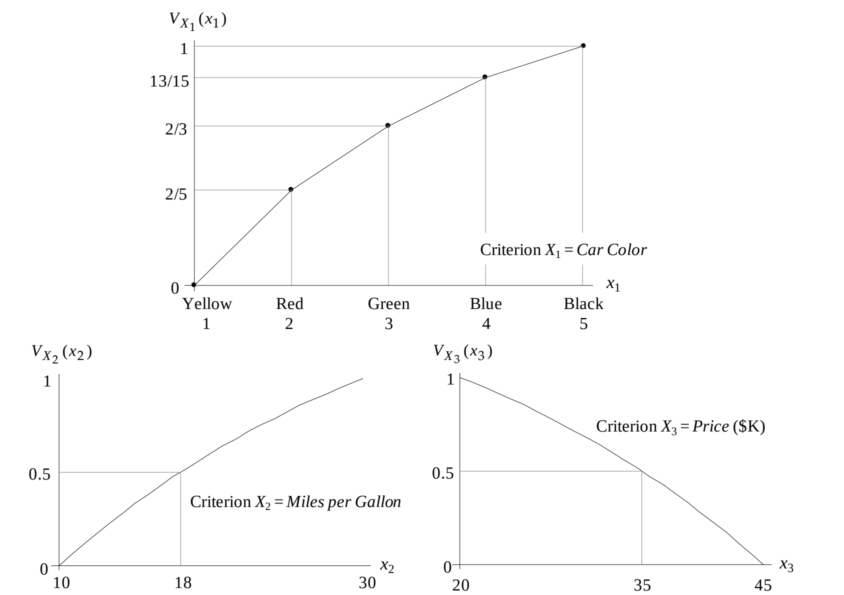

Figure 4 Illustrative Utility Functions: Preference Values for Color, Miles per Gallon, and Price

The functions in Figure 4 are utility functions in the spirit and heritage of Bernoulli's theory of utility, and his original log utility function (Bernoulli, 1738). Alone, these individual utility functions may not be enough to base a decision or a policy — but if they can be combined, then their contribution would make for a more robust and integrated decision basis than if considered separately. Under certain conditions, a rational decision basis for selecting the "best" option from a set of competing options characterized by multiple attributes each expressed by separate utility functions is a linear additive model of a form given by the following equation:

$$V_Y(y) = w_1 V_{X_1}(x_1) + w_2 V_{X_2}(x_2) + w_3 V_{X_3}(x_3) + \ldots + w_n V_{X_n}(x_n)$$ [10]

This represents the basic structure for rational choice in the presence of uncertainty as, in the present context, when inputs come from separate model outputs on different scales and in different units. Recent work by a MITRE team applied this approach to develop a decision-analytic protocol to integrate and synthesize findings from many different social science models and data sources on the Sudan. The aim was to normalize data and model outputs such that a

[10] See Keeney and Raiffa for explication of their linear additivity theorem.

rational and coherent basis for exploring policy options, and their efficacies, could be made. The protocol created was called topHAT™, which stands for topological Hypothesis Analysis Tool. The basic analytical engine inside topHAT™ is a utility function-based approach as described in the preceding discussion. Figure 5 illustrates the basic analysis process.

