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Challenges for Human, Social, Cultural, and Behavioral Modeling

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Challenges for Human, Social, Cultural, and Behavioral Modeling

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ABSTRACT

Today's military focus has moved away from the force-on-force battlefield of the past century and into the domain of irregular warfare and its companion security, stability, transition and reconstruction missions. With that change in focus has come a need to examine the operational environment from a far wider perspective, one that includes the whole range of human experiences and circumstances. As the set of factors and list of players expands, the need for reliable modeling and simulation increases, if for no other reason than to help the human decision maker make sense of this expanded decision space. However, to do this, the models and simulations must take into account the "whole of government," "whole of society," and all those with an interest in region in question – allies, trade partners, adversaries, individuals, and networks of influence. The ideal solution would be to inject models from the human sciences into our kinetic simulations and declare success, but this is not possible. The different disciplines that comprise social and human sciences have different vocabularies and interpretations of events. They understand measurement, data, and models in diverse ways and their time scales vary from those we understand from working with kinetic models. The intent of this paper is to examine some of these differences and the challenges they present both technically and managerially.

1 INTRODUCTION

Within the military and across other application domains, models and simulations are used to support a variety of important activities including training, decision making at various levels, and understanding the interplay of options in a complex environment. The requirement for such models is that they reflect – to the extent needed for the specific application – the actors and the environmental factors that influence their actions. This requirement is easily stated but not as readily implemented as the complexity of the environment in which the actions take place increases, particularly when that complexity involves the full range of human, social, cultural and behavioral factors.

When irregular warfare missions are involved, avoiding the human element invites failure. The need to include the human element has been recognized and documented in US military warfighting concepts:

> *Irregular warfare depends not just on our military prowess, but also our understanding of such social dynamics as tribal politics, social networks, religious influences and cultural mores. People, not platforms and advanced technology, will be the key to irregular warfare success. The joint force will need to be patient, persistent, and culturally savvy people to build the local relationships and partnerships essential to executing irregular warfare. [IWJOC, 2007]*

This concept of irregular warfare as an engagement, building relationships and partnerships, is consistent with the understanding that the military mission is a part of an overall national security policy that involves all pillars of national power – diplomacy, information, military and economic (DIME).

The NATO Code of Best Practice for Command and Control (C2) assessment, written in support of analyzing operations other than war, observed that military forces are used increasingly as an integrated part of overarching political operations [NATO, 2002]. If this is the case, and the need involves modeling the outcome of the overall operation, what were formerly purely military simulations must now incorporate "whole of government" and "whole of society" roles, factors, and environments. Thus the requirement to model actors and the environmental factors that influence their behavior becomes significantly more difficult.

Military simulations to date have relied on the familiar areas of attrition, maneuver, weaponry, and battle damage in environments that, while complex, were largely governed by physical laws readily cast into mathematical relationships. Interactions among systems were difficult, but the relationships governing them were reasonably well known and computable. The data to support the models had been collected over many years using field and laboratory experiments. While the "end-to-end" system of interactions in a complicated joint land, air, and sea battle still required some level of assessment by subject matter experts, these experts could rely on having experienced the same type of scenario in the course of their military careers.

The universe changes when the human domain becomes a driving factor in the simulation. Social sciences have also used various types of models, but the nature and basis of the models are different across the various social science disciplines and from the physical models of traditional military simulation. The data to support social science models comes from different sources, and its collection is often complicated in ways unknown to physical scientists. Laboratory experiments are made difficult by timelines, often generational, and the problem of holding variables constant. It may take years for a social change to take place; during that time the world may change in ways that cannot be controlled by an experiment. Social science experiments give physical scientists headaches. All these challenges must be understood, met, and addressed before the human sciences can become full partners in military simulation. Just enumerating the relevant human factors and the disciplines that study them strikes fear into the heart of the simulation community – or should. **Fig. 1** (next page) illustrates the factors that form and govern the human actor.

The technical complexity spawns managerial difficulties. Advancing our ability to model the full range of military problems, including the militarily relevant aspects of human behavior, requires approaches that bridge managerial as well as technical problems.

The first problem is a lack of common vocabulary among the physical scientists, social scientists, and user communities. This observation has been made by NATO and in the United States by Joint Forces Command and by participants when conferences and workshops have brought these communities into direct contact. The presence of so many different academic disciplines in Fig. 1 is testimony to the fact that cultural (and lexical) divisions separate the groups engaged in the study of the human domain.