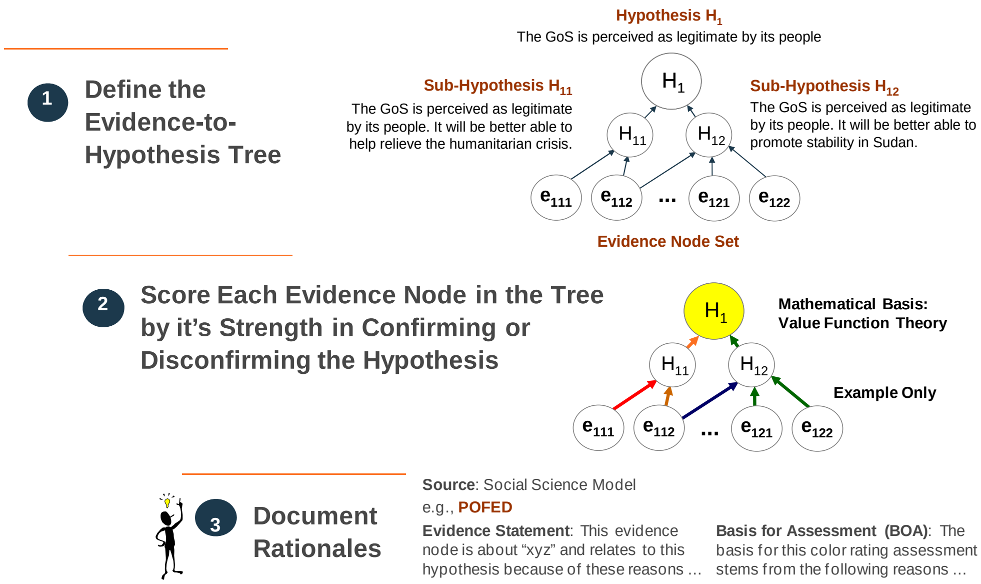

Figure 5 topHAT™ Decision Analytic Protocol

In topHAT™, a hypothesis is structured into evidence nodes to form a graph as shown in Figure 6. Evidence nodes come from the outputs of social science models, where each addressed aspects of the hypothesis being evaluated. Each evidence node is scored along a common utility function with respect to its strength of confirming or disconfirming the hypothesis. The function used has similar characteristics to those illustrated in Figure 4. Within the evidence-hypothesis graph (or tree), the confirmative strength of a hypothesis was measured as a function of the confirmative strength of all its descendant evidence nodes, as these nodes contribute to confirming or disconfirming the hypothesis. Measurement scales in the form of utility functions were also defined for assessing the veracity and the confirmative (or disconfirming) strength of each piece of evidence. Modern decision analysis, utility functions,

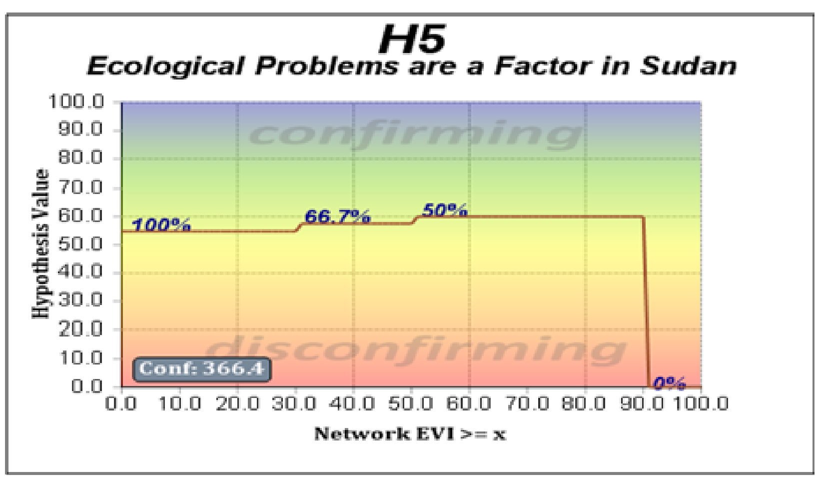

Figure 6. A Hypothesis Value from topHAT™: A Decision-Analytic Protocol

and measurement theory operated on these evidence nodes to derive an index that measured the degree a hypothesis was confirmed or disconfirmed by its evidence topology. Table 1 illustrates a utility function used to assess the performance of an evidence node as it contributes to the veracity of the hypothesis being examined.

Ordinal Scale Rating Level (Score)	Definition/Context Confirmative Strength Scale: Evidence Node	Cardinal Interval Scale Rating Level (Score)
5 B BLUE	The evidence node is *very strongly favorable* towards confirming the parent sub-hypothesis.	80 to < 100 Midpt = 90
4 G GREEN	The evidence node is *strongly favorable* towards confirming the parent sub-hypothesis.	60 to < 80 Midpt = 70
3 Y YELLOW	The evidence node could be reasoned as *slightly favorable toward confirming* or *slightly favorable towards disconfirming* the parent sub-hypothesis	40 to < 60 Midpt = 50
2 O ORANGE	The evidence node is *strongly favorable* towards disconfirming the parent sub-hypothesis.	20 to < 40 Midpt = 30
1 R RED	The evidence node is *very strongly favorable* towards disconfirming the parent sub-hypothesis.	> 0 to < 20 Midpt = 10