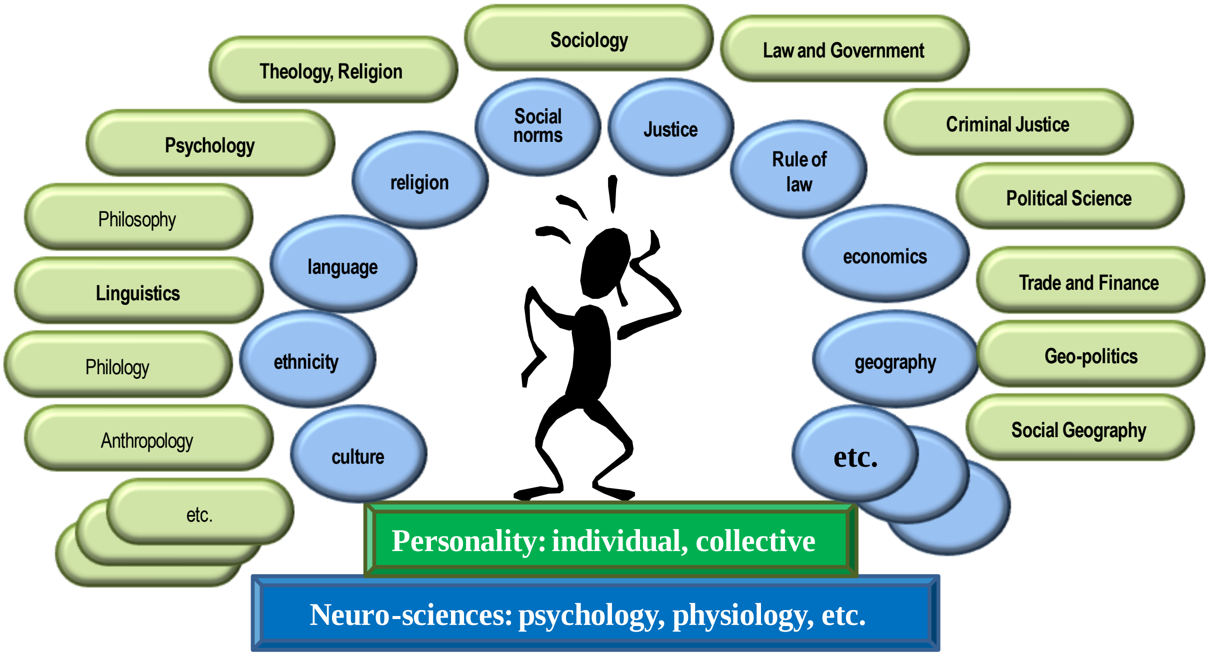

Figure 1. Factors involved in human decision making and their formal academic disciplines

The next problem is that the management structure in military simulation, including the groups that fund the development of new models, is dominated by physical scientists – those very people who get headaches whenever they are confronted with the issues and methods of the human sciences. When their comfort zone is the physical sciences, it is difficult for resource sponsors to place their trust in the results of social science research, experimentation, and modeling. This is compounded by the fact that social science models do not yield to traditional approaches for validation, verification, and accreditation. **Fig. 2** shows some modeling approaches arranged along a scale with engineering models on the left and heuristics-based modeling on the right. The comfort zone of the defense modeling establishment is solidly on the left while the models most useful in many social and human contexts fall to the right. The MINERVA program was initiated to open dialog between the military and the social science community without requiring that the research be sponsored under the defense establishment. It is one of a number of efforts on the part of the military research community to engage social scientists and take advantage of their expertise in solving the new and difficult problems that face the defense community.

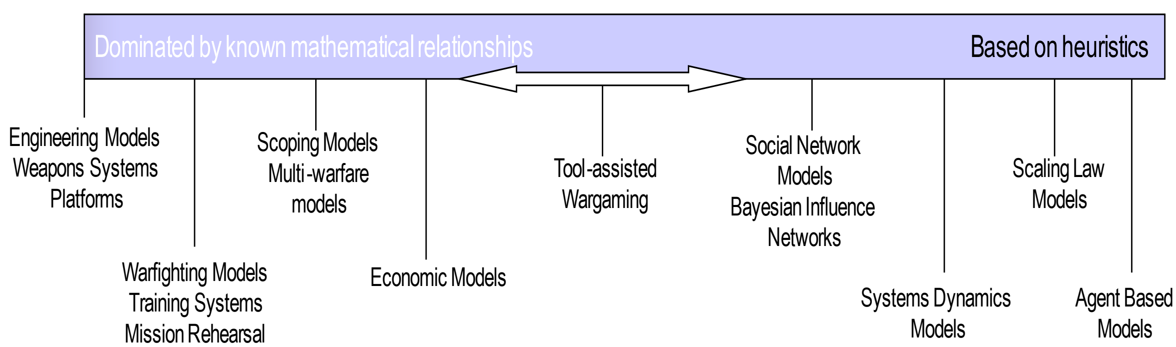

Figure 2. Modeling domain (engineering models on the left, social science models on the right).

Finally, nobody wants to be responsible for data. Everyone needs data, but the prospect of having to be the collection, storage, and dissemination agent for the data are daunting, particularly since there are no universally accepted taxonomies or metadata standards upon which to rely when working across social science disciplines.

2 A RESEARCH AGENDA FOR SOCIAL SCIENCE MODELING

In response to the changes in military missions and their implication for research in modeling, the US Air Force requested the National Research Council (NRC) to review the state of the art in modeling the behavior of humans as individuals and in groups of various sizes (the larger social context). The application areas included the development of doctrine, strategies, and tactics for dealing with both state and non-state adversaries; the analysis of current political and military situations for planning and future operations; and the development of models and simulations for training and mission rehearsal. Once gaps had been identified, the NRC study panel was asked to develop a research roadmap for filling those gaps.

The study [Zacharias, 2008] organized its conclusions in five major categories:

1. *Modeling strategy—matching the problem to the real world: Difficulties in this area are created either by inattention to the real world being modeled or by unrealistic expectations about how much of the world can be modeled and how close a match between model and world is feasible.*
2. *Verification, validation, and accreditation: These important functions often are made more difficult by expectations that verification, validation, and accreditation (VV&A)—as it has been defined for the validation of models of physical systems—can be usefully applied to IOS (individual, organizational, societal) models.*
3. *Modeling tactics—designing the internal structure of a model: Problems are sometimes generated by unwarranted assumptions about the nature of the social, organizational, cultural, and individual behavior domains, and sometimes by a failure to deliberately and thoughtfully match the scope of the model to the scope of the phenomena to be modeled.*
4. *Differences between modeling physical phenomena and human behavior—dealing with uncertainty and adaptation: Problems arise from unrealistic expectations of how much uncertainty reduction is plausible in modeling human and organizational behavior, as well as on poor choices in handling the changing nature of human structures and processes.*
5. *Combining components and federating models: Problems arise from the way in which linkages within and across levels of analysis change the nature of system operation. They occur when creating multilevel models and when linking together more specialized models of behavior into a federation of models.*

The study regarded the modeling of human behavior as an emerging science and acknowledged the many disciplines from which it had drawn. It also acknowledged that to provide a robust scientific foundation for such modeling, researchers from different domains needed a common framework for expressing concepts and forums in which to compare, discuss, and evaluate their findings and results.

The study's recommendations included the following:

1. Sponsor an integrated, cross-disciplinary research program that would include the development of theory; the ability to model uncertainty, dynamic adaptability, and rational (or irrational) behavior; methodologies for the collection of data, particularly in denied or dangerous areas; the ability to federate models and understanding of when such federation is appropriate; ways of validating and assessing the utility of models; and development of tools and infrastructure for enabling model building.
2. Incentivize multidisciplinary conferences and workshops to assist social science model developers in understanding the nature of military decision making, and to help military sponsors and users to realize the nature and applicability of social science models.

3. Develop a roadmap for future research and development based on a dialog between the scientist and the user, and focused on a series of challenge problems with clear specifications for the uses of the model together with well-defined military needs.

The recognition of the need to couple the research to demanding user needs as a way of engaging the military community is a critical insight, one that is also important in scaling the problem down to tractable size.

3 CRITICALITY OF HAVING USER NEEDS SPECIFIED

Unless there is a significant effort made to engage the military user in determining what should be modeled, the modeling community will be condemned to try to model everything – an impossibility. Not all facets of human existence are militarily relevant; however, only a concerted effort at defining mission-oriented needs can provide the appropriate framework for modelers. While some missions require highly detailed data a the local level, for example, data about needs and interests of a village, not all applications need this type and resolution of data. Thus it is important both to modeling and data collection to understand the questions that have to be addressed for different military missions.