Table 1. An Illustrative Utility Function in topHAT™

From this, a series of analyses could be conducted on a variety of hypotheses as a function of their evidence sets, which were derived by normalizing social science model outputs into common utility scales. Figure 6 presents one of many types of outputs generated by topHAT™. For the Sudan Study the hypothesis analysis approach provided:

- Traceability, Transparency: A traceable and transparent way to "holistically" interpret the indicative truthfulness (i.e., confirmative strength) of each hypothesis by fusing social science modeling and subject expert findings into a common analytic framework.
- Hypothesis Drivers: A way to separate, measure, and derive the drivers most influencing the truthfulness of each hypothesis and whether confirmative strength is driven by models only, by expert judgment only, or some combination.
- Contribution by Evidence Veracity: A way to analytically measure the truth or falsity of each hypothesis as a function of evidence veracity (i.e., the degree the confirmatory strength of a hypothesis is based principally on "high" versus "low" evidence veracity).

- Documented Trace Narratives: Fully documented rationales and narratives supporting all modeler and subject expert findings, inferences, and judgments for how their results relate to each hypothesis and the basis for whether these relationships contribute to confirming or disconfirming hypotheses.

A summary thought on the theory and formalisms presented is well-stated by R. L. Keeney, currently research professor of decision sciences, Duke University. In his book, *Value-Focused Thinking: A Path to Creative Decision Making* (Keeney, 1992), Professor Keeney discusses the question: Are Value Models Scientific or Objective? He offers the following:

> *The final issue concerns the charge that value models are not scientific or objective. With that, I certainly agree in the narrow sense. Indeed values are subjective, but they are undeniably a part of decision situations. Not modeling them does not make them go away. It is simply a question of whether these values get included implicitly and perhaps unknowingly in a decision process or whether there is an attempt to make them explicit and consistent and logical … It certainly seems more reasonable — even more scientific — to approach important decisions with the relevant values explicit and clarified rather than implicit and vague.*

From the foregoing discussion, it should be apparent that C2 for current and future missions involving irregular warfare, counter-insurgency, and SSTR operations will require non-traditional modeling capabilities, many of which are yet to be discovered and elaborated.

The Programmatic Challenges

To develop the kinds of non-traditional capabilities now in demand, the DoD needs models and understanding of societies, cultures, and human behavior for individuals and groups. These "individuals and groups" are not only the adversary, but non-hostile foreign populations, our own forces, other arms of our government, coalition partners, and non-governmental organizations. However, as described above, socio-cultural behavior models have particular characteristics that users will need to accommodate in order to bring them into regular use. Special technical assessment procedures will need to be employed to authoritatively assess these complex models' forecasting of inherently uncertain behavior. Multiple models will need to be integrated to deal with the multiple aspects of the human terrain. Finally, to using such models to support more culturally sensitive DoD planning and decision making, will require a move from seeking optimal courses of action, to seeking robust courses of action. The challenge of developing, integrating and deploying models for operational uses is extraordinarily complex, as previously illustrated in Figure 3.

Because of these characteristics, beyond purely technical challenges, there are a number of programmatic challenges impeding progress toward effective, integrated leveraging of model-based capabilities. First, there needs to be a technical socio-cultural behavior core capability for the military domain (drawn from academia, government labs, or industry). There also is a need to develop U.S. commercial and government capability, and furthermore to tap socio-cultural behavior understanding and experiences outside the U.S.

Another challenge has, counter-intuitively, been the growing investment in tools because that investment has been primarily ad hoc, a product of unorganized demand for work in this area.

The result has been an over-focus on near term deliverables that support current operations and support for a relatively narrow customer base (e.g., analysts).

A final challenge concerns transferability. There has been limited 'reuse' of data and software and no life-cycle management plan for products. DoD has not invested in resources needed to port and/or extend relevant data, knowledge and tools from one system to another. Products have been designed with limited capability, and not to receive the kind of deeper cultural understanding that would make tools and models generalize (e.g. to new regions, or new tribal/societal structures).