A few simple illustrative examples show the different types of models and data sets that service specific missions. Consider the problem of a regional combatant commander who is responsible for the security of the area of the world that is his domain. One of the most critical factors for him is to anticipate when a fragile state is likely to erupt into violence. Generally stability assessments rely on large sets of statistical data and a few clusters of factors that appear to be leading indicators of problems. There is no need to have a detailed understanding of tribal customs, for example, to evaluate the likelihood of violence breaking out. An ongoing research program sponsored by the Defense Advanced Research Projects Agency [DARPA, 2009] is developing a set of linked tools for addressing this type of application.

If you are a military commander engaged in a reconstruction operation, you may need to assess the success of your projects in achieving the overall goal of returning the governance and welfare of the country to its own government. In this case, the model must describe the principal factors that determine stability in a country, factors that contribute to or detract from stability. Such a model has already been developed collaboratively by the Department of Defense, State Department, and US Agency for International Development; it is based on assessing the following factors: political moderation, a safe and secure environment, the rule of law, a sustainable economy, and social well-being [Dziedzic, 2008]. There are both objective and subjective components of each of these factors; therefore, the data collected to evaluate performance have to include both concrete evidence of performance and perception of performance.

While stability is an issue for both the regional combatant commander and for the military commander in charge of reconstruction, the models and data vary with the specific mission and the questions arising from that mission. A completely different approach is needed for the commander who must work in a region where hostilities are active and security is at issue. The forward based commander, like the commander in Khost or Helmand in Afghanistan, needs to understand the population at a much more refined level. A taxonomy for state and non-state actors including their interests, capabilities, operational context and decision-making styles, could direct the military user toward the information he must collect to begin to understand the dynamics of his environment [Numrich, 2008]. Using such data, agent-based models might then be used to explore possible futures or the potential success of courses of action [Chaturvedi, 2005; Silverman, 2006 a, b].

Consider a different problem – tracking global terrorist movements and determining which of the many groups might be contemplating the use of weapons of mass destruction. As a global problem with security implications, this becomes a military mission. With limited resources, the hundreds of terrorist groups cannot all be watched with the same intensity. To make this problem tractable, the military user must determine a subset of groups that is more likely than the others to be able to acquire and use such weapons. Taking the Bayesian view that past performance is an indicator of future action, modelers have used regression analyses to compare key parameters of terrorist groups and identify correlations and similarities, thereby reducing a list of hundreds to the top twenty or thirty [Asal, 2008]. The data useful in this analysis are incident data extracted from unformatted textual accounts of incidences of violence.

Breaking out the complexity of human, social, cultural, and behavioral modeling through a careful examination of mission needs is a practical way of understanding the data and modeling requirements. While it is certainly possible to incorporate social science modeling into military applications without first understanding the mission needs, the NATO Code of Best Practices [NATO, 2002] would argue against such an approach. The Code places emphasis on problem formulation as fundamental to any analysis, especially when the problems are ill-defined and complex, and involve many dimensions with a rich context. There is much wisdom in specifying a problem with care before attempting a solution, but time and resource constraints get in the way of wisdom.

4 A WORD ABOUT DATA AND MODELS

The examples above allude to an interplay between data and models that is significantly different from what has been observed in physics-based modeling. Some modeling approaches make extensive use of statistical data, a form of data that we consider to be objective or "hard" data. In other cases, the issue and hence the model requires soft or subjective (perceptual) data. Often the combination of both types of data are required.

For example, if the issue is whether a population is likely to react negatively to a situation, the critical factor may be the difference between the actual situation and the people's perception of it. The statistical values alone do not tell the story. Suppose the issue is the availability of reliable electrical power, and the statistical data indicates that reliable power is available four hours a day, seven days a week. In West Africa, having four hours of reliable power every day may be close to a miracle, but in Atlantic City, New Jersey, this degree of deprivation could well cause riots in the streets. In many human circumstances, the issue is not the reality but the difference between the expectation and the reality – an interplay between the objective and subjective data.