The HSCB Program

Beginning in Fiscal Year 2008 the DoD has a new research and development (R&D) program to develop a science base and associated technologies for socio-cultural behavior modeling. The Human Social Culture Behavior Modeling (HSCB) Program is rooted in social science theory and centered on computational, methods and tools. The overarching goal is to provide DoD and the US Government with the ability to understand and effectively operate in human social culture terrains inherent to non-conventional warfare missions. The military capability needs being addressed center on enablement of modeling for irregular warfare and SSTR operations and on using computational models to support operations analysis, intelligence analysis, training and joint experimentation. It is an integrated R&D effort focused toward rapid transition of computational models to acquisition programs of record (e.g., U.S. Army Distributed Common Ground System).

The HSCB program has direct links to the National Security Strategy for the Global War on Terror (GWOT), and the 2006 Quadrennial Defense Review (QDR) common call for a focus on irregular warfare. It is linked directly to the QDR stated goals and operational mandates (OPPLAN 7500) to improve our understanding of cultural factors, how they influence the spread of extremism, and how they affect the desired outcomes from our military kinetic and non-kinetic actions. It is configured to support policy (e.g., DoDD 3000.05) and field doctrine (e.g., Army FM 3-24 and FM 3-7) by providing enabling capabilities for socio-cultural behavior modeling and simulation for the full spectrum of Joint Operations.

The extramural component of the program is being executed in conjunction with the Military Services, relevant organizations of the Office of the Secretary of Defense (OSD), and in coordination with work across other Federal agencies. The Office of Naval Research is one of several offices through which the HSCB Program is supporting research and development efforts. Broad Agency Announcements may also be issued by the Counter Terrorism Technology Support Office (CTTSO), the US Army Geospatial Center, or possibly other DoD entities. The HSCB Program will also be working through the DoD Small Business Innovation Research (SBIR) program to sponsor projects.

Objectives and Goals

The HSCB Program will develop a military science base and field technologies that support socio-cultural understanding and human terrain forecasting in intelligence analysis, operations analysis/planning, training, and joint experimentation. Broadly speaking, the program aims to build technical capability in data collection and management, socio-cultural theory and model development, and visualization and training. More specifically, the program has three objectives:

- Develop an applied science base and general-use, cross-domain capabilities/tools to support all socio-cultural applications. These shall include computational/analytical anthropological data collection, data models, theory development, and application methodologies and tools;
- Mature, harden, and validate human, social, culture, and behavior modeling related software for integration into existing programs of record architectures, or maturing software via open architectures to allow broad systems integration; and
- Develop computational modeling capabilities, visualization software toolsets, and training/mission rehearsal systems that provide forecasting capabilities for socio-cultural (human terrain) responses at the strategic, operational and tactical levels.

HSCB Program technical goals span three progressive levels: applied research, advanced research, and demonstration and transition. In the first area, work will focus on developing infrastructure, models, and methods that provide a foundation for eventual advanced research and, ultimately, transition to programs of record. The program will support applied research on data infrastructure, theory-driven model development, visualization infrastructure, and training tools. Work during this phase will develop: data and database architectures that provide vertical and horizontal dissemination of social/cultural information; computational models of social/cultural factors in coalition, enemy, and neutral forces and validate models for military applications; common categorization of meta-information and methods for visually depicting uncertainty; and tools to speed development of socio-cultural understanding and skills.

Advanced research sponsored by the Program will focus on: creation of valid, dynamic synthetic adversaries for U.S. and coalition planning and Joint experimentation; integration and demonstration of decision support tools that include socio-cultural factors within battle command planning/re-planning and C2 systems; demonstration of a battle command/C2 common visualization tool that vertically integrates cultural information into operational planning; and demonstration of operational/tactical training systems that use flexible cultural models/entities. The final level of work supported by the HSCB Program will focus on maturing and hardening models, tools, and products for transition to programs of record. This will include data collection tools and software to support tactical level collection and dissemination of social/cultural data; visualization software that supports cultural referenced, actionable information within operational-tactical level C2; and validated, generalized societal and cultural behavior models, with supporting software architectures, applied within multiple user domains.

Program Development

As it progresses, the HSCB Program will maintain focus on three principles. First, it will rest on a solid scientific foundation. The program will seek and support work that builds on established (e.g. peer reviewed) social science theory and methodology, and that leverages leading edge computational techniques. It will implement a rigorous, competitive environment to ensure that innovative and sophisticated work is done. That environment will include a carefully-specified process for assessment and testing. Second, the program will keep the end user always in mind. Support will flow to development of data, models, tools, and capabilities that will be valued by a DoD user community and that can be transitioned to a program of record.   Finally, the program will strive to evolve an integrated portfolio of research and development, so that resulting products inter-relate and offer transferable capability.

To adhere to these principles, the program will coordinate and collaborate among stakeholders across and beyond the DoD. It will also leverage systems engineering practices. Figure 7 provides a preliminary depiction of the program's development, assessment and transition process.

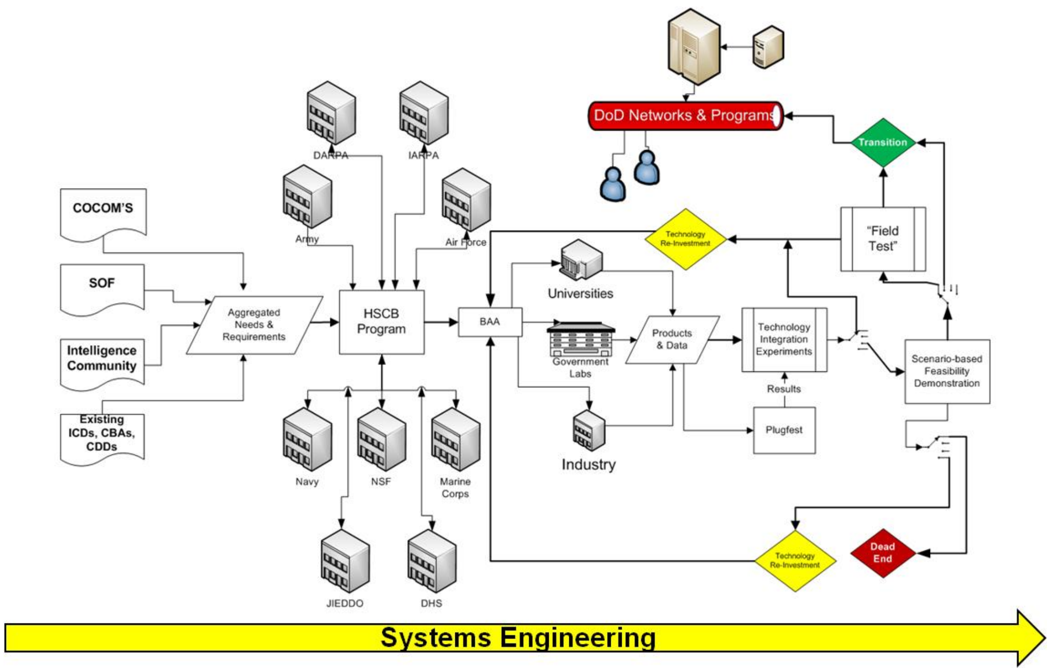

Figure 7 HSCB Program Development, Assessment and Transition Overview

Conclusions

An implicit but significant issue that arises in operational usage of socio-cultural behavior analysis is the need for multi-disciplinary expertise. The process of using these models is one of human translation or transformation of information, from the real world into the models, and out of the models into real-world implications.

Consequently, conscientious operational usage will require development of policies, procedures, information systems, and requisite training to guide people in this endeavor and to ensure that their activities are audited and documented. In addition, doctrine and mission rehearsal venues will need to be developed to ensure decision makers are sensitive to the capabilities and limits of using such models of operational planning and policy development.

Of all the concepts presented in this paper, the movement from "optimal" to "robust" decision making is most significant. It is this shift in perspective that enables the most effective use of socio-cultural behavior models. Ultimately, this usage of these models can enable planning even under circumstances of deep uncertainty. They will support the identification of more robust courses of action and policies, which will inherently improve the success of our decision making, and thereby enable effective, relevant C2. Putting socio-cultural behavior models into operational usage may incur a non-trivial cost in time and resources. However, as this paper suggests, and the HSCB program intends to demonstrate, their conscientious operational usage is technically feasible.

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