But where do the data come from, how easy is it to get, and how reliable is it? One might hope that statistical data are readily available and reliable; however, that is not always the case, and particularly for developing nations that are among the most likely to be fragile and on the verge of state failure. Statistical variables are not always interpreted uniformly, nor are they computed in a standard way. The United Nations is currently engaged in a multi-year program to standardize the interpretation and computation of statistical data across its member nations. However, even in cases where the interpretation and computation are not in question, frequently there are gaps in the availability or currency of the data. Data at the provincial and district levels are absent entirely for the majority of developing nations. In countries without a solid resource base or where security issues impede collection of data, statistical tables may be a decade or more out of date. For some countries, even the most basic demographic data may be lacking. For example, in Sudan, the last census was taken more than ten years ago, and the interim migrations, caused by war and drought, have changed the population densities in both the eastern and western frontiers.

Statistical tables are not the only hard data that are important in social science modeling. The characterization of terrorist groups done by Asal and Rethemeyer [Asal, 2008] relies on event data. No agency or entity is currently tasked with recording all incidents of violence. Extensive work has been done to extract that information from numerous sources, most often press releases. Such sources do not come coded in database format but rather exist in plain text with a somewhat-haphazard handling of details such as time, location, and lethality. To create a reliable event database, a dedicated research group must first create a *code book* – a list of all the desired variables and a description of how the variable is to be interpreted. The code book and the media articles are then given to research assistants who extract the variables from the information in the articles. Their work is carefully checked by a verifier and then entered into the database. Most individual sources will not contain the full set of variables sought, resulting in gaps in the data. In addition, sources must be compared carefully to make sure that multiple reports of the same incident are handled properly. This is a manual process; attempts to automate it have been met with only limited success.

The common sources for perceptual or subjective data are structured polls, discussions with subject matter experts, or extraction of information from media sources (press releases, information published on web sites, audio and video clips). Accurate polling data are hard to acquire, particularly when crossing cultural and linguistic barriers that tend to blur meaning. Eliciting the desired information frequently requires breaking the direct questions suitable for American audiences into clusters of related but culturally appropriate concepts. Professional polling groups earn their reputations by producing statistically consistent, culturally adjusted polls that are repeated at least annually to permit the construction of trend lines. When professional polls are not available, casual surveys can provide useful information; however, the results can be suspect on technical grounds including selection of the sampled population, nature of the questions and the manner in which the survey is administered.

Subject matter experts are important sources of information and their perspectives on a situation can add critical insight. However, the same experiences and training that contribute to their expertise can also create a bias in their perceptions. Since choosing the "right" subject matter expert is extremely difficult, the safest approach to using subject matter experts is to use a wide enough variety to minimize the impact of relying on any single point of view or bias.

Media extraction presents a very different set of issues. All media articles are biased in some way. The editorial policy of the newspaper or the perspective of the reporter may be the source of bias. In nations where the press is both monitored and controlled, the media will publish what the government wants. Translations can be biased based on the skill of the translator. Automation has been used to speed the extraction of data from texts. Some types of extraction rely on word matching and statistical analyses, and are referred to as "bag of words" approaches. Other methods use natural language processing to extract a more nuanced meaning; however, these methods are hard to apply beyond the English language. This is particularly unfortunate since the most reliable reporting is done in the vernacular.

Data acquisition for social science models is not easy, and there are normally gaps in the available data. A careful analysis based on *mission needs* can help focus data acquisition on militarily relevant information and avoid expending scarce resources on creating overly large taxonomies, data bases and metadata standards.

5 COMMUNITIES OF INTEREST (COI)

Joint Forces Command (JFCOM) recognized the need for locating and linking a network of experts who could explore effective methods for applying social science models to irregular warfare problems [Garrett, 2009]. This effort capitalized on the prior work done under NATO in building a framework for collaboration. To identify initial group membership, the research group supporting COI created a questionnaire to identify and catalog the knowledge of experts. Initially, the structure of the NATO Code of Best Practice for C2 Assessment guided the categorization. Experts in human and social sciences have improved this structure to reflect a better characterization of their disciplines. The catalog was implemented using a global visualization tool, "The Brain," instead of traditional databases. The Brain supported not only the immediate visualization of the COI, it also showed where gaps existed, and where overlapping functionality resided. Experts and military practitioners were encouraged to enter a collaborative environment through which they could share ideas and work with the Brain. Every effort was made to create a welcoming virtual environment for all researchers, not only those who would normally work with the military.

A number of problems are associated with the formation of communities of interest, at least two of which are critical and involve resourcing. The first problem involves creating an incentive for individuals to participate regularly; the second, providing sustainment of the COI over time. While nearly all groups and individuals involved with the application of human sciences to military modeling agree that cross-disciplinary engagement of experts and users is essential to breaking down the language barriers and creating an environment of mutual understanding, nobody has yet solved the problem of incentivizing busy people to spend part of their limited time engaged in a COI. While JFCOM was able to create a novel and effective environment for the COI, their effort was in the nature of an experiment; to date, no entity has been willing or able to resource the sustainment of the COI.

While these issues are not peculiar to social science modeling, the inability to solve them has a greater negative impact on a field that is struggling to establish itself.

6 FINDING A WAY FORWARD

For those who feared that the modeling and simulation (M&S) community had solved the hard problems and was destined to a future of limited improvements, the need to incorporate the human dimension – the "whole of government" and "whole of society" factors into military simulation – has created myriad challenges. The demands for social science modeling, or the results thereof, have now been heard and resources are being brought to bear on addressing the attendant problems. The lessons learned in working with kinetic models and simulations must be carried forward, but new challenges requiring new approaches have arrived with the introduction of new disciplines. From model design to validation, technical and managerial processes must be rethought to accommodate the theories and methods of the social sciences. Data acquisition takes on new dimensions with the need to blend objective and subjective data. Both incentivizing and sustainment will present problems as the field of social science modeling attempts to find its footing in military applications. With challenges come opportunities. While the field is in its early stages, the M&S community would be wise to engage across the user and expert communities to define clear mission-driven needs as suggested by the National Research Council. Time and resources expended to specify the problems clearly and create meaningful conversations between the military users and experts in social science modeling will save time and resources as we strive to meet the challenges of human, social, cultural, and behavior modeling for military missions.

REFERENCES

Asal, V., Rethemeyer, R.K. (2008). "The Nature of the Beast: Organizational Structures and Organizational Lethality." *Journal of Politics*, 70(2), 437–449.

Chaturvedi, A., Mehta, S., Dolk, D., Ayer, R. (2005). “Agent-based simulation for computational experimentation: Developing an artificial labor market,” *European Journal of Operational Research* Vol. 166, 694–716

DARPA (2009). See the ICEWS program description on DARPA website, http://www.darpa.mil/ipto/programs/icews

Dziedzic, M., Sotirin, B., Agoglia, J. (2008). *Measuring Progress in Conflict Environments (MPICE) – A Metrics Framework for Assessing Conflict Transformation and Stabilization. Version 1.0*. Corps of Engineers, Report A942884, Washington, DC.

Earnest, D.C., Gaubatz, K.T. (2007). “Modeling, Simulation, and the Social Sciences: An Agenda for Integration.” *Proc. Spring Simulation Interoperability Workshop*, Norfolk, VA: March 25–30

Garrett, R.B., Tolk, A., Bacon, T.J. (2009). “Exploring Effective Methods for Modeling a Comprehensive Approach to Political, Military, Economic, Social, Information, and Infrastructure (PMESII) / Human, Cultural, Social, and Behavioral (HSCB) Community of Interest (COI).” *Proc. Winter Simulation Conference*, Austin, TX: Dec 13–16 (in press).

IWJOC. *Irregular Warfare Joint Operating Concept*. 11 September 2007. http://www.fas.org/irp/doddir/dod/iw-joc.pdf.

NATO. (2002). *NATO Code of Best Practice for Command and Control Assessment*. Revised 2002, Reprinted by CCRP Press. Washington, DC.

Numrich, S K “Culture, Models, and Games: Incorporating Warfare’s Human Dimension.” *IEEE Intelligent Systems* July/August 2008, 58–61.

Silverman, B.G., Johns, M., Cornwell, J., O'Brien, K. (2006a). “Human behavior models for agents in simulators and games: Part I: enabling science with PMFserv.” *Presence: Teleoper. Virtual Environ.* Vol. 15, No. 2: 139–162

Silverman, B.G., Bharathy, G., O'Brien, K., Cornwell, J. (2006b). “Human behavior models for agents in simulators and games: Part II: gamebot engineering with PMFserv.” *Presence: Teleoper. Virtual Environ.* Vol. 15, No. 2: 163–185.

Tolk, A. “Emerging M&S Challenges for Human, Social, Cultural and Behavioral Modeling *Proc. Summer Computer Simulation Conference 2009*.

Zacharias, G.L., MacMillan, J., Van Hemel, S.B., editors. “Behavioral Modeling and Simulation: From Individuals to Societies.” National Research Council, National Academies Press, 2008.

